Documentation of Cold Fusion Research at the Sidney Kimmel Institute for Nuclear Renaissance (SKINR)

A Project of the LENR Research Documentation Initiative

Stage 1. Information Collection

Volume 2 of 2. Draft Appendices

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Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

The University of Texas at Austin
Energy Institute

Contents

Introduction

The Sidney Kimmel Institute for Nuclear Renaissance (SKINR) was a LENR research organization at the University of Missouri that operated for over five years (April 2012 to December 2017). It was developed from a predecessor organization, Energetics Technologies. SKINR employed most of the experimental methods known to achieve LENR utilizing sophisticated equipment and advanced methods. The research results were published in many papers, presentations, and other public venues. A large volume of hard-copy and electronic files containing experimental results, reports, images, and other LENR-related files was also developed.

An Initiative[1] is underway to mitigate the risk of loss of research records of LENR investigators and organizations. Its objectives are to capture, organize, document, and archive these records as well as develop a timeline of SKINR research. The LENR Research Documentation Initiative (LRDI) is being performed at the Energy Institute[2] of The University of Texas at Austin.

When SKINR ceased operations in December 2017, Dr. Dennis Pease, purchased much of the equipment and most of files of SKINR. Starting with discussions between Dr. Pease and Dr. Thomas Grimshaw at the 21st International Conference on Cold Fusion (ICCF-21, June 2019), a project is being performed under the umbrella of the LRDI to secure the SKINR research materials. Dr. Arik El-Boher, former Research Group Leader, has joined the SKINR Research Documentation Project (SLRDP). Dr. Graham Huber, former SKINR Director, is also assisting with the project. Like other projects under the LRDI, the SLRDP performed in three Stages:

1. Information Collection
2. Organization
3. Documentation

The Stage 1 report consists of two parts. Volume 1, Draft Report, presents an inventory of the records found and sets forth a plan for more inventory and analysis in Stage 2. This Volume 2 provides the appendices referenced in Volume 1.

The 2026 update was made to prepare a consolidated volume of the appendices.

[1] Collection, Organization, and Documentation of LENR Research Results ("LENR Research Documentation Initiative"). Guideline, January 2019.

[2] https://energy.utexas.edu

Appendix A. SKINR Descriptions

Appendix B. Professional Biographies

Appendix C. Transcripts of Participants' Inteviews

Appendix D. Documents from Arik El-Boher

Appendix E. Annual Reports

Appendix F. Lab Procedures

Appendix A. SKINR Descriptions

Overview of the Sidney Kimmel Institute for Nuclear Renaissance (SKINR)

G.K. Hubler, A. El-Boher, O. Azizi, D. Pease, J.H. He, S. Gangopadhyay

Abstract: The Anomalous Heat Effect (AHE) is the appearance of excess energy in the form of heat when a Pd cathode is electrolyzed in heavy water (D_2O) and is much less evident when light water (H_2O) is used.[1-4] This paper describes the organization, motivation and plans of an institute formed to perform fundamental research aimed at discovering the mechanism of the AHE.

Introduction

The Sidney Kimmel Institute for Nuclear Renaissance (SKINR) was established in April 2012 as an entity within the Department of Physics and Astronomy at the University of Missouri (UM) that reports directly to the Vice Chancellor for Research. The Institute was formed through negotiations between Dr. Robert Duncan and philanthropist Sidney Kimmel. Mr. Kimmel provided initial 5-year funding totaling $5.5 M. The nucleus of the SKINR staff originated with the company Energetics LLC. Energetics had carried out research since 2002 in the anomalous heat field.

The MISSION of SKINR is "to find the origin of the Anomalous Heat Effect (AHE) with a sound materials science approach and with no preconceptions as to the origin of the phenomenon. To publish findings in the open literature and to openly collaborate worldwide with researchers in the field and in cross disciplines."

The SKINR staff is composed of:

- ◆ Orchideh Azizi, Ph.D. (Electrochemist)
- ◆ Arik El-Boher, Ph.D. (Group Leader, Mechanical Engineer)
- ◆ Jinghao He, Ph.D. (Materials Scientist)
- ◆ Graham K. Hubler, Ph.D. (Director, Physicist)
- ◆ Martin De Stefano (Technician)
- ◆ Dennis Pease, Ph.D. (Physicist)

Additional members include four undergraduate students at SKINR, three graduate students, two Post-Docs and two research staff in collaborating departments.

Dr. Duncan initiated SKINR projects with several UM professors. Their activities are supported and guided by SKINR. The experiments are fundamental investigations into aspects related to the Anomalous Heat Effect. The collaborators, and a short description of their experiments, are listed below:

- ◆ Prof. John Gahl, Electrical Engineering: Pd(d,p); Ni(p,p), high intensity ion bombardment using MURR cyclotron, reaction cross-section and exploding PdH/PdD wires using pulsed power
- ◆ Prof. Shubhra Gangopadhyay, Electrical Engineering: Carbon nanotubes (CNT) and graphene-oxide based cathodes, nanoparticle deposition on cathodes, artificially structured cathodes and Pd/Pt/Au deposition on membranes
- ◆ Prof. Kattesh Kattie, Dept. of Radiology: *In situ* Pd nanoparticle deposition on Pd cathodes
- ◆ Prof. Mark Prelas, Nuclear Engineering: PdH/NiH films deposited on Diamond particle detectors and neutrons from thermally shocked TiDx

SKINR Experimental Instruments

Sidney Kimmel Institute for Nuclear Renaissance

Electrochemical systems:
- -9 open/hybrid cells in isoperibolic calorimeters
- -1 closed cell differential isoperibolic TEM calorimeter
- -2 closed cell isoperibolic TEM calorimeters (from TSEM, Italy)
- -2 open cell mass flow calorimeters (MFC) with ultrasound stimulation
- -1 open testing cell, no calorimetry
- -2 open cell with thin membrane, no calorimetry
- -1 dual electrochemical cell hydrogen permeation system
- -3 SS closed cell mass flow calorimeters
- -1 laser triggering cell with calorimetry on loaded cathode
- -1 cell allowing stress on loaded cathode
- -1 Gorsky Effect cell

Gas systems:
- -1 High Temperature gas reactor with mass flow calorimetry

Diagnostic systems:
- -2 X-ray detectors
- -Gamma detector
- -Neutron detector
- -RF spectrum analyzers (1 kHz-13 GHz)

Materials characterization:
- -SEM
- -Power spectral density
- -AFM
- -X-ray diffraction
- -X-ray texture
- -Electrochemical impedance spectroscopy
- -Hydrogen permeation kinetics
- -Charging protocols

Glow Discharge:
- - 2 Pd-D2 Low Temp. Ion Bombardment with MFC
- - 1 Ni-H2 High Temp. Ion Bombardment with MFC

All systems equipped with National Instruments data collection and control hardware and LabView software

SKINR, ENEA, TSEM have robust collaboration with National Instruments who has furnished hardware, software and training

Table 1. SKINR experimental systems.

The facilities in-house at SKINR are shown in Table 1 and in the photographs. Our materials fabrication capabilities are detailed in Table 2. Dr. Gangopadhyay has a complete VLSI capability that SKINR makes use of through our strong collaboration.

SKINR collaborates worldwide with several of the foremost institutions involved in AHE research. These are detailed in Figure 1. It shows the time-line of involvement by the collaborators, the U.S. funding sources (depleted as of 2013), and the path of Energetics Inc. from a company formed in Israel, to moving to Missouri, to being incorporated into the UM system as an institute in 2012.

Sorting out which experiments will bear fruit is the most difficult task of SKINR. Due to limited resources, we cannot pursue many of the experiments we believe would help elucidate the mechanism of anomalous heat. Anomalous heat is fundamentally a solid-state-physics problem requiring new information about the local environment around Pd and D atoms (and Ni and H atoms). New experiments that we think are important, a few of which we are pursuing, include:

Nuclear Mechanism
—Real time detection of low-energy emissions with a thin membrane system
—Move materials to Ge cave detector ~ minutes after MJ heat event
—Try to detect ^4He in closed cell by mass spectroscopy

General Mechanism
—*In situ* neutron scattering during heat events (in discussion with several groups)
—Systematically study effects of polarizing (pulsed) magnetic field
—Stimulate AHE using a femtosecond laser in the structured palladium deuteride system
—Stimulate by tuning acoustic frequencies to resonate with defect processes in cathodes
—Fabricate surface-structured cathodes
—Perform *in situ* perturbed angular correlation (PAC) Hyperfine field measurements during heat production at CERN (performed May-July 2015, to be published)
—Perform *in situ* Mossbauer (in discussion)
—Hydrogen permeation kinetics studies using two cells separated by Pd membrane[5]

Solid State Theory
—Density functional theory for electronic band structure of D in Pd and its alloys

Cathode Development (many choices)
—Self assembled Pd nanoparticle cathodes
—Pd coated carbon nanotube/graphene oxide cathodes
—Artificially structured Pd cathodes
—New alloy compositions
—Understand the metallurgy of Pd in the process of cold rolling and thermal annealing[5]
—Understand the role of electrolyte impurities on the ability to obtain high D/Pd fractions

High Temperature Gas Loading of Ni-H System
—Use SKINR gas reactor to explore heat production in Ni powder/LiAlH up to 1200°C

As an example of a new experimental method, Figure 2 shows schematically the thin membrane experiment being carried out at SKINR and ENEA.[6] The thin membrane allows transmission of X-rays down to 1 keV, alpha particles over ~20 keV and RF out of the electrochemical system to be sensed by the appropriate detectors in air. Most calorimeters have power sensitivity in the range of 1 to 10 mW. Suppose that the anomalous heat mechanism is active much of the time but at the micro-, nano- or pico-Watt level. The calorimeter is insensitive to such low power outputs. If, for example, in the membrane experiment we detect a 1 keV X-ray at a rate of 1 Hz, the corresponding power is 0.2 femtowatts, an excess power sensitivity improvement of 10^{12}.

This experiment was run for over a year with null results.[6] It is running now, improved by depositing a Pt resistor temperature sensor over 100 nm Al_2O_3 directly on the air side of a 50 μm thick Pd membrane. That arrangement provides a very fast, sensitive thermal measurement.

Table 2. SKINR materials fabrication capabilities.

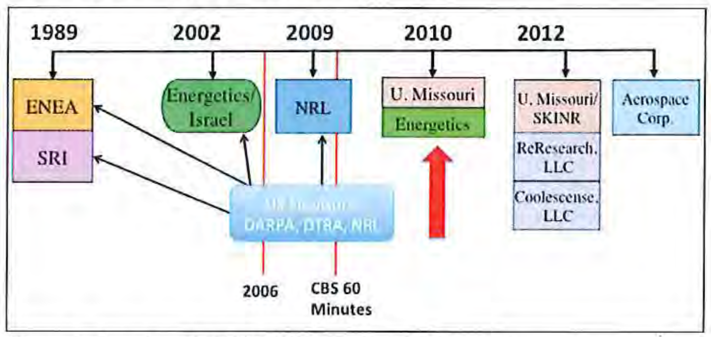


Figure 1. Time-line of SKINR formation and collaborators.

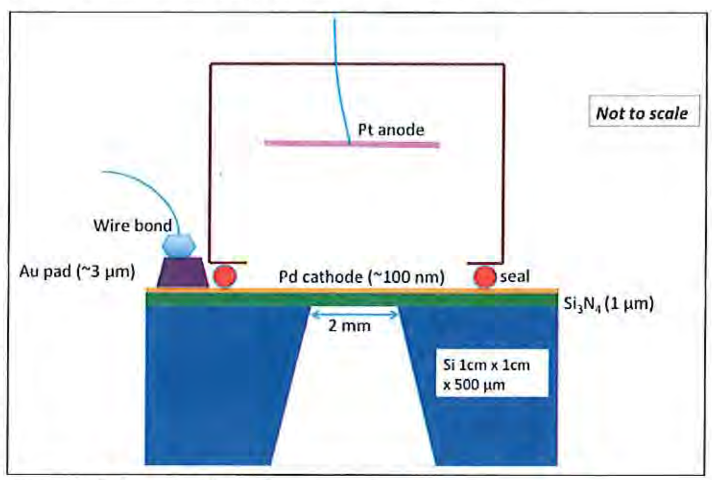
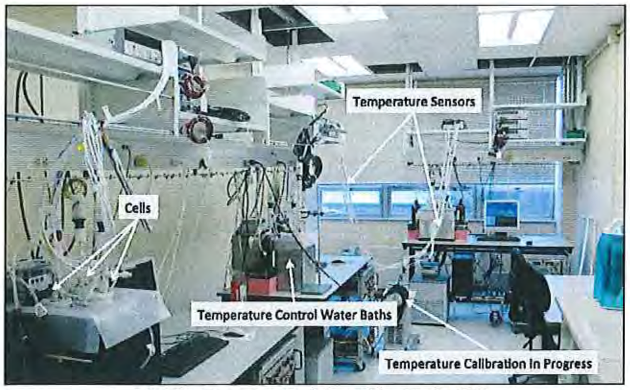
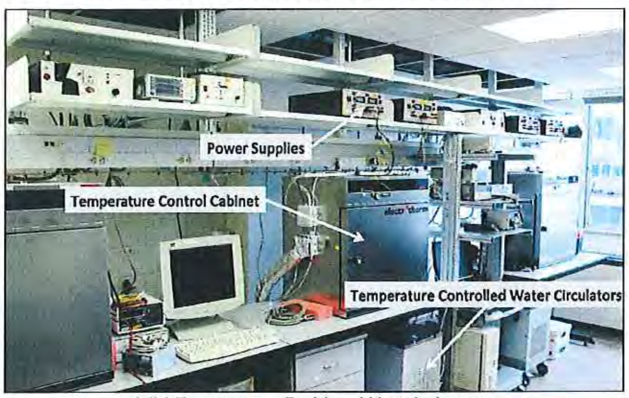


Figure 2. Schematic of membrane experiment.

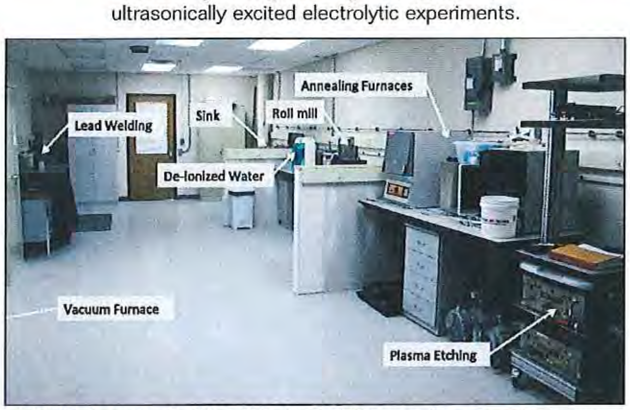


MU Engineering Building West Lab-139, electrolytic open cell experiments.

MU Engineering Building West Lab-137, hermetically sealed closed electrolytic experiments.



MU Engineering Building West Lab-137, ultrasonically excited electrolytic experiments.



MU Engineering Building West Lab-135, sample preparation room.

While the AHE mechanism is not clear, certain facts have become apparent regarding features of cathodes that will produce excess heat. Here we list these facts that have been collected for years.

Facts that support generation of excess heat

—[100] texture of polycrystalline grains[2,4]

—Laser triggering

—Magnetic polarization (from Mitchell Swartz, Dennis Cravens, Dennis Letts)

—D loading ratio > 0.88

—Specific cathode preparation[2,4]

Facts describing foil cathode surface

—Surface contaminants important (Pt, Ni, Fe, Si, Al, other?)

—Labyrinth morphology promotes excess heat[2,4]

—Peaks in power spectral density correlated with appearance and amplitude of anomalous heat[2,4]

—Strong RF emission from heat producing cathodes

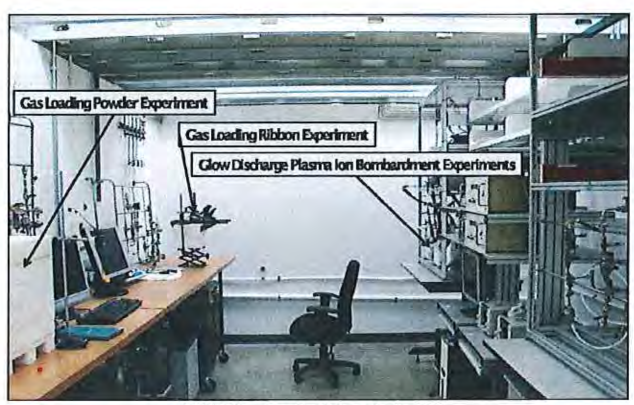
Summary

SKINR owes its existence to Sidney Kimmel, Energetics LLC, CBS News and Dr. Rob Duncan. We are studying both electrochemical and gas loading experiments in palladium deuterium/hydrogen systems, but with main emphasis on the electrochemical method where we have had all of our positive results. Our near-term goals are increasing reproducibility in electrolysis experiments, and mechanistic studies that may lead to improved understanding of the origin of anomalous heat. Results from more fundamental experiments are needed to be able to formulate a working model for the FPE. Extensive collaborations were developed inside UM and with outside institutions, and we invite more collaborators. We believe in open research objectives, plans and publication of results. We have much optimism at SKINR that the rate of unraveling the mysteries of the AHE is accelerating.

References

1. Hubler, G.K. 2007. "Anomalous Effects in Hydrogen-Charged Pd: A Review," *Surf. Coatings Tech.*, 201, 8568.

2. Violante, V., Castagna, E., Lecci, S., Sarto, F., Sansovini, M., Makris, T.D., Torre, A., Knies, D., Kidwell, D., Grabowski, K., Dominguez, D., Hubler, G.K., Duncan, R., El Boher, A., Azizi, O., McKubre, M. and La Gatta, A. 2013. "Excess of Power During Electrochemical Loading: Materials, Electrochemical



MU Physics Building Lab-301.

Conditions and Techniques," *Proc. 18th Inter. Conf. on Cold Fusion.*
3. Azizi, O., El-Boher, A., He, J.H., Hubler, G.K., Pease, D., Isaacson, W., Violante, V. and Gangopadhyay, S. 2015. "Progress Towards Understanding Anomalous Heat Effect in Metal Deuterides," *Cur. Sci.*, 108, 565.
4. Violante, V., Castagna, E., Lecci, S., Sarto, F., Sansovini, M., Torre, A., LaGatta, A., Duncan, R., Hubler, G.K., El-Boher, A., Azizi, O., Pease, D., Knies, D. and McKubre, M. 2015. "Review of Materials Science for Studying the Fleischmann-Pons Effect," *Cur. Sci.*, 108, 540.
5. Azizi, O., He, J., Paterson, D., El-Boher, A., Pease, D. and Hubler, G. 2015. "Effect of Cathode Pretreatment and Chemical Additives on H/D Absorption into Palladium via Electrochemical Permeation," *Proc. ICCF19*, April 2015, Padua, Italy, to be published.
6. Pease, D., Azizi, O., He, J., El-Boher, A., Bok, S., Mathai, C., Gangopadhyay, S., Katti, K., Katti, Kav. and Hubler, G. 2015. "Search for Low-energy X-ray and Particle Emissions from an Electrochemical Cell," *Proc. ICCF19*, April 2015, Padua, Italy, to be published.

Hubler, El-Boher, Azizi, Pease and He are in the Department of Physics and Astronomy at the University of Missouri (Columbia). Gangopadhyay is in the Department of Electrical Engineering at the University of Missouri (Columbia).

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Sidney Kimmel Institute for Nuclear Renaissance

G. K. Hubler[1,*], A. El-Boher[1], O. Azizi[1], D. Pease[1], J. H. He[1], W. Isaacson[1], S. Gangopadhyay[2] and V. Violante[3]

[1]Department of Physics and Astronomy and [2]Department of Electrical Engineering, University of Missouri, Columbia, Missouri, 65211, USA
[3]ENEA Frascati Research Center, Frascati (Rome), 00044 Italy

Anomalous heat effect (AHE) is the appearance of excess energy in the form of heat when a palladium cathode is electrolysed in heavy water, and is much less evident when light water is used. The present article describes the organization, motivation and plans of an institute formed to perform fundamental research aimed at discovering the mechanism of AHE.

Keywords: Anomalous heat effect, excess energy, hydrogen, palladium.

Introduction

THE Sydney Kimmel Institute for Nuclear Renaissance (SKNIR) was established in April 2012 as an entity within the Department of Physics and Astronomy at the University of Missouri (UM), USA, that reports directly to the Vice Chancellor for Research (VCR), Doctor Rob Duncan. The Institute was formed through negotiations between Robert Duncan and philanthropist Sydney Kimmel, which concluded on an agreement between UM and Kimmel to provide initial 5-year funding totalling US$ 5.5 million. The nucleus of the SKINR staff (Box 1) originated with the company Energetics, LLC. Energetics had carried out research since 2002 in the anomalous heat (AH) field.

The mission of SKINR laid out by Duncan is 'to find the origin of the Anomalous Heat Effect (AHE) with a sound materials science approach and with no preconceptions as to the origin of the phenomenon. To publish findings in the open literature and to openly collaborate worldwide with researchers in the field and in cross disciplines.'

Duncan initiated SKINR projects with several UM professors. Their activities are supported and guided by SKINR and experiments are fundamental investigations into aspects related to the anomalous heat effect. The collaborators, and a short description of their experiments, are listed in Box 2.

The in-house facilities at SKINR are listed in Table S1 and Figure S1 (see Supplementary Information online), and materials fabrication capabilities are detailed in Table S2 (see Supplementary Information online). In addition, Shubra Gangopadhyay has complete VLSI capability that SKINR makes use of through strong collaboration.

SKINR collaborates worldwide with several of the foremost institutions involved in AH research. These are

Box 1. The SKINR staff

- Orchideh Azizi, Ph D (electrochemist)
- Arik El-Boher, Ph D (Research group leader, mechanical engineer)
- Jinghao He, Ph D (materials scientist)
- Graham K. Hubler, Ph D (director, physicist)
- William Isaacson (technician)
- Dennis Pease, Ph D (physicist)

Additional members include four undergraduate students at SKINR, five graduate students, two Postdocs and one research staff in collaboration departments.

Box 2. SKINR project collaborators

John Gahl: Electrical engineering: Pd(d,p); Ni(p,p), high intensity ion bombardment using MURR cyclotron, reaction cross-sections, exploding PdH/PdD wires using pulsed power.

Shubhra Gangopadhyay: Electrical engineering: carbon nanotubes and graphene oxide-based cathodes, artificially structured cathodes; Pd/Pt/Au deposition on membranes.

Helmut Kaiser: Department of Physics and Astronomy/MURR: *in situ* neutron scattering during electrolysis on the PdD system.

Kattesh Kattie: Department of radiology: *in situ* Pd nanoparticle deposition on Pd cathodes.

Scot Kovaleski: Electrical Engineering: piezoelectric ion sources, low-energy ion bombardment.

Mark Prelas: Nuclear engineering: PdH/NiH films deposited on diamond particle detectors; neutrons from thermally shocked TiDx.

*For correspondence. (e-mail: hublerg@missouri.edu)

detailed in Figure 1 that shows the timeline of involvement by the collaborators, the US funding sources (depleted as of 2013), and also the path of Energetics Inc. from a company formed in Israel, to moving to Missouri, and to being incorporated into the UM system as an Institute in 2012.

Sorting out which experiments will bear fruit is the most difficult task for SKINR. Due to limited resources we cannot pursue many of the experiments we deem would help elucidate the mechanism of anomalous heat. New experiments that we consider important, a few of which we are currently pursuing, include the following.

Nuclear mechanism

- Real-time detection of low energy emissions with thin membrane system.
- Move materials to Ge cave detector a few minutes after MJ heat event.
- Try to detect ^{4}He in closed cell by mass spectroscopy.

General mechanism

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- Stimulate by tuning acoustic frequencies to resonate with defect processes in cathodes.
- Fabricate surface-structured cathodes.
- Perform perturbed angular correlation hyperfine magnetic field measurements during heat production at CERN (in discussion).
- Hydrogen permeation kinetics studies using two cells separated by Pd membrane.

Solid state theory

- Density functional theory for electronic band structure of D in Pd and its alloys.

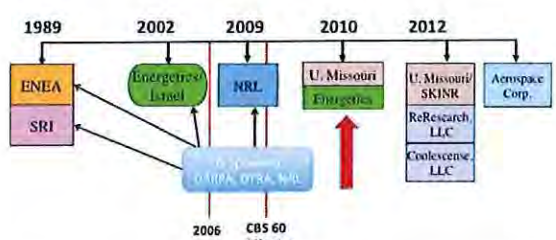

Figure 1. Timeline of anomalous heat research in the Sydney Kimmel Institute for Nuclear Renaissance, USA.

Cathode development (many choices)

- Self-assembled Pd nanoparticle cathodes.
- Pd-coated carbon nanotube/graphene oxide cathodes.
- Artificially structured Pd cathodes.
- New alloy compositions.
- Understanding the metallurgy of Pd in the process of cold rolling and thermal annealing.

As an example of a new experimental method, Figure 2 schematically shows the thin membrane experiment being carried out at SKINR and ENEA, Frascati Laboratory. The thin membrane allows transmission of X-rays down to 1 keV, alpha particles over ~20 keV and radio frequency (RF) out of the electrochemical system to be sensed by the appropriate detectors in air. Most calorimeters have power sensitivity in the range 1–10 mW. Suppose that the anomalous heat mechanism is active much of the time but at the micro-, nano-, or pico-watt level. The calorimeter is insensitive to this power output. If, for example, in the membrane experiment we detect a 1 keV X-ray at a rate of 1 Hz, the corresponding power is 0.2 femtowatts, an excess power sensitivity improvement of 10^{12}. While the AH mechanism is not clear, certain facts have become apparent regarding features of cathodes that will produce excess heat. Here we list these facts that have been collected for years.

Facts that support generation of excess heat[1–4]

- [100] texture of polycrystalline grains.
- Laser triggering.
- Magnetic polarization (from Mitch Swartz, Dennis Cravens and Dennis Letts).
- D loading ratio >0.9.
- Specific cathode preparation (rolling, annealing and etching – consult papers from Violante, ENEA).

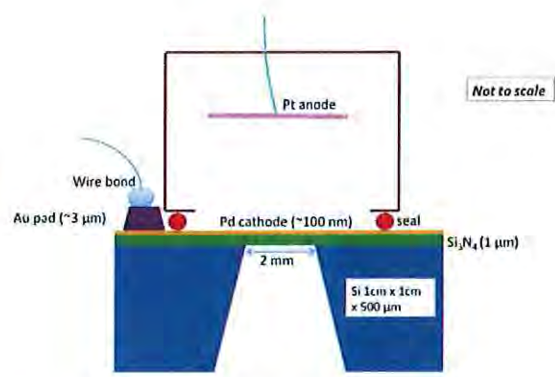

Figure 2. Schematic of membrane experiment.

Facts that do not support nuclear model

- No high-energy neutron or gamma ray emission.
- No activation of materials in electrochemical cell.

Facts describing foil cathode surface

- Surface contaminants important (Pt, Ni, Fe, Si, Al, other?)
- Labyrinth morphology promotes excess heat.
- Peaks in power spectral density correlated with appearance and amplitude of anomalous heat.
- Strong RF emission from heat-producing cathodes.

Summary

SKINR owes its existence to Sidney Kimmel, Energetics LLC, CBS News and Rob Duncan. We are studying both electrochemical and gas-loading experiments in palladium deuterium/hydrogen systems, but with main emphasis on the electrochemical method where we have had all of our positive results. Our near-term goals are increasing reproducibility in electrolysis experiments, and mechanistic studies that may lead to improved understanding of the origin of anomalous heat. We have developed extensive collaborations inside UM and with other institutions as well and we invite more collaborators. We believe in completely open research objectives, plans and publication of results. We have much optimism at SKINR that the rate of unravelling the mysteries of AH is accelerating.

1. Hubler, G. K., 'Anomalous effects in hydrogen-charged Pd – a review. *Surf. Coatings Technol.*, 2007, **201**, 8568–8573.
2. Dardik, I. *et al.*, Excess heat in electrolysis experiments at energetics technologies. In Condensed Matter Nuclear Science, Proceedings of the 11th International Conference on Cold Fusion, Marseilles, France, 31 October–5 November 2004, pp. 84–101.
3. Dominguez, D., Kidwell, D., Knies, D. L., Grabowski, K. S., Hubler, G. K., He, J. H. and Violante, V., Are oxide interfaces necessary in Fleishmann–Pons-type experiments? *J. Condens Matter Nucl. Sci.*, 2012, **8**, 219.
4. Violante, V. *et al.*, Excess of power during electrochemical loading: materials, electrochemical conditions and techniques. In Proceedings of the 18th International Conference on Cold Fusion, Columbia, Missouri, USA, 21–27 July 2013.

Sidney Kimmel Institute for Nuclear Renaissance
G. K. Hubler[1,*], A. El-Boher[1], O. Azizi[1], D. Pease[1], J. H. He[1], W. Isaacson[1], S. Gangopadhyay[2] and V. Violante[3]

Supplementary Information

SKINR Experimental Instruments

Electrochemical systems:

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- -1 closed cell differential isoperibolic TEM calorimeter
- -2 closed cell isoperibolic TEM calorimeters (from TSEM, Italy)
- -3 open cell mass flow calorimeters (MFC) with ultrasound stimulation
- -1 open testing cell, no calorimetry
- -1 open cell with thin membrane, no calorimetry
- -1 dual electrochemical cell hydrogen permeation system
- -3 SS closed cell mass flow calorimeters

Gas systems:

- -1 Celani replication reactor with mass flow calorimetry
- -1 High temperature gas reactor

Diagnostic systems:

- -X-ray detector
- -Gamma detector
- -Neutron detector
- -RF spectrum analyzer

Materials characterization:

- -SEM
- -Power spectral density
- -AFM
- -X-ray diffraction
- -X-ray texture
- -Electrochemical impedance spectroscopy
- -Hydrogen permeation kinetics
- -Charging protocols

Glow Discharge:

- - 2 Pd-D2 Low Temp. Ion Bombardment with MFC
- - 1 Ni-H2 High Temp. Ion Bombardment with MFC

All systems equipped with National Instruments data collection and control hardware and LabView software

SKINR, ENEA, TSEM have robust collaboration with National Instruments who has furnished hardware, software and training

Table S1.

file:///Users/thomaswgrimshaw/Dropbox/SKINR/0%20Phase%201%20Report%20181222/10%20Resources%20181223/0562-suppl.pdf

SKINR Materials Fabrication

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

SKINR:

-2 annealing ovens
-2 rollers
-Alloy fabrication
-2 glow discharge cathode etching reactors

Electrical & Computer Engineering (Dr. S. Gangopadhyay)

-Thin-film deposition
-CNT composites
-Nanoparticle fabrication and deposition
-Lithographically defined micro- & nano-structures
-Electrodeposition
-Nanoporous cathodes
-
-

SKINR has Laboratory space in the Department of Physics and in the Department of Electrical Engineering – Dr. Shubhra Gangopadhyay was instrumental in donating space to SKINR

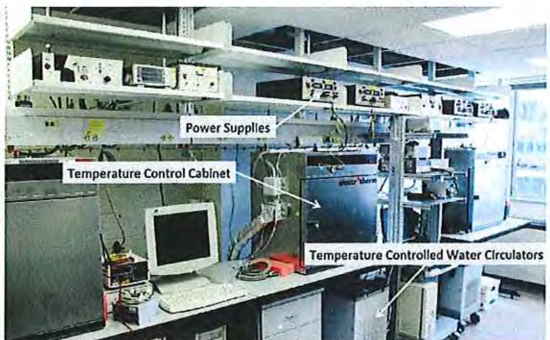
Department of Radiology (Dr. K. Kattie)

-nanoparticle suspensions for In situ deposition on cathodes

Table S2.

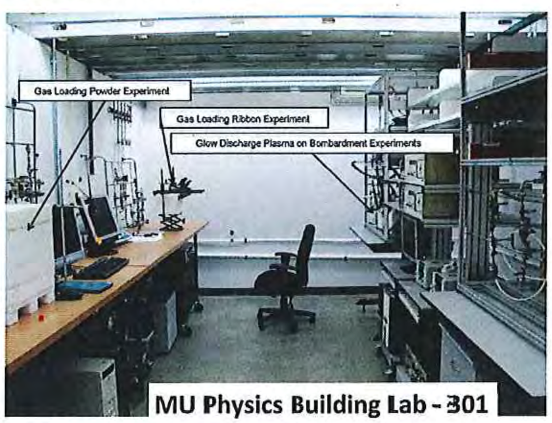
MU Engineering Building West Lab - 139
Electrolytic Open Cell Experiments

MU Engineering Building Lab - 137
Hermetically Sealed
Closed Electrolytic Experiments



MU Engineering Building West Labs - 137
Ultrasonically Excited Electrolytic Experiments

MU Engineering Building West Labs
Sample Preparation Room - 135



MU Physics Building Lab - 301

Figure S1.

Sidney Kimmel Institute for Nuclear Renaissance (SKINR) Overview

Progress Toward Understanding AHE

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

Arik El-Boher, Ph.D.
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SKINR Directive: **To find the origin of the Anomalous Heat Effect (AHE) with a sound materials science approach and with no preconceptions as to the origin of the phenomenon. To publish findings in the open literature and to openly collaborate world wide with researchers in the field and in cross disciplines.**

Progress Toward Understanding Anomalous Heat

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

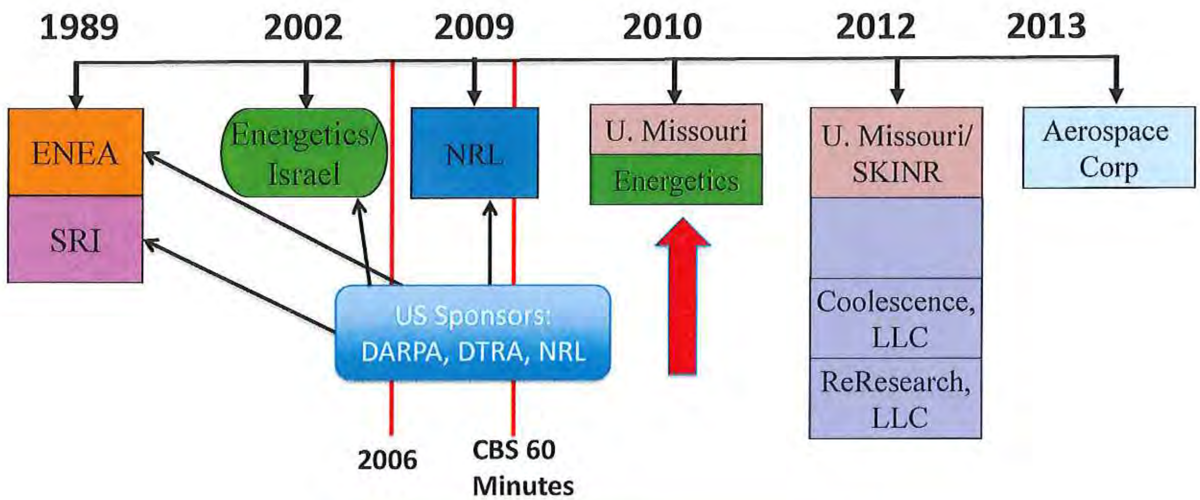
Outline

✓ **Description of SKINR**

- Anomalous heat results among collaborators - SKINR, NRL, ENEA, TSEM
- SKINR initiatives
- Some known conditions to obtain anomalous heat results
- Experiments suggested by theories
- Quantitative impact
- Conclusions

International Collaboration and Time-Line of Partner Involvement

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri



Expected Progress:
- **Improve Reproducibility**
- **Reveal Mechanism**

SKINR Staff

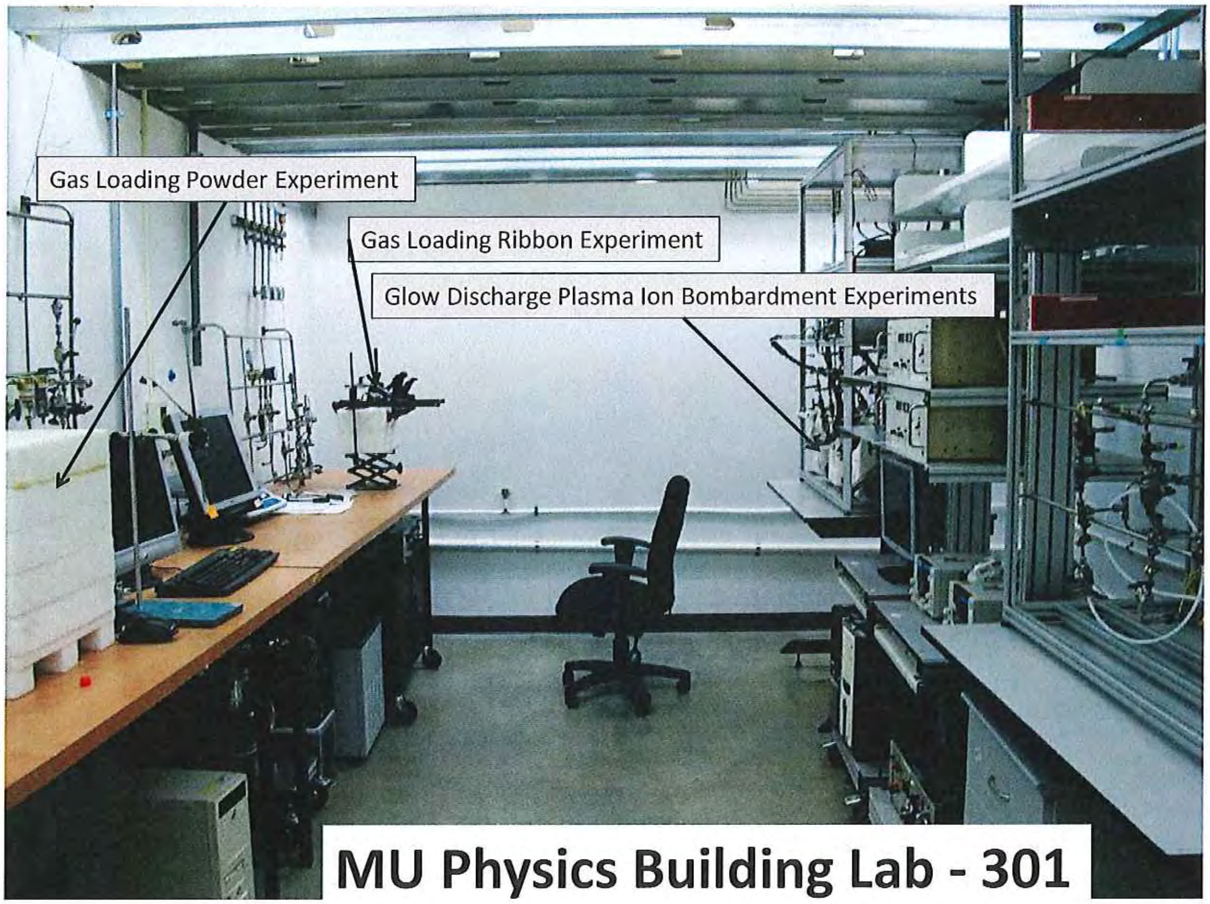
Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

Administratively located in the UM Department of Physics and Astronomy

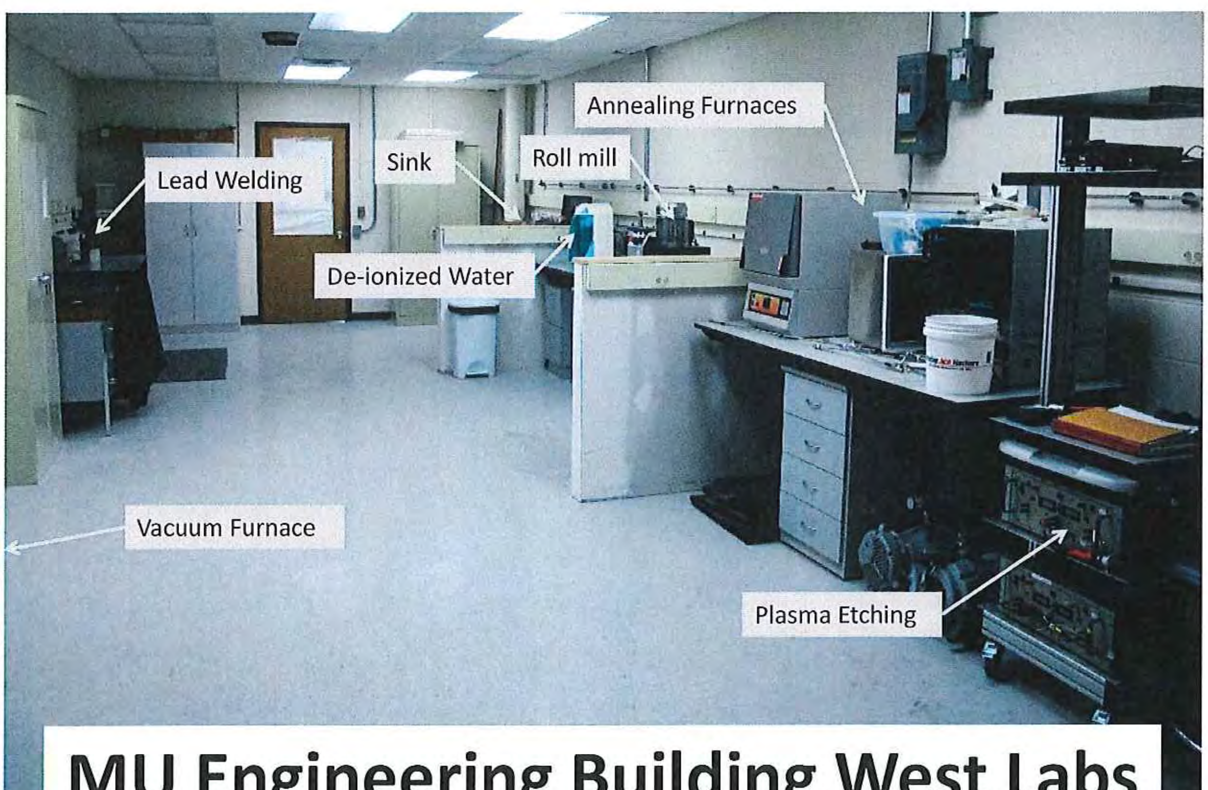
Orchideh Azizi
Arik El-Boher (Research Group Leader)
JingHao He (new hire)
Graham Hubler (Director)
William Isaacson
Dennis Pease

SKINR has Laboratory space in the Department of Physics – Dr. Peter Pfeifer
the Department of Electrical Engineering – Dr. Shubhra Ganghopadhyay

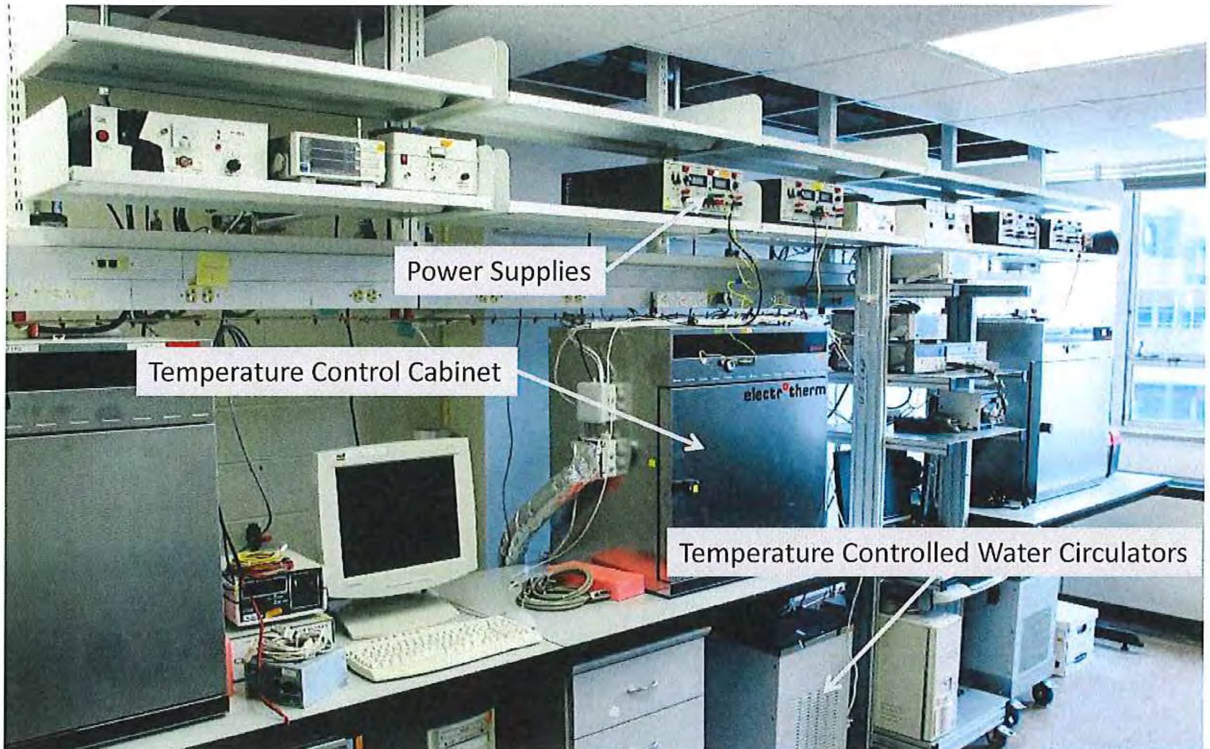
R. Duncan; former UM Vice Chancellor for Research
S. Gangopadhyay; Associate to SKINR



MU Physics Building Lab - 301

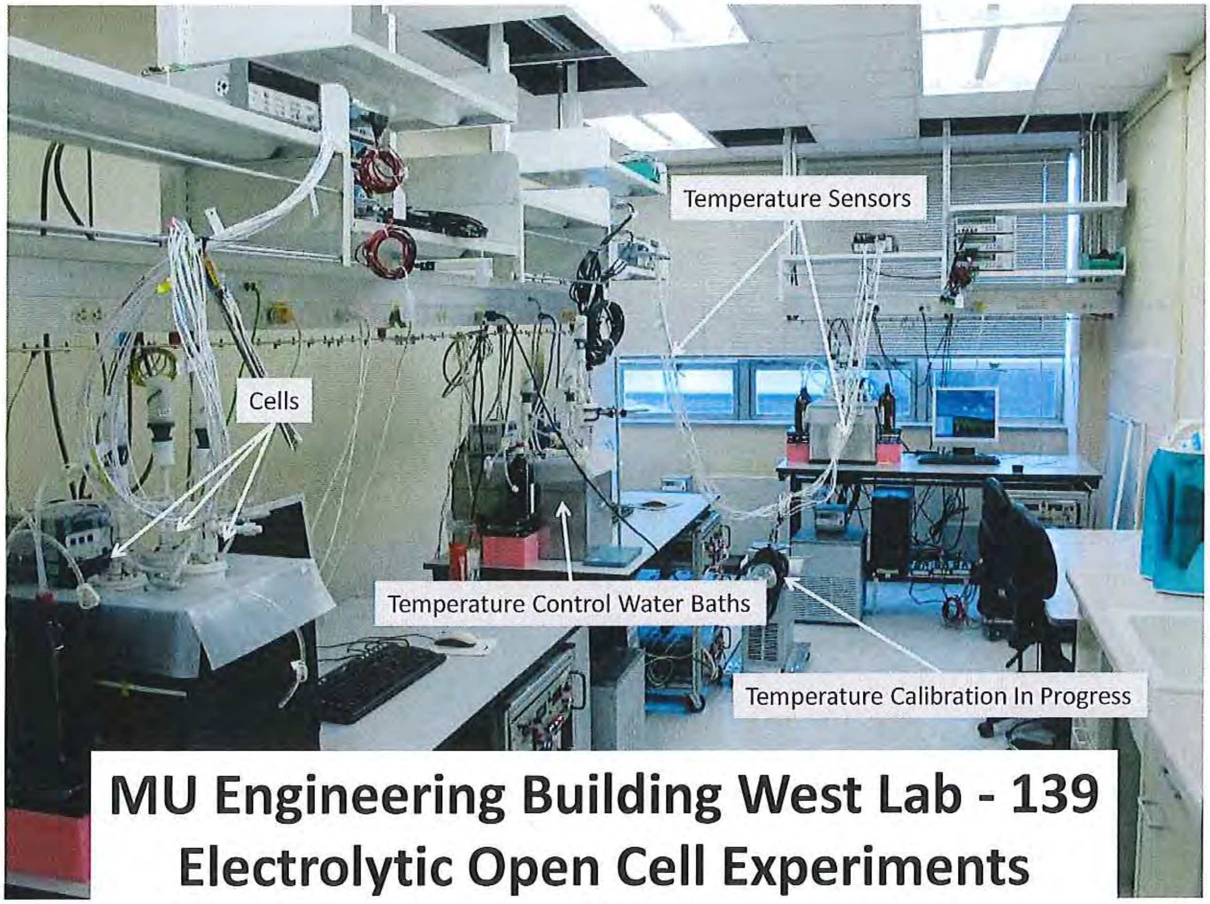


MU Engineering Building West Labs
Sample Preparation Room - 135



MU Engineering Building West Labs - 137
Ultrasonically Excited Electrolytic Experiments

MU Engineering Building Lab - 137
Hermetically Sealed
Closed Electrolytic Experiments



MU Engineering Building West Lab - 139
Electrolytic Open Cell Experiments

Involvement of UM Professors in SKINR-related Activities

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J. Gahl, Electrical Engineering
-Pd(d,p); Ni(p,p) on cyclotron, exploding wires

S. Gangopadhyay; Electrical Engineering
-CNT; nanoporous; artificially structured cathodes; Pd deposition on membranes

H. Kaiser: Dept. of Physics & Astronomy/MURR
-neutron scattering on PdD. PdH

K. Kattie; Dept. of Radiology
-In situ nanoparticle deposition on cathodes

S. Kovaleski, Electrical Engineering
-Piezoelectric ion sources, low energy ion bombardment

M. Prelas, Nuclear Engineering
-Neutrons form thermally shocked TiDx, diamond particle detectors

P. Pfeiffer; Dept. of Physics & Astronomy
-Fundamental Hydrogen charging of metals studies

Cathode Development Plan
Empirically guided cathode modifications

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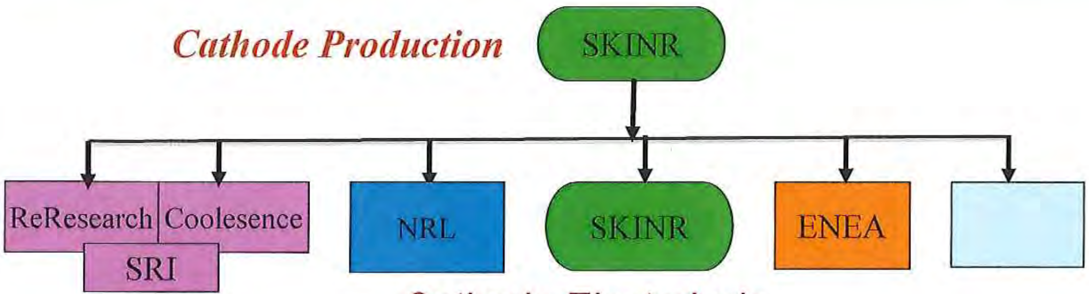

Cathode Electrolysis

Electrochemical cell

With collaboration partners, run hundreds of fabricated cathodes in parallel using SKINR & NRL designed *common equipment and common protocols.*

Expected Progress: Improved Reproducibility

Cell in calorimeter

Progress Understanding Anomalous Heat

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Outline

- Description of SKINR
- ✓ **Anomalous heat results among collaborators - NRL, SKINR, ENEA, TSEM**
- SKINR initiatives
- Some known conditions to obtain anomalous heat results
- Experiments suggested by theories
- Quantitative impact

Summary of ET electrolysis experiments 2002-2009

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			Repr.	2002		Repr.	2003		Repr.	2004		Repr.	2005		Repr.
	Total	EH	%	Total	EH	%	Total	EH	%	Total	EH	%	Total	EH	%
Alloys	36	9	25.0	2		0.0									
Coating Vapor Dep	5	1	20.0	1		0.0	4	1	25.0						
Coating RF	17	4	23.5												
Storms	4	4	100.0				2	2	100.0				2	2	100.0
Diamond	0	0													
Pd-V	8	2	25.0												
Afonichev	0	1													
Pd-Ca	6	1	16.7												
Pd-Y	0														
Annealings	20	3	15.0												
Pd-ZrO	2	1	50.0												
Pd-Ni	0														
Pd-Fe	8	3	37.5												
Pd-NT-Re	14	5	35.7												
Nanowires	1	1	100.0												
Pd-La	7	4	57.1												
GD etching	64	19	29.7							7	1	14.3	18	4	22.2
Pd-PdO	18	4	22.2										2		0.0
NT	90	17	18.9												
Pd-Re	17	7	41.2												
Commercial	50	2	4.0				8		0.0	6		0.0	13		0.0
Vittorio	180	22	12.2	4 .	1	25.0	10	2	20.0	26	3	11.5	57	2	3.5
ET	110	6	5.5							18	1	5.6	50		0.0
Rejected	199			7			2		0.0	43		0.0	30		
Total	856			14			26			100			172		
Relevant exp.	657	116	17.7	7	1	14.3	24	5	20.8	57	5	8.8	142	8	5.6

	2006		Repr.	2007		Repr.	2008		Repr.	2009		Repr.
	Total	EH	%	Total	EH	%	Total	EH	%	Total	EH	%
Alloys	3	2	66.7	24	6	25.0	2		0.0	5	1	20.0
Coating Vapor Dep												
Coating RF							10	3	30.0	7	1	14.3
Storms												
Diamond												
Pd-V				2	1	50.0	6	1	16.7			
Afonichev												
Pd-Ca							6	1	16.7			
Pd-Y												
Annealings							8	2	25.0	12	1	8.3
Pd-ZrO							2	1	50.0			
Pd-Ni												
Pd-Fe				8	3	37.5						
Pd-NT-Re				6	4	66.7				8	1	12.5
Nanowires				1	1	100.0						
Pd-La				3	2	66.7	4	2	50.0			
GD etching	6	5	83.3	17	2	11.8	16	7	43.8			
Pd-PdO	5	2	40.0							11	2	18.2
NT	40	11	27.5	39	4	10.3	11	2	18.2			
Pd-Re	3	2	66.7	12	4	33.3	2	1	50.0			
Commercial	15	1	6.7				8	1	12.5			
Vittorio	44	12	27.3	17		0.0	19	2	10.5	3		0.0
ET	5		0.0	12	2	16.7	12		0.0	13	3	23.1
Rejected	41			32			33		0.0	11		
Total	162			173			139			70		
Relevant exp.	121	35	28.9	141	29	20.6	106	23	21.7	59	9	15.3

Reproducibility of ET EH generation

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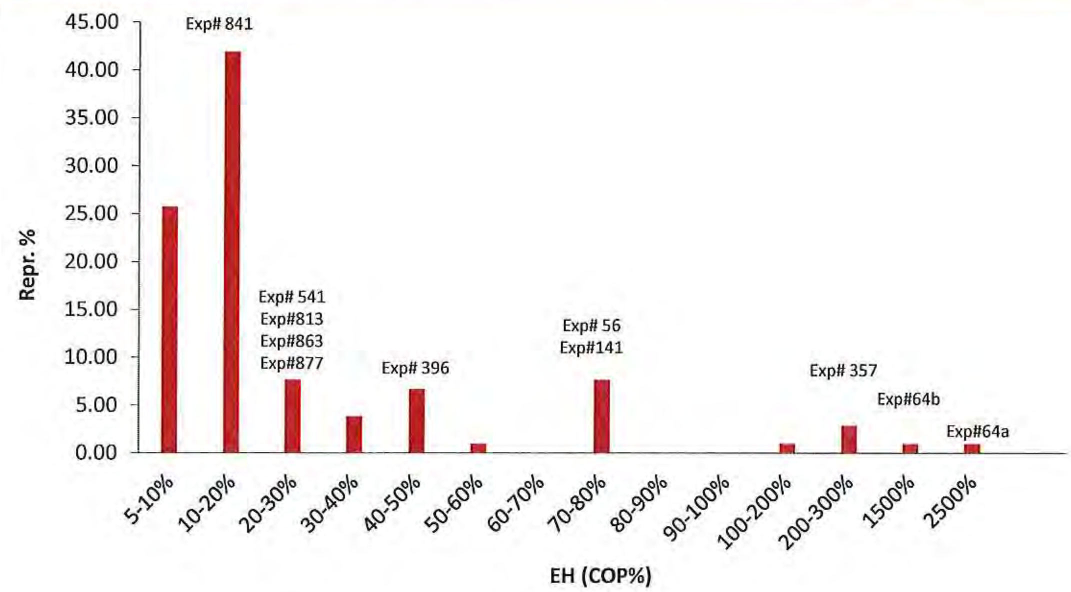

	Excess Heat %											
	5-10%	10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	100-200%	200-300%	1500%	2500%
No of Exp.	27	44	8	4	7	1	0	8	1	3	1	1
Repr. %	25.96	42.31	7.69	3.85	6.73	0.96	0.00	7.69	0.96	2.88	0.96	0.96

Exp. # 64a: Excess Heat

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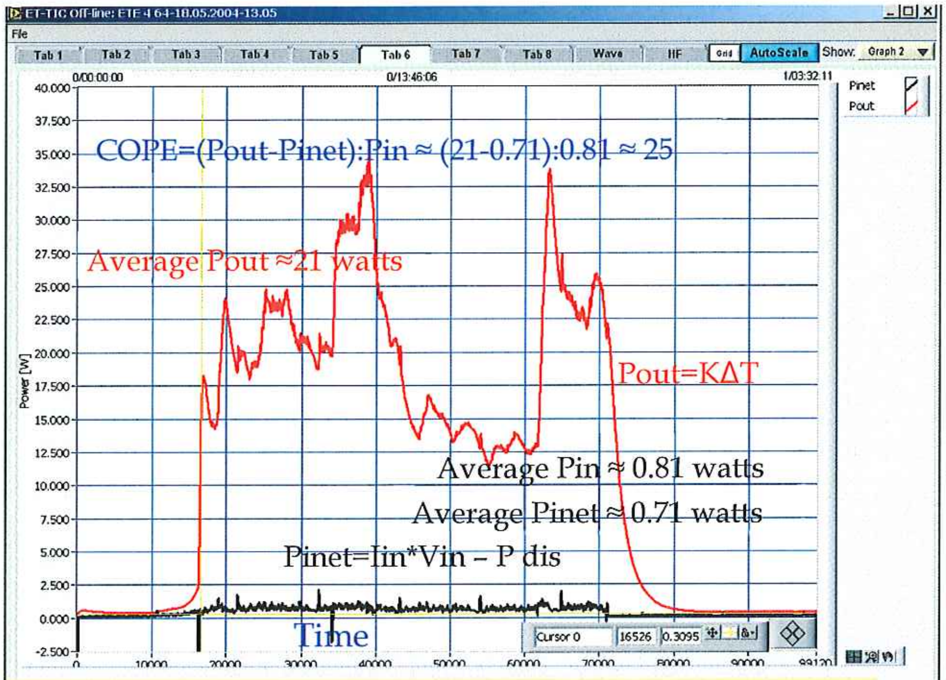
University of Missouri



Excess Power of up to 34 watts; Average ~21 watts for 17 h

Exp. # 64a: Temperature Evolution

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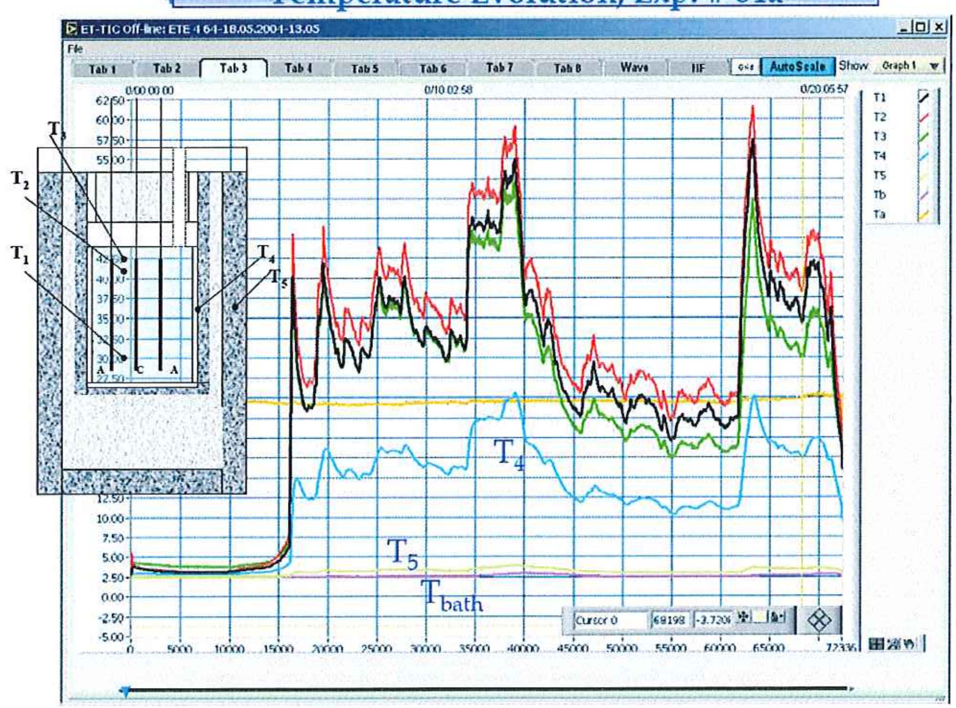
Temperature Evolution, Exp. # 64a



Exp. # 64a: ***Current & Voltage***

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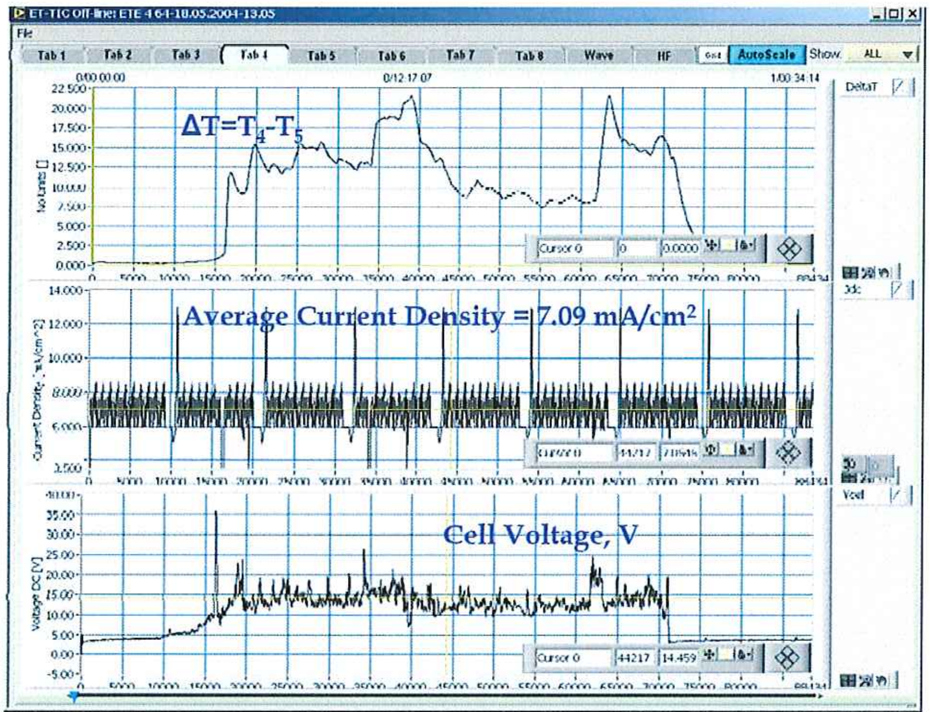

Exp. # 64a: ***Excess Energy***

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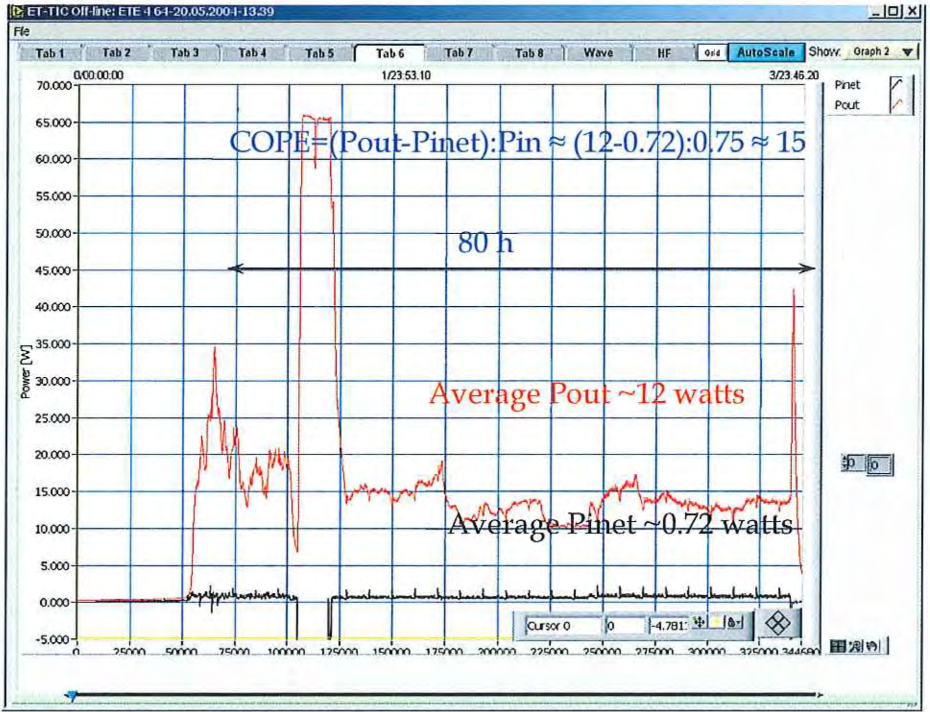
Excess energy of ~1.1 MJ

Exp. # 64b: Excess Heat



Excess Power of up to 32 watts; Average ~12 watts for 80 h

Exp. # 64b: Temperature Evolution

Exp. # 64b: ΔT, Current Density & Voltage

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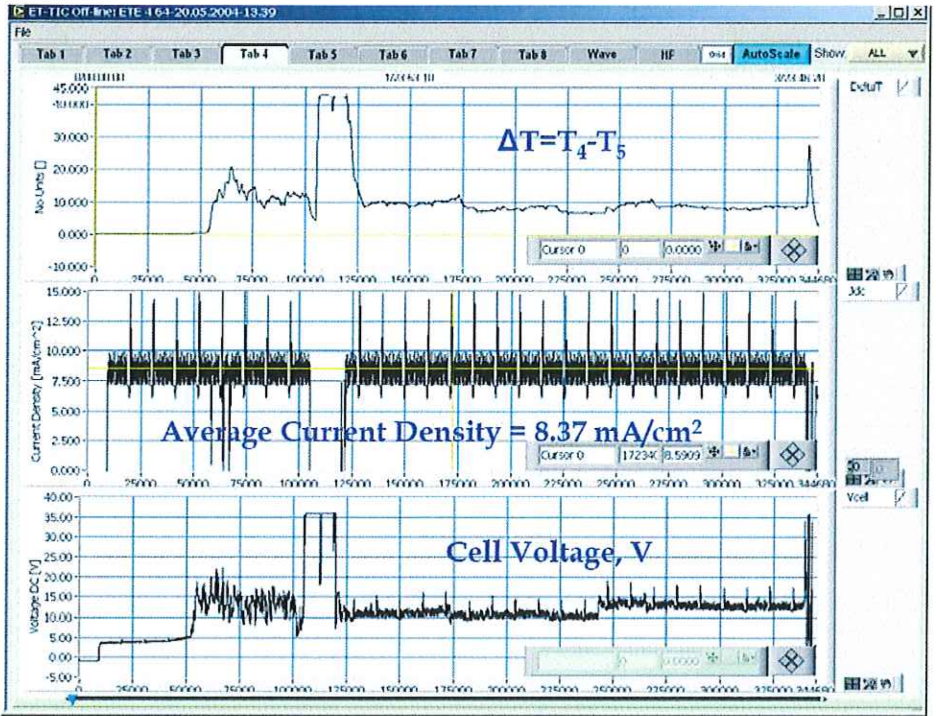

Exp. # 64b: Excess Energy

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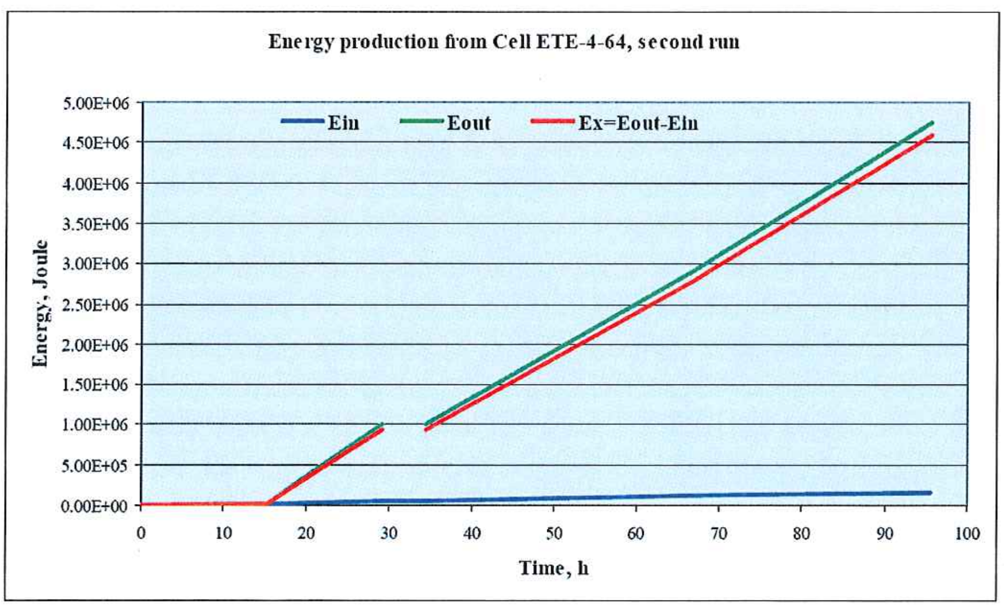

Excess energy of ~4.6 MJ

SEM-EDS analysis of foil # 64 vs. 63

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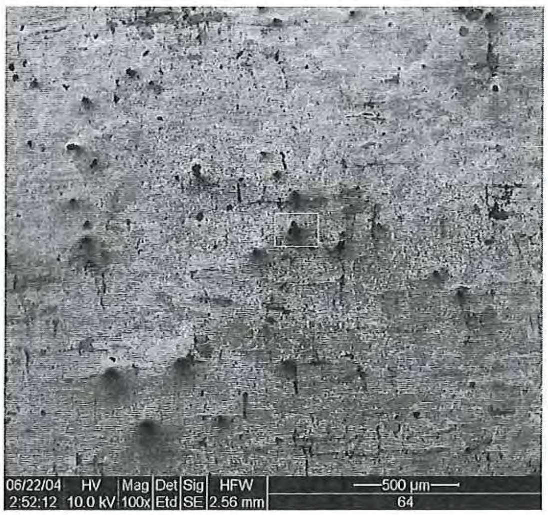
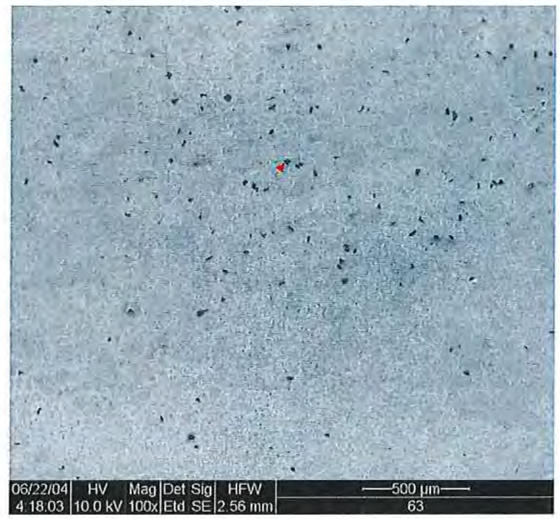
Surface of Pd foil after rolling and annealing at 870^{0}C

foil #64 (EH)
many "black spots"



foil #63 (no EH)



View of Typical Black Spot on # 64 and its composition

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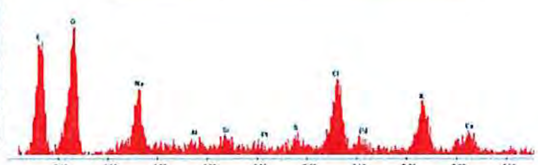
SEM-EDS

Element	Wt %	At %
C	35.77	52.48
O	26.19	28.84
Na	4.92	3.77
Al	0.43	0.28
Si	1.05	0.66
Pt	0.39	0.04
S	1.44	0.79
Cl	10.68	5.31
Pd	2.55	0.42
K	11.07	4.99
Ca	5.52	2.43
Total	100.00	100.00



Brittle destruction of Pt Wire Sample #64

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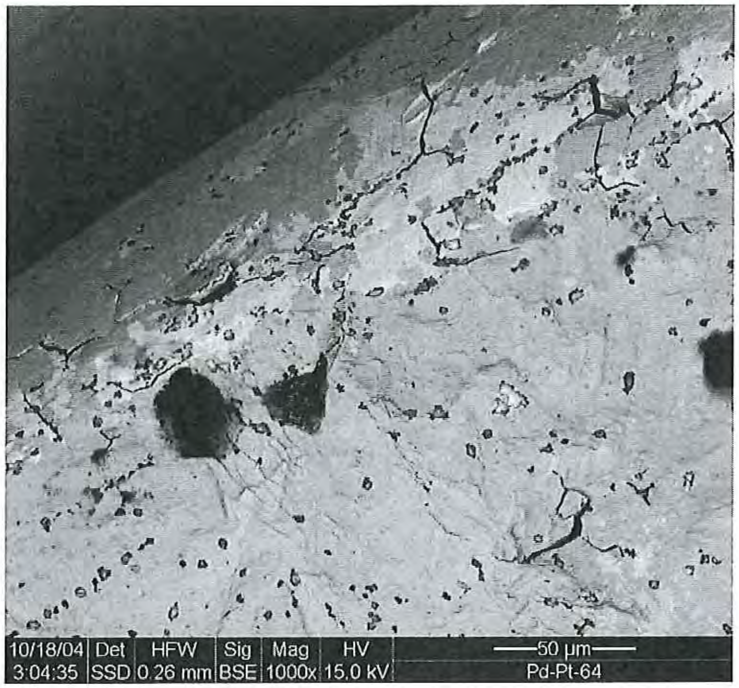

Pd grains size

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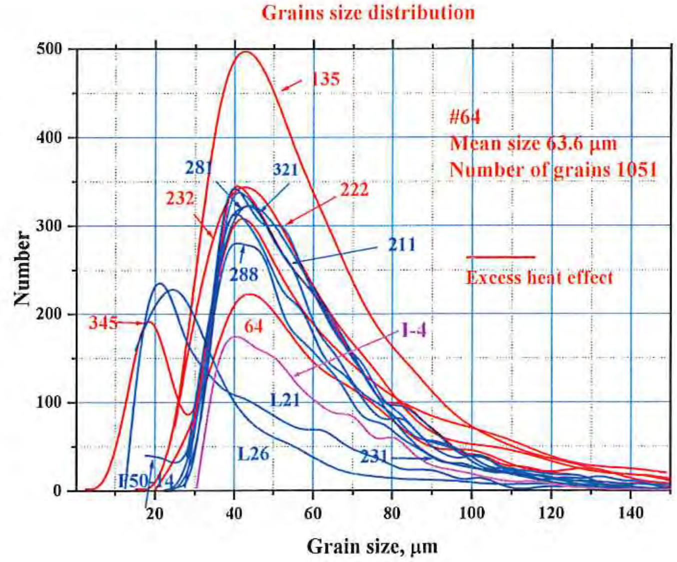
The grains size in certain limits, has no influence on the probability for excess heat effect.

The annealing temperature (optimally 850 C) of the rolled metal does play a role in the absorption kinetics by releasing the internal stresses in metal.

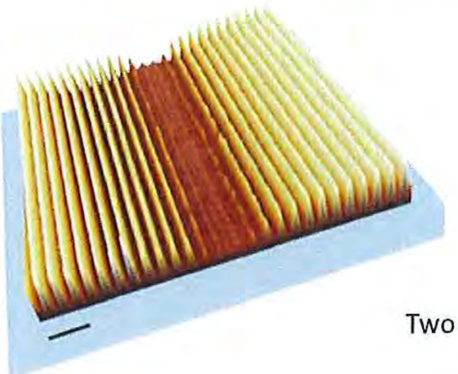


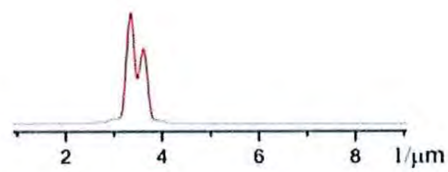
Surface

- Crystal orientation and specific contaminants modify the effect of the chemical etching leading a different surface status.

-The surface morphology is acting on the interface electrochemical structure.

Power Spectral Density Function (PSDF) has been selected as surface merit figure.





Two periodicity system

SEM-PSD analysis of foil # 64

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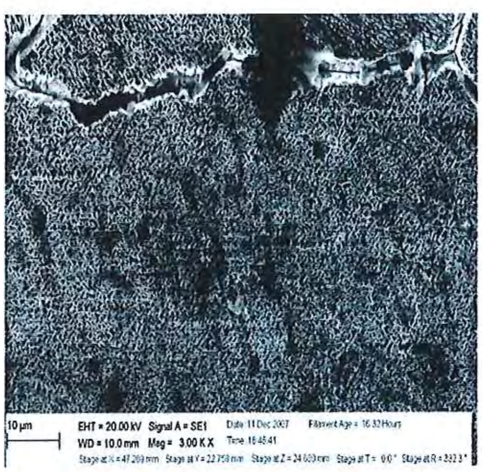
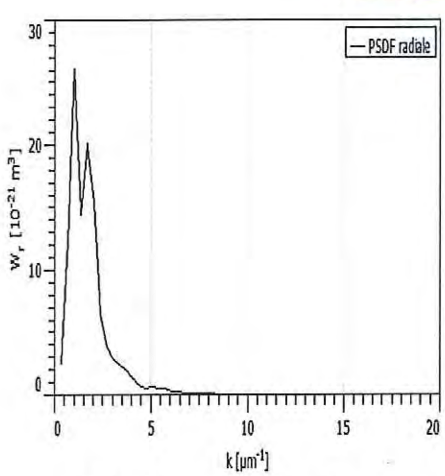
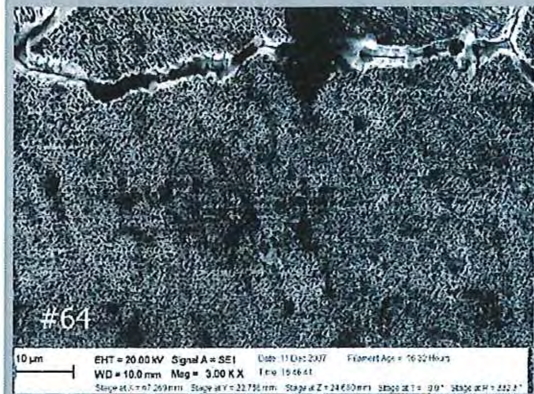


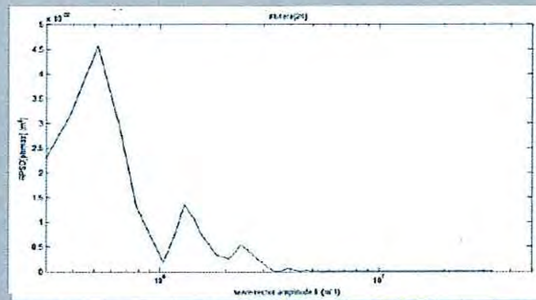
SEM of the surface of #64 electrode giving up to 2500 %.



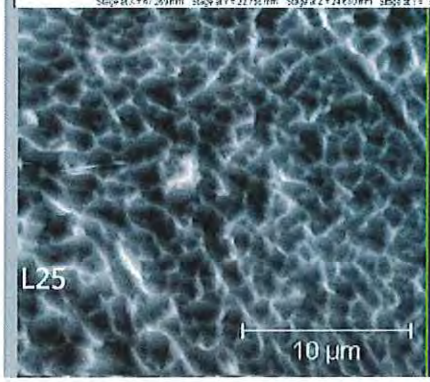
PSD #64 cathode surface

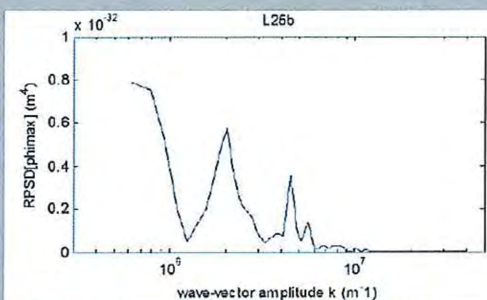
Typical Surface Morphology (after Etching) giving Excess of Heat





PSDF of sample #64 producing 3500% excess of heat.





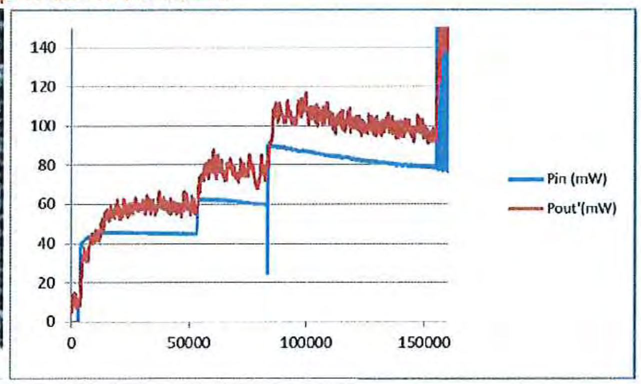
PSDF of sample L25 producing up to 250% excess of heat.

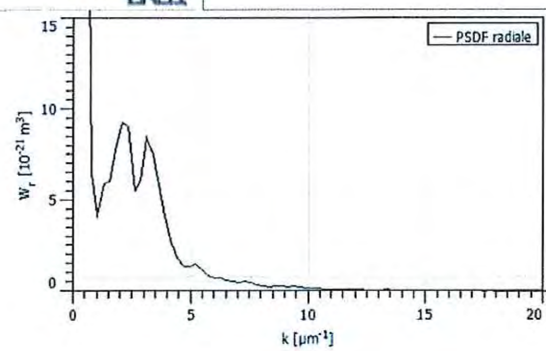
ICCF 18 University of Missouri, July 22-26 2013

Again

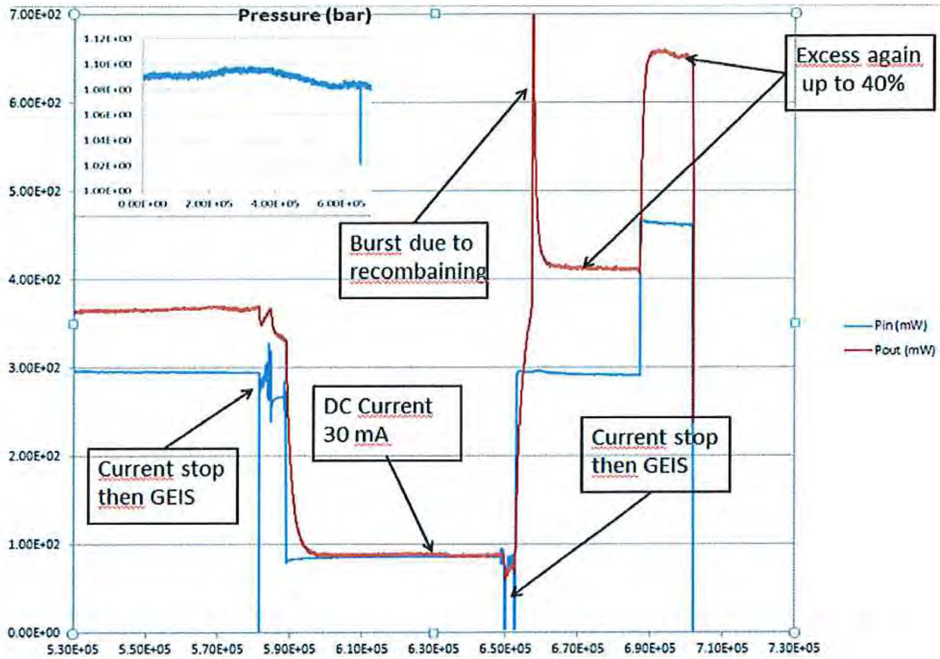
L66 (160-200) Platinum added

up to 25-30% excess





ENEA Pt-coated Pd Cathode, April, 2013



Glow Discharge etching – Statistics

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First Series

Gas	# of significant experiments	# giving EH	% of Power gain	R/R_0
Argon	1	1	10-20	peak
Argon-Oxygen	0	0	n/a	n/a
Deuterium- Helium	5	2	17-20	1.93-1.32
Deuterium	5	1	25-75	1.87-1.26
Helium	2	1	8-10	1.88-1.62

Total **13** **5** **38%**

Recent Series

Gas	# of significant* experiments	# giving EH	% of Power gain	R/R_0
Deuterium	8	5	10-25	1.95-1.22

Total **8** **5** **62.5%**

Selective sputtering of Pd [100] in glow discharge deuterium plasma

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Summary of electrolysis experiments in Columbia MO, USA

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University of Missouri

	2010-2012		
Material	Total	EH	Repr. %
Vittorio	7	0	
ET	15	5	33.33
Pd-nanoporous	3	0	
Pd-10% Rh (NRL)	4	1	25.00
Total	27	6	22.22

Exp. # 1012: Pd-Total duration 41 days

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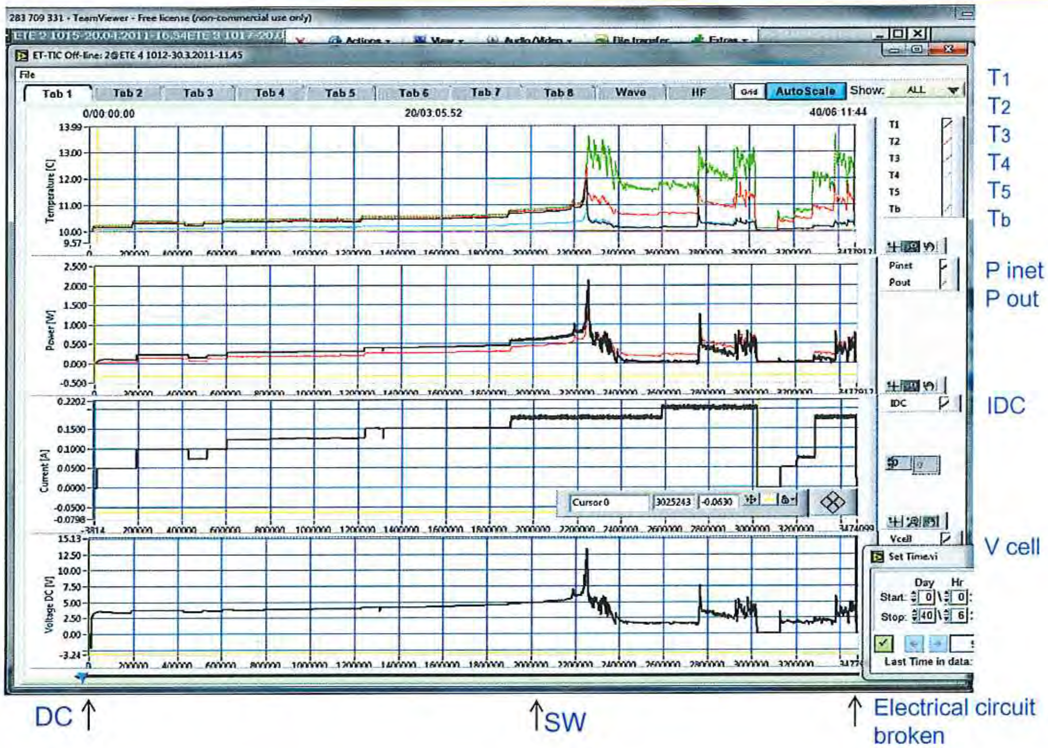

Some surface structures of Pd cathodes Quanta 600 (UM EM Core)

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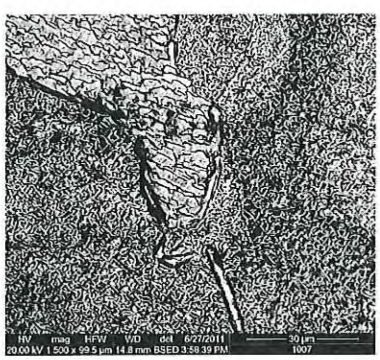
Cathode 1012 negative crystals
(AHE)



Cathode 1007
Grains disorientation
(AHE)

Summary of US-Excited electrolysis experiments

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material	Total	EH	%	2006 Total	2006 EH	2006 %	2007 Total	2007 EH	2007 %	2008 Total	2008 EH	2008 %	2009 Total	2009 EH	2009 %
0.5 mm wire	7	3	43	5	2	40	2	1	50						
1.0 mm wire	40	16	40				21	9	43	19	7	37			
1.0 mm wire new	4	0	0							3	0	0	1	0	0
0.5 mm wire new	5	2	40										6	2	33
Ni alloy	4	1	25							3	1	33			
Relevant	60	22	37	5	2	40	23	10	43.5	25	8	32	7	2	29
Rejected	25														
Total	85														

US-Excited electrolysis experiments

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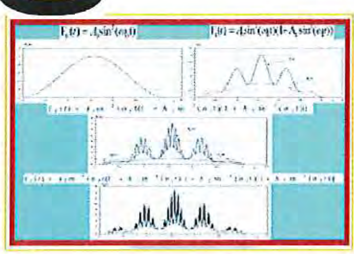
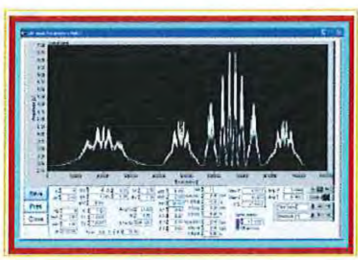
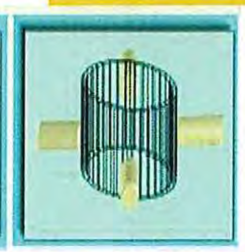
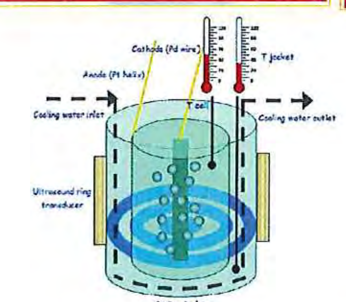
University of Missouri

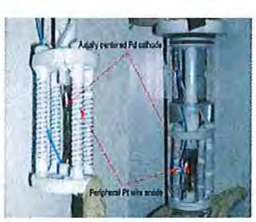



Experiment	56	64a	64b	GD-141	US1-15	US3-05	US3-06	US3-21
Cathode source	ENEA	ENEA	ENEA	ET	ET	ET	ET	ET
Ex (MJ)	3.1	1.1	>3.5	2.4	0.19	1.1	1.32	0.026
Px (W)	3	19	>11	14	0.25	0.8	0.9	0.13
Max COP (%)	80	2500	>1500	75	600	3000	525	650
Duration of EH (h)	300	17	80	90	280	960	445	55
Specific EH (W/g Pd)	11	71	>48	29	4	6	15	24
Specific EE (keV/Pd)	13	5	>15	11	4	22	27	13

Versus: Heat of D desorption in Pd lattice: ~ 0.3 eV per D atom
Heat of D oxidation: ~ 1.5 eV per D atom (max D/Pd ~ 1)
Heat of evaporation of Pd: ~ 31 eV per Pd atom

* pertaining to effective part of cathode

Cell #	Type of Transducer	Frequency (kHz)	Max power (W)
1	Ring	16	15
2	Ring	38	15
3	Four tubular	30	60

Electrolysis with ultrasonic wave excitation

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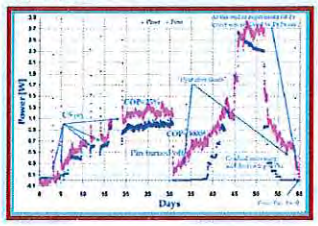
University of Missouri

2007-2008 statistics US excited electrolysis experiments

Cell No.	No. of exp.	Giving excess heat (EH)	
		No. of exp.	% giving EH
1	8	6	75%
2	5	4	80%
3	6	4	67%
Total	19	14	74%

Exp. # US3-5

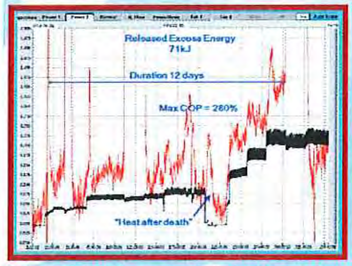


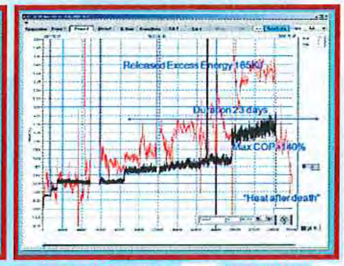
Exp. # US3-6

Effects of cavitation in vicinity of the cathode has the following effects:

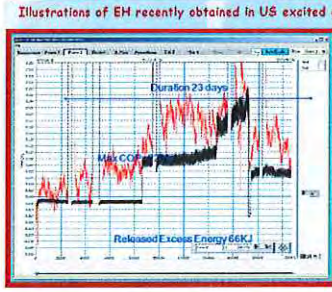
- Mechano-chemical "cleaning" of the surface resulting in enhanced surface activation
- Mechanical deformation of the near-surface layer of the Pd target caused by the shock wave generated by impingement of the accelerated deuteron jets. The result is a strong near-surface distortion of the Pd crystalline lattice.
- Massive dislocation and vacancy generation. These defects provide for deep deuterium traps in the Pd cathode.

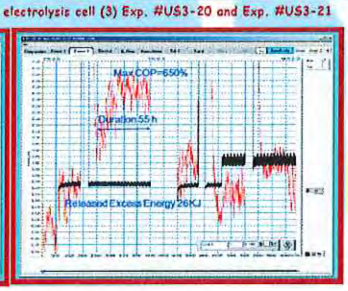
Illustrations of EH recently obtained in US excited electrolysis cell (1) Exp. # US1-17 and cell (2) Exp. #US2-11





Illustrations of EH recently obtained in US excited electrolysis cell (3) Exp. #US3-20 and Exp. #US3-21





Electrolysis with ultrasonic wave excitation

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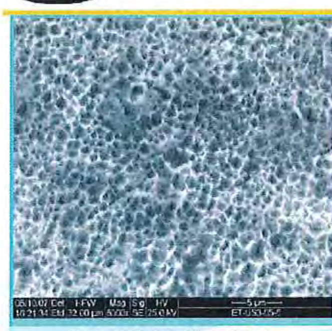
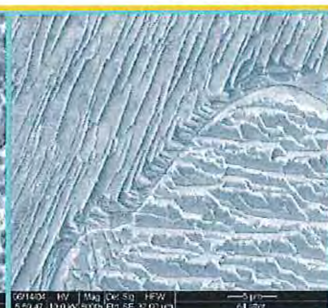
University of Missouri





Strongly pitted surface with US

Plastic deformation without US

Craters with melting signs found on surface of cathodes

Conclusions

In-cell exposure of cathode to ultrasonically induced cavitation, combined with SuperWaves electric current enables:

- High deuterium loading using low current densities
- Higher reproducibility of EH generation
- Mode of application of US excitation is yet to be optimized
- For commercial application, duration, power and temperature of excess heat generation need be further increased

Observations

Significant amount of excess heat and excess energy has been generated in ET experiments using Dardik's SuperWaves. Best performance parameters obtained so far are:

- Excess energy: 4.5 MJ
- Excess power: 32 W
- COP: 3000%
- Duration: 40 days
- Specific energy: 27 keV per Pd or D atom
- Specific power: 71 W/g Pd*

*versus 20 to 50 W/g U in commercial fission reactors

Acknowledgement

This work was fully funded by Mr. Sidney Kimmel

X-Ray Diffraction Analysis

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University of Missouri

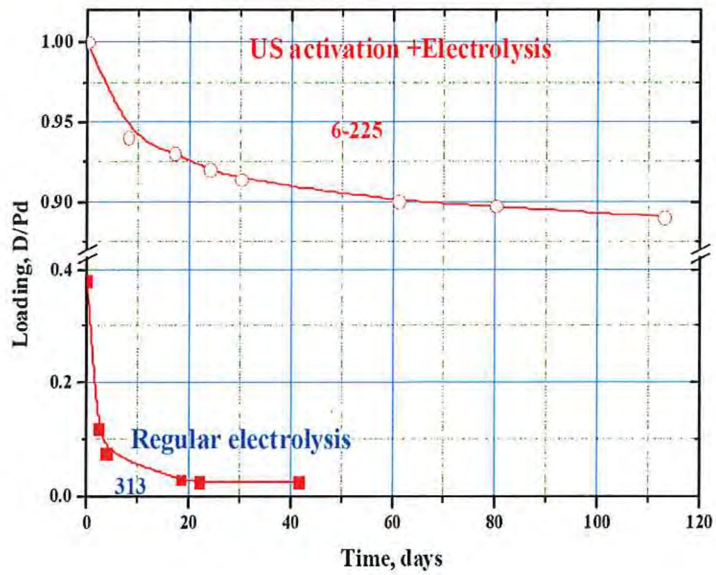

Figure 17. Rate of deuterium desorption from a Pd cathode that was subjected to ultrasonic cavitation ("US activation") (top), versus a Pd cathode that was subjected regular electrolysis (bottom)

Effect of Pd micro-melting during electrolysis

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University of Missouri

Craters' rims, as a rule, are consist of Pd-Pt alloys. Pt content in the rims are higher than that in the rest sample's surface due to higher Pt melting point. This is clear proof of the melting of the area close to crater.

The patterns of the craters

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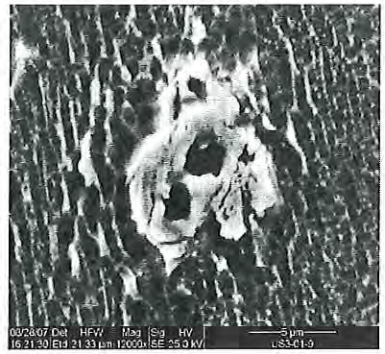
University of Missouri

That is not true crater. Most probably, we are seeing the zone of the very fast Pd mass-transfer.

Faceted rim around the crater. Misorientation of the nearest grain is seen distinctly.



Multi-craters "volcano".

Electrolysis with US excitation (cont.) Slip bands and negative crystals are seen

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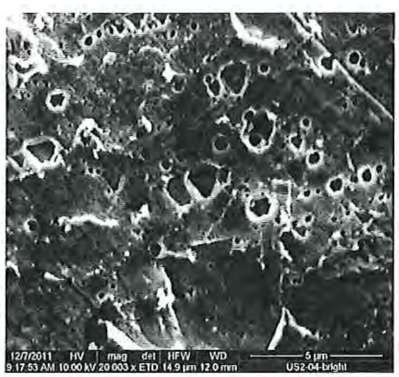

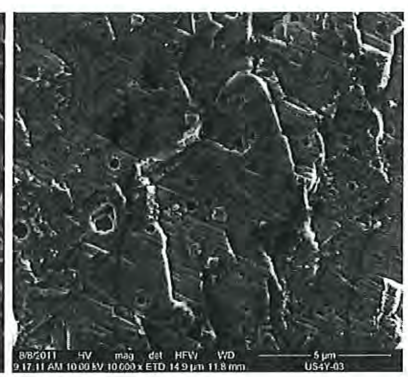

Slip bands. (111) Pd plane

Negative crystals (cont.). BGU (Israel) and Quanta 600 (UM EM Core)

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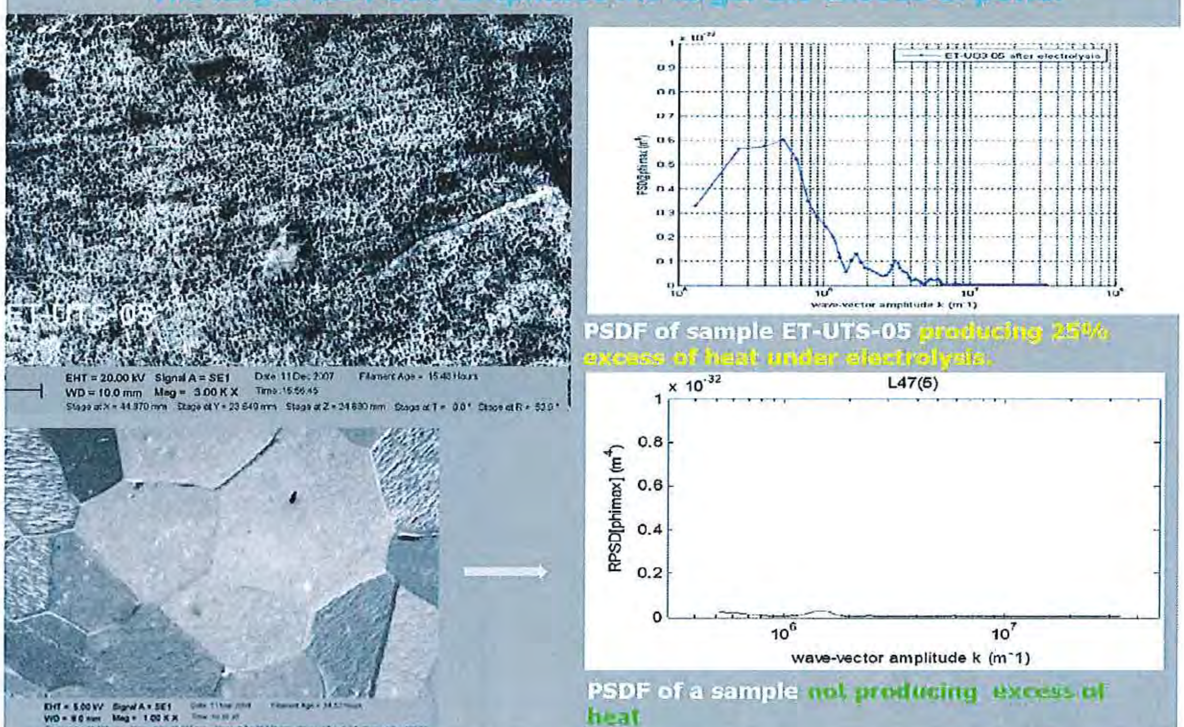
University of Missouri

ICCF 18 University of Missouri, July 22-26 2013

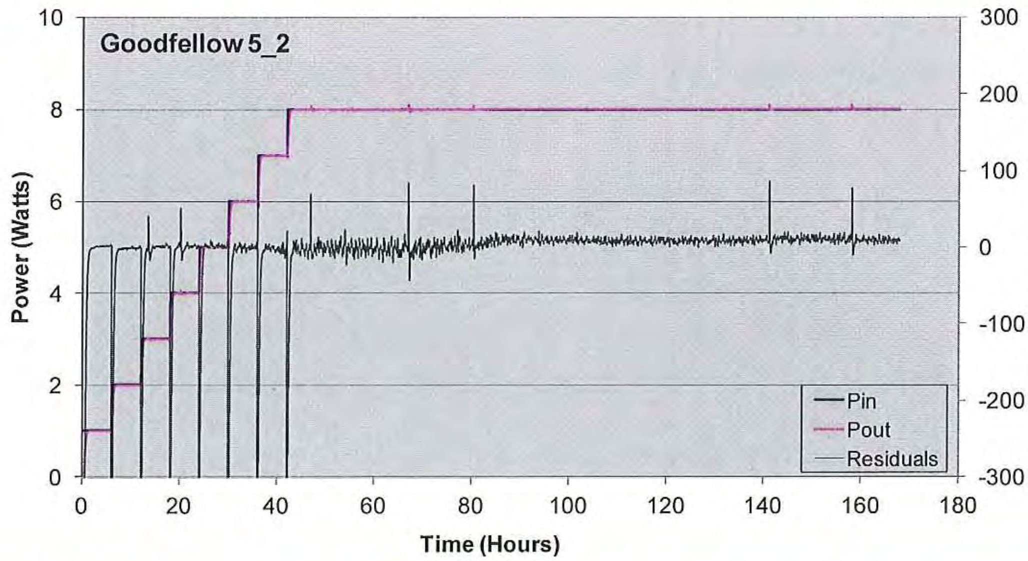
ENEA

The larger the PSDF amplitude the larger the excess of power



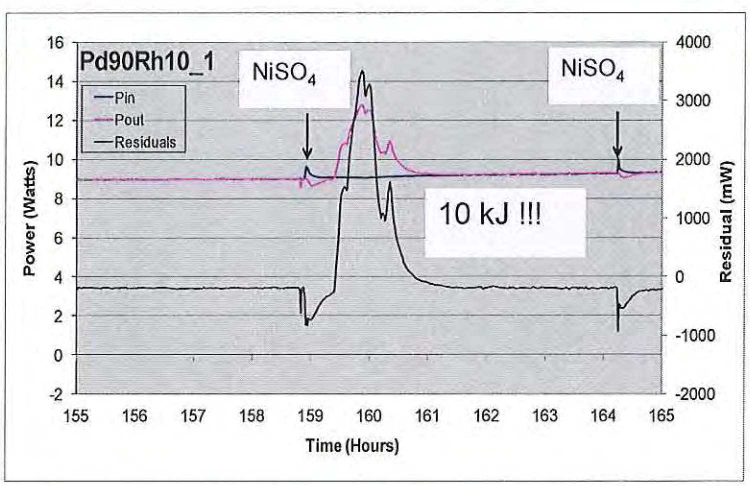
Surface morphology results to be a fourth condition

Pd Cathode with No Chemical Addition by Naval Research Lab



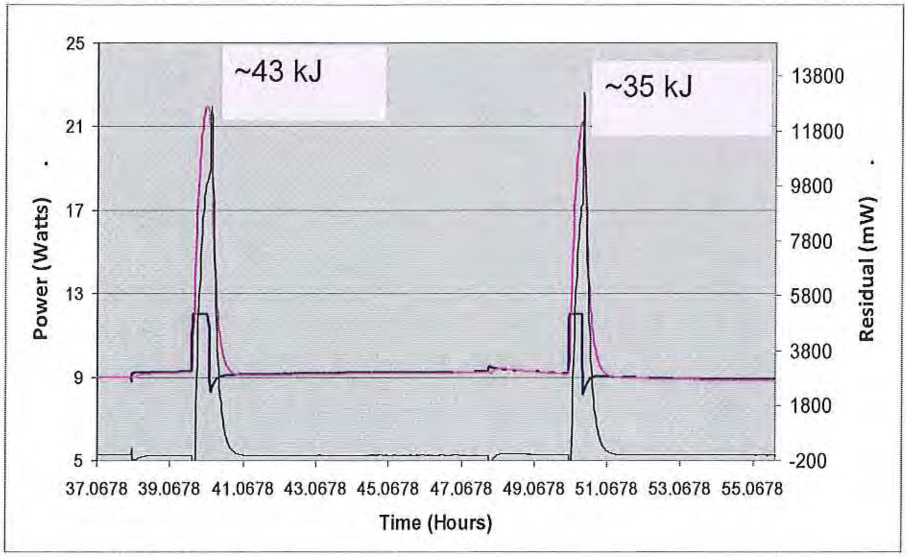
- **120 experiments over 24 months with consistent results**
  - **$Power_{in}$ = $Power_{out}$**

NRL Pd90%Rh10% Cathode – "Eve"



- 10 kJ over 90 minutes – 140% excess
- Event triggered by metal/metal oxide additions
- Small grain size with significant grain boundary etching
- Fractal surface generated with oxide contamination

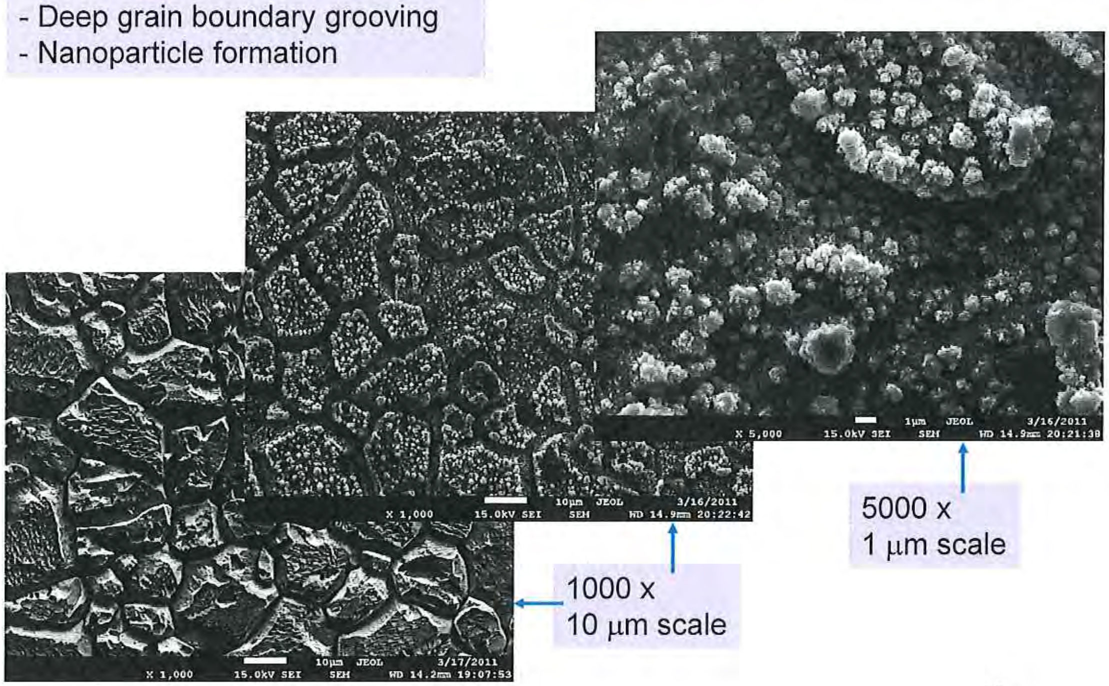
Another NRL Pd90%Rh10% Cathode



- Excess power >> stored chemical energy

Scanning Electron Micrographs (SEM) of Excess Heat producing cathodes after electrolysis

- Deep grain boundary grooving
- Nanoparticle formation



SKINR Pd/SWCNT Gangopadhyay Cathode Nov. 18–20, 2013

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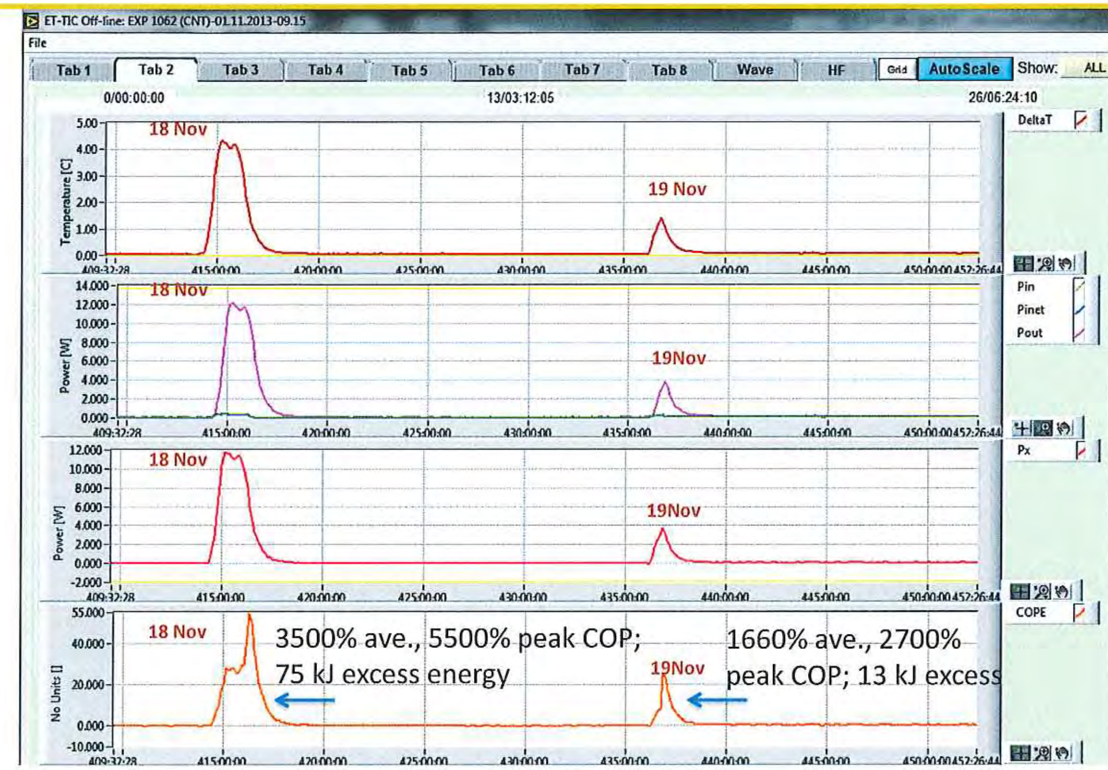
University of Missouri



SKINR Pd/SWCNT Gangopadhyay Cathode Nov. 18–20, 2013

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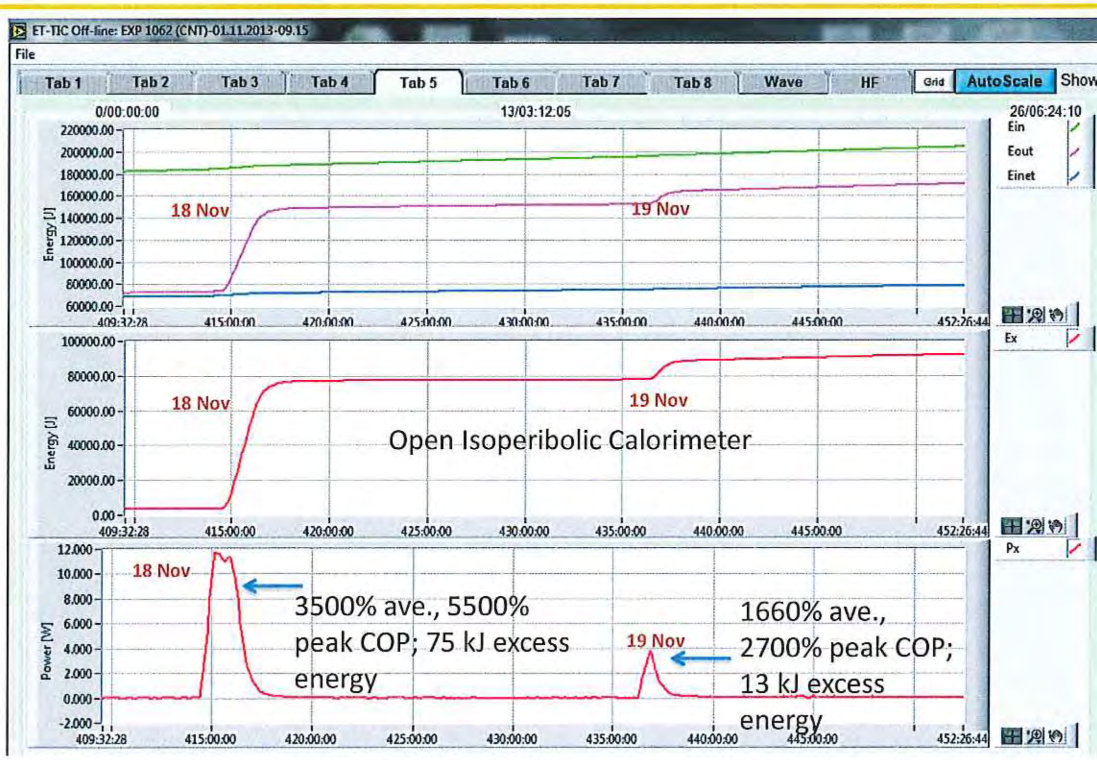
University of Missouri



SWCNT Cathode which gave AHE

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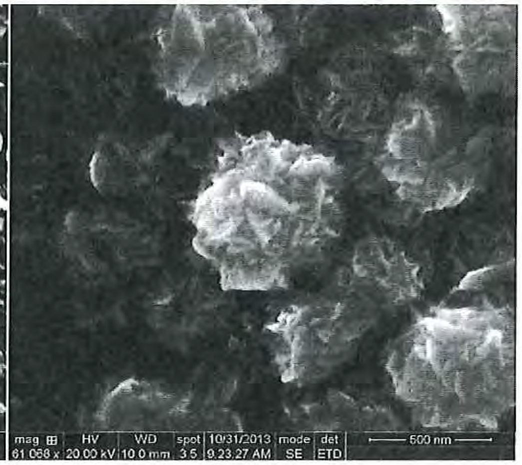
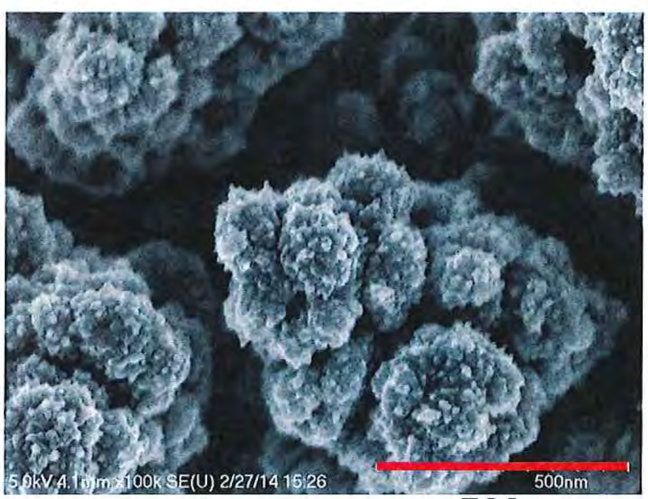
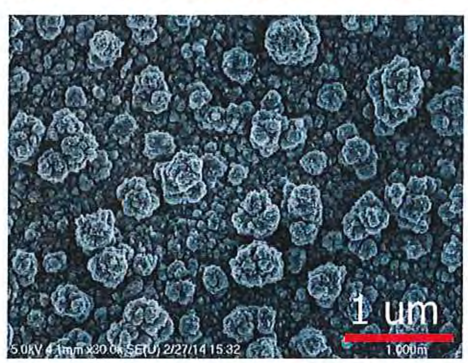


Drop casting of SWCNT, electroplating(2.5mA)
Prepared by Prof. Shubhra's team

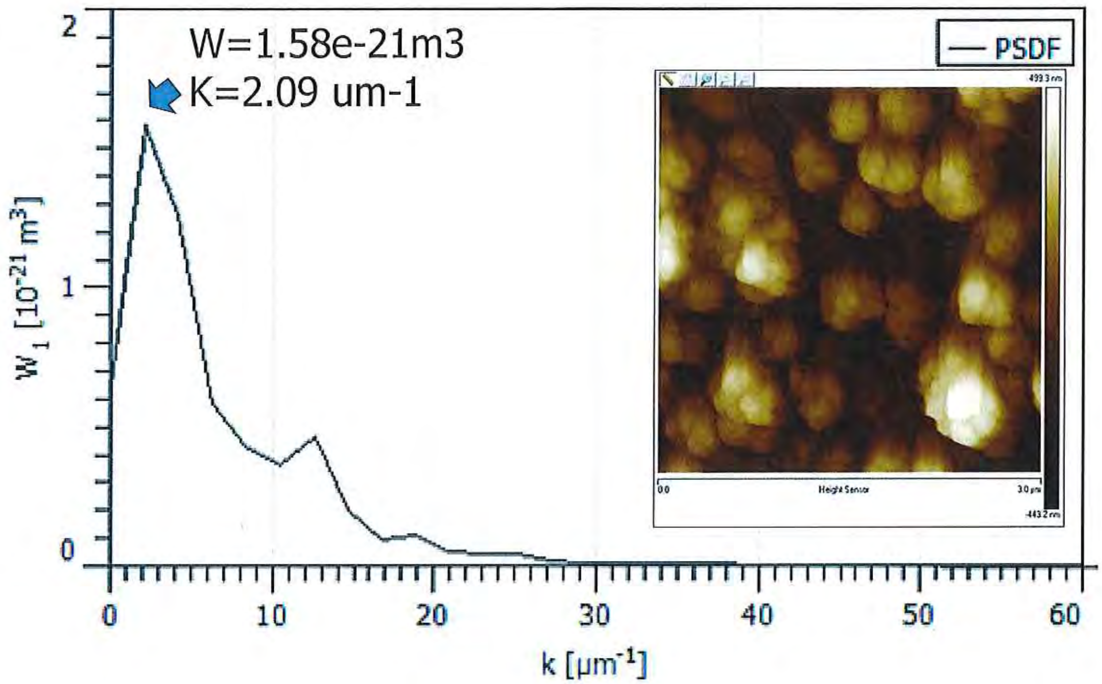
Electrodes (ID: SN1)



500nm



Electrodes (ID: SN1)



Progress Toward Understanding Anomalous Heat

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University of Missouri

<u>Outline</u>

- Description of SKINR
- Anomalous heat results among collaborators -
  - SKINR, NRL, ENEA
- ✓ SKINR initiatives
- ✓ Some known conditions to obtain anomalous heat results
- ✓ Experiments suggested by theories
- ✓ Quantitative impact
- ✓ Conclusions

Many Initiatives at SKINR

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Gas Reactors:

-Celani replication

-High temperature reactor/calorimeter

Electrochemical cells: Cathode development (many choices)

-Self assembled Pd nanoparticle cathodes

-Pd coated carbon nanotube cathodes

-Artificially structured Pd cathodes

-New alloy compositions

-Dealloying for nanoporous Pd

-Magnetic fields

-In situ ultrasound surface stimulation

-Glow discharge etching

-Hydrogen permeation kinetics

-Radiation detection (thin membrane)

Related studies

-Exploding PdD wires (with SRI)

-Neutron scattering in situ of Pd Loading with D/H

-MeV and keV bombardment of D on Pd

-Thermal shock of TiD2

-Hydrogen absorption thermodynamics at high pressure/temperature

-Diamond radiation detectors

-Theory

What we know about effect

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University of Missouri

New data: During excess heat events

- Inductive resonance
- Unstable voltage, current and R/R0 resistance measurement
- Surface contaminants important (Pt, Si, Al, LiAlO3, other?)
- RF emission – indication of resonance in cathodes
- Acoustic triggering
- **No** activation of materials in electrochemical cell

Older data

- [100] orientation
- Labyrinth morphology
- Peaks in power spectral density correlated with appearance and amplitude of anomalous heat
- Voltage increase
- High loading
- Sharp increase in temperature coefficient of resistance of Pd cathode
- No real time high energy neutron or gamma ray emission

New and old data strongly suggest that:

Mechanism tied to Resonant THz coupling to phonons in dynamic metamaterial on surface?

Mechanistic Experiments

Two Examples

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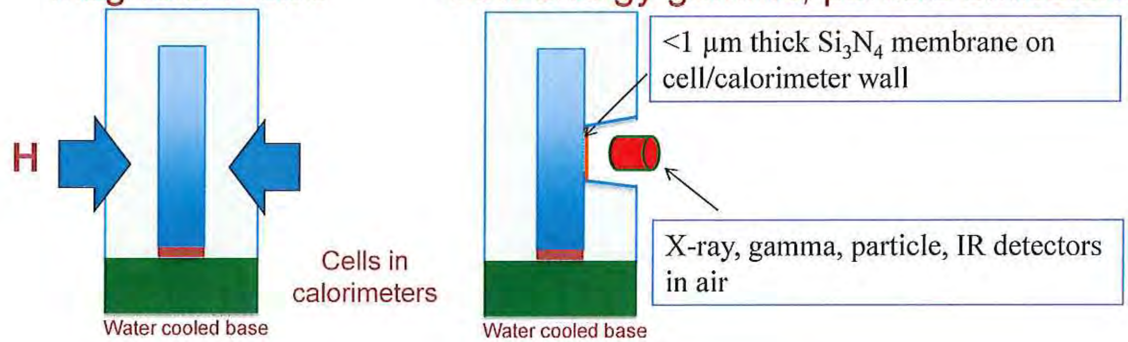
University of Missouri

Magnetic Fields / Low energy gamma, particle emissions



Build on previous work by:
Bockris – Texas A&M
Boss & Gordon – SPAWAR
Cravens & Letts – NM
Swartz – Jet Energy
LaGatta - TSEM

Low energy emissions have never been thoroughly investigated in REAL TIME

Expected Progress: Reveal Mechanism

Membrane Experiment Schematic

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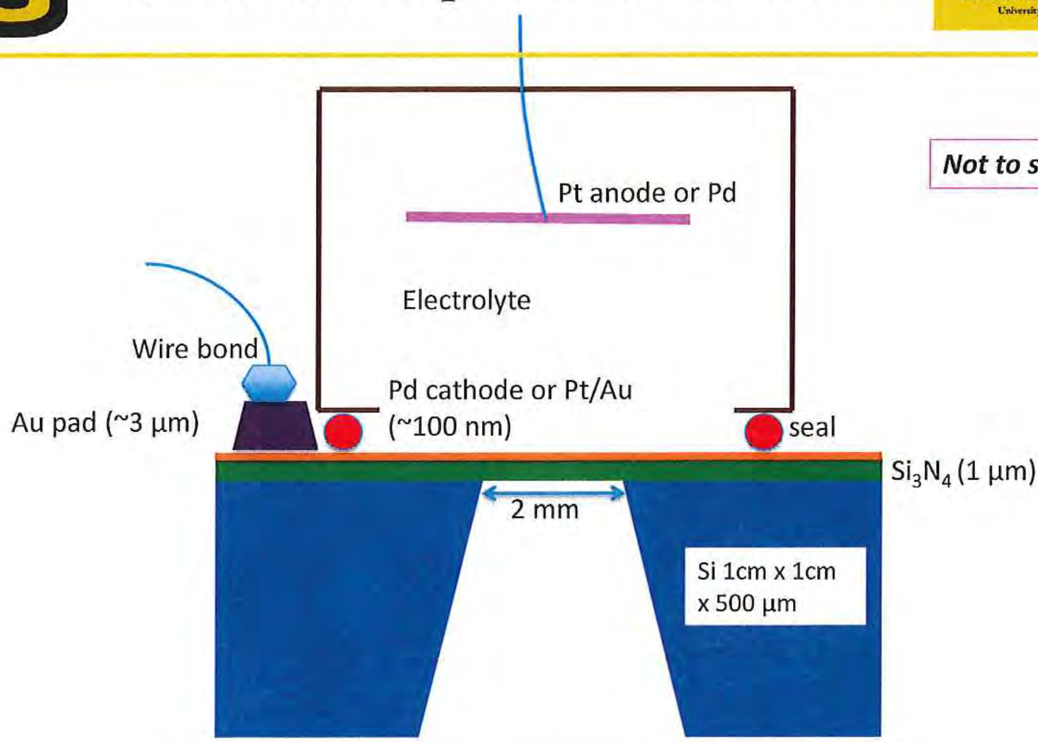

1.5 keV x-rays predicted by Hagelstein, Takahashi

Membrane Experiment Sensitivity

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Most calorimeters have power sensitivity in the range of 1 to 10 mW

Suppose that the anomalous heat mechanism is active much of the time but at the micro-, nano-, or pico-Watt level. The calorimeter is insensitive to this power output

If in the membrane experiment we see a 1 keV x-ray at a rate of 1 Hz, the corresponding power sensitivity is 0.2 femtowatts, an excess power sensitivity improvement of **10^{12} ! If it's Nuclear?**

Sidney Kimmel Institute for Nuclear Renaissance (SKINR) Overview

Sidney Kimmel Institute for Nuclear Renaissance University of Missouri

Experiments for Anomalous Heat

- ❑ Cathode development - ENEA, SKINR
- ❑ Cathode testing - - ENEA, SKINR
- ❑ Computations for Triggering Resonance
- ❑ Experiments for Nuclear Mechanism
- ❑ membrane experiments at SKINR and ENEA
- ❑ more experiments like ultrasound at SKINR, ENEA, TSEM, Pd/ alloys and CNT cathodes and ENEA cathodes; exploring effect of magnetic fields (All)
- ❑ IR and RF emission spectroscopy from heat producing cathodes (SKINR, NRL, TSEM); (Jinghao He, and perhaps DeChario); surface nanoplasmonic calculations (U. Rome).

Most Energetic Anomalous Heat Events by the University of Missouri (SKINR)

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

	ENEA fabricated cathodes				40% reproducibility			
Experiment	**56**	**64a**	**64b**	**GD-141**	**US1-15**	**US3-05**	**US3-06**	**US3-21**
EE, MJ	3.1	1.1	> 3.5	2.4	0.19	1.1	1.32	0.026
EP, W	3	19	> 11	14	0.25	0.8	0.9	0.13
Max COP, %	80	2500	> 1500	75	600	3000	525	650
Duration of EH, h	300	17	80	90	280	960	445	55

SKINR- 2 event with 27-50X excess (2014)
The Naval Research Laboratory – 5 events from 2-10X excess (2011-2102)
Stanford Research International – dozens of events 2-10x excess (1990 to present)
ENEA, Frascati Laboratory, Italy – dozens of events 2-10x excess (1990 to present)

Conclusions

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University of Missouri

1. Palladium delivered by metallurgical companies on the market, and certificated as the metal of high purity, really contains a lot of foreign conductive and non-conducting inclusions.

2. The addition of controlled inclusions on the lattice surface, affect very strongly both: a. the formation of the initial structure/morphology, b. the phase composition of the material and the mechanism of Pd deuteration and of the generation of AHE under cathodic polarization. Typical morphology structure as analyzed by AFM-Power Spectral Density Function (PSDF) led to higher reproducibility.

3. The presence of local high-intensity electric fields on the phase boundary between Pd and non-conducting inclusions causes intense local mass transfer and local temperature increase, growth of secondary crystals and formation of highly-defective zones. Apparently, the initiation of low-temperature nuclear processes is possible just in these areas.

Conclusion

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University of Missouri

4. In-cell exposure of palladium cathodes to ultrasound cavitation, combined with SuperWave electric current driven electrolysis, was found to enable remarkably high deuterium loading with surprisingly low current density. The rate of deuterium desorption from palladium cathodes removed from ultrasonic-assisted electrolysis cells was found to be remarkably slow: the palladium remained in beta phase loading for many days. The outer layer of palladium foils exposed to ultrasonic cavitation experiences a large plastic deformation that is characterized by a highly pitted rough surface. Craters showing clear signs of palladium melting were found on palladium cathodes that underwent ultrasonic excitation during electrolysis. Better diagnostics will be required to analyze these craters.

5. The most reproducible excess heat generation of all experiments performed so far at Energetics Technologies has been obtained with ultrasonic excitation. Several episodes of "heat-after-death" were observed during some of the ultrasonically excited experiments. It is necessary to optimize the application of the ultrasound to minimize the energy needed to generate the cavitation versus the amount of excess energy generated. The mechanism by which ultrasonic excitation intensifies the excess heat also needs to be thoroughly investigated.

Conclusion

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University of Missouri

Significant amounts of excess power and excess energy were generated and very large Coefficient Of Performance (COP) were obtained in several of Energetics Technologies experiments. The best performance parameters obtained so far are:

- Excess energy 3.5 MJ
- Excess power 34 W
- COP 5000%
- Duration 40 days
- Specific energy 27 KeV per Pd or D atom
- Specific power 70 W/g Pd

The latter can be appreciated when compared against the 20 to 50 W/g of uranium that is achieved in large commercial fission power reactors.

Acknowledgment

This work was funded by Mr. Sidney Kimmel.

Appendix B. Professional Biographies

(805)-252-4068
optvac.pease@gmail.com

Dennis C. Pease, Ph.D.

4009 Day Flower Ct.
Columbia, MO 65203

OBJECTIVE

My current goal is to leverage my broad multi-disciplinary experience as a creative physicist/engineer into determining the basic physical processes which underlie anomalous heat effect (AHE) and other associated, but less accepted, effects such as elemental transmutation. Throughout my product development oriented career I have had the opportunity and privilege of functioning in much the same capacity as a university researcher and I have always gotten my greatest satisfaction from discovering unique and unusual phenomena while working on "breakthrough technology" tasks. It is the intent of this curriculum vitae to demonstrate my unusually diverse experience and proficiency in pursuing unique state-of-the-art proprietary and/or classified research and product development tasks.

EXPERTISE

I am interested in the innovation, conceptual design, development, analysis, production, and use of precision electro-opto-mechanical MEMS and macro sized sensors for use in real-world environments extending from sea-level to aeronautical to aerospace environments. My experimental expertise spans an unusually wide range of physics with my initial graduate and post-doctoral career being centered around spectroscopic diagnostics for fusion related high-power transient plasmas. In subsequent years I acquired analytical and experimental expertise in nuclear radiation detection, lasers, UV/VIS/NIR/MWIR/LWIR optics, LED lighting & display technologies, vacuum package life & gas diffusion analysis, acoustical properties of materials & resonators for inertial navigation, and hyperspectral/UWB/THz detection of homemade explosives & IED's. Finally, my most recent appointment has been as a University researcher working in the field of anomalous heat effect and low energy nuclear reactions. I am accomplished at technical completion of early phase research, analysis, and product development projects and am proficient at creating and presenting technical proposals and progress reports. Most of all; I enjoy monitoring, sharing, and discussing with those around me new ideas and innovative approaches for doing R&D.

EDUCATION

Ph.D. in Physics University of Texas Austin, TX Advisor: Dr. Roger Bengtson **1982**
Dissertation: ***An Experimental Study of Ion Dynamic Effects on Helium Line Profiles***
M.A. in Physics University of Texas Austin, TX Advisor: Dr. Roger Bengtson **1978**
Thesis: ***An Experimental Study of High Frequency Plasma Wave Effects in Hydrogen***
B.S. in Physics University of Missouri Rolla, MO **1973**

UNIVERSITY RESEARCH & MENTOR EXPERIENCE

SKINR – Physics Dept., Univ. of Mo - Columbia Research Scientist 2012 – 2017

- Member of the Sidney Kimmel Institute for Nuclear Renaissance (SKINR) multidisciplinary team that included professional researchers and students studying the origins of anomalous heat effect (AHE) using electrolytic, high temperature, and high pressure gas loading cells.
- Innovated automated x-ray and RF spectral AHE tests including hardware/software design with continuous 24/7 digital data collection with computerized instrument control, real-time numerical data analysis, and student refined VI's for event alarms.
- Supported legacy LabVIEW V6&7 code revisions and authored "next generation" V12,13,14 VI's enabling high speed automated data collection with high bandwidth simultaneous recording, display, and real time analysis (e.g. fast Fourier transform) of data,
- Participated in design of experiments, troubleshooting, authoring, and editorial review of reports.

(805)-252-4068 **Dennis C. Pease, Ph.D.** 4009 Day Flower Ct.
optvac.pease@gmail.com Columbia, MO 65203

CPPE – ECE Dept., Univ. of Mo - Columbia **Research Scientist** **2011 – 2012**

- Aided in the completion of several DOD related projects at the Center for Physical and Power Electronics (CPPE) in the Electrical and Computer Engineering department (ECE). This work entailed conceptual design of experiments, mentoring of undergraduate / graduate students, and maintaining a routine laboratory presence to support data acquisition and problem resolution.
- Assisted CPPE faculty members with writing of reports and review of proposed publications.
- Completed in < 2 months the detailed design, parts procurement, assembly, and testing of a high vacuum system for a unique dual high power virtual cathode (Vircator) microwave generator.
- Innovated and implemented time and performance improvements to a LabView controlled suite of instruments being used to quantify device re-radiation within an RF anechoic chamber.
- Created a macro enabled EXCEL spreadsheet to process large RF data sets and discern patterns.

Textron Systems – IST Operations/GRDC/TDS **Principal Physicist** **2006 – 2010**

- Served as technical advisor and graduate student mentor for Labview based testing of a novel proprietary MEMS based sensor being developed in collaboration with the Berkeley Sensor and Actuation Center (BSAC) at the University of California at Berkeley.
- Provided employee training and instructional materials for safe handling of LN_2 and lasers.

University of Texas at Austin Graduate Student / Teaching Assistant **1979 – 1981**

- Instructed and graded mechanics & electromagnetics labs for engineering physics students.
- Improved and repaired engineering physics lab equipment and wrote manual supplements.

RESEARCH & PRODUCT DEVELOPMENT EXPERIENCE

Consultant - Sole Proprietor of OptVac **2010 - 2012**

- Aided the Jet Propulsion Lab (JPL) in acquiring DARPA funding to develop a 10 mm^3 inertial measurement and timing module using MEMS integration and a fused silica acoustic resonator.
- Provided expertise to two local companies, MirMar Associates and Sensors in Motion, for small business innovative research (SBIR) proposals.

Textron Systems – IST Operations/GRDC/TDS **Principal Physicist** **2006 – 2010**

- Provided sensor expertise for development and testing of various military survivability systems.
- Provided concepts, detailed subject research, and modeling for many diverse Homeland Security and DOD related projects involving gamma spectrometers and neutron radiation detectors, MEMS sensors, Ultra Wide Band communications, robotic platforms for improvised explosive device (IED) mitigation, and THz lasers.
- Identified and worked with government sponsors, other companies, university professors, and National Lab scientists to establish teams for authoring of white papers and proposals.

Consnltant - Sole Proprietor of OptVac **2002 - 2006**

- **Flir-Indigo Systems** – Designed, built, and used an ultra high vacuum ($<10^{-10}$ torr) system for accelerated package life testing and RGA vacuum analysis of low cost μbolometer IR detectors.
- **Innovative Survivability Technologies (IST)** – Provided optical, nuclear radiation, and instrumentation expertise to support various military and Homeland Security related projects.

Northrop Grumman (formerly Litton GCS, Hughes, and Delco Systems Operations) **1984 - 2002**
The Goleta branch of Northrop Grumman was a $60 million dollar manufacturer of Hemispherical Resonating Gyroscope (HRG) inertial grade navigation systems used in satellites, and space probes.

Member of Technical Staff, (1995 – 2002)

- Instrument specialist team member for prediction of radiation effects on HRG resonators in the Trident D5LE strategic missile environment. Aided in test fixture design and data interpretation for HRG gyro strategic level ride-through radiation tests using NRL's Gamble flash x-ray and a high level Cobalt 60 isotopic source.

- Principal innovator and technical lead for an automated CO_2 laser mass trimming system used for <10 PPB balancing of fused silica acoustic resonators used in IMU's. Responsible for all phases of this multi-year project including evaluation of alternate mass removal techniques, definition of laser system requirements, resonator balancing proof-of-concept tests, creation of automated balance algorithms, final system design, production hand-off, and SPC based optimization.

- **Served as technical lead for critical HRG R&D projects** lasting from 2 - 18 months including:

  - Development and experimental verification of a Fortran simulation for Helium diffusion in fused silica. This tool aided HRG product improvement and provided critical GO/NOGO launch decision data following accidental He exposures at several different customer facilities. Detailed He simulations were done for the Cassini spacecraft HRG inertial reference unit that received a NASA Achievement Award for innovative design and timely delivery.

  - Innovation and use of a diffusive based Helium sensor, which allowed stable and non-perturbative measurement of Helium partial pressures of < 1 PPM in STP air.

  - Quantification of gas flow and He diffusion for the HRG HIRU sealed and vented IMU. Computer modeling and experimental testing used novel techniques to simulate launch & launch abort scenarios with high fidelity. Analysis of results culminated in the derivation of GO/NOGO and N_2 purge criteria.

  - Creation of special fixtures and custom modification of a COTS He leak detector to achieve ultra high He leak checking sensitivity (< 10^{-12} torr*liter/sec). Used in conjunction with modeling and analysis to investigate thin film coatings to reduce He diffusion into fused silica and to evaluate low diffusivity electrical feedthroughs.

Sr. Systems Engineer, (1988 – 1995)

- Contributed optical UV/VIS/MWIR/TIR radiometric and spectral calibration expertise to a small project team that developed, built, and successfully field-tested a computer controlled classified military survivability system.
- Evaluated diverse materials for use as HRG tactical grade resonators and investigated surface finishing, heat treatment, and balancing techniques to enhance Q. Discovered a heat treatment process to increase the Q of a certain metal alloy by >8X and which resulted in metal Q's higher than any to be found (even in 2010) within the published literature.
- Aided in the development of very high Q ($>10^7$) harmonic mode measurement and surface finishing techniques for fused silica resonators that enabled inertial grade HRG performance.
- Served as Laser Safety Officer responsible for MPE and NOHD calculations and evaluation of safe use procedures for He-Ne, Nd:Glass, Er:YAG, CO_2, and Raman:YAG lasers.

Sr. Experimental Engineer, (1984 – 1988)

- Designed experimental vacuum apparatus and used optical scattering from an Ar:Ion laser to study condensation within a pulsed supersonic gas jet.
- Conceptualized a unique space chamber design to provide real-time NEO simulation for IR signature and thermal analysis of subscale re-entry vehicles.
- Evaluated various advanced optical techniques (e.g. intensity interferometry) for potential use in re-entry vehicle detection, sizing, and discrimination.

Los Alamos National Laboratory Post-Doc / Staff Member **1983 - 1984**

- Studied plasma turbulence in an 800kV, 900kA, pulsed (<10^{-8} sec), annular argon gas z-pinch.
- Diagnostics included VUV spectrometer, PIN diode, x-ray pinhole camera, and streak camera.

Texas Tech University Post-Doc / Research Associate **1982 - 1983**

- Investigated time-resolved (<10^{-8} sec) breakdown processes in a Nd:YAG laser triggered spark gap via laser shadowgraphy and laser induced fluorescence imagery.

University of Texas at Austin Graduate Student / Research Assistant **1974 – 1979**

- Verified effects of ion dynamics on Stark broadened spectral line shapes from time-resolved spectroscopy of a transient low-pressure helium / hydrogen linear discharge using a SIT-OMA.
- Measured plasma parameters on several experimental Fusion Research Center plasmas (TTT, PRETEXT, Z-Discharge, and Cylindrical Gas Shell.) using a variety of spectroscopic techniques (e.g. laser interferometry, absolute line intensities, line-to-line or continuum intensity ratios, and hydrogen Stark broadening.)
- Used 30", 36" and 82" telescopes for spectroscopy and photoelectric uvby filter photometry of variable stars during Astronomy Dept. summer observing course at McDonald Observatory.

University of Missouri at Rolla Undergraduate Student / Graduate Assistant **1973 - 1974**

- Constructed a cycloidal electrostatic mass spectrometer and used it for measurements of electron impact ionization cross-sections in lithium

University of Missouri at Rolla NSF Research Participant Summer **1972**

- Modified a Newtonian telescope to accept a photoelectric photometer. Devised, assembled, and used an analog data recording system for UBV filter photometry of various variable stars.
- Student team member on an NSF grant sponsored total solar eclipse trip to the Gaspe' Peninsula.
- Had total responsibility for optical photometry and custom fabrication of aluminized solar filters.

University of Missouri at Rolla Undergraduate Student Assistant **1970 - 1973**

- Helped with electronics inventory, stocking, and construction of special apparatus related to cloud simulation studies in the Cloud Physics Research Center.

University of Missouri at Rolla Astronomy Club – Co-founder **1970 - 1974**

- Charter member of UMR's astronomy club and actively involved in its inception and growth
- Aided in the instigation, site selection, design, and construction of one radio telescope and three optical (12.5" Celestron, 10" custom Newtonian, 16" Group 128) telescope installations.
- Designed and built various accessories for the three university telescopes to facilitate prime focus photography, photoelectric photometry, public viewing, and video recording.

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Dennis C. Pease, Ph.D.

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Columbia, MO 65203

COMPUTER SKILLS

MCNP5, Labview, LTSpice, DeltaEC, Opticad, Mathcad, Matlab, Boxiemp, Lowtran, MuSES, Fortran, C++, DOS Win 2007, Visual Basic - Excel, Word, Outlook, PowerPoint, Access

CERTIFICATIONS and TRAINING

DOD Security Clearance		1984 - Active
Space Systems Hardening Radiation Course	SAIC	1999
Team Leadership & Facilitating for Results	Zenger Miller	1998
Predictive Vacuum Pump Maintenance	Metro-Line Industries, Inc.	1996
Laser Safety Course	Safety Center, Inc.	1992
Static Awareness / ESD / ISO 9001	Northrop / Litton / DSO	1982+

AFFILIATIONS

Acoustical Society of America	2010 - 2011
American Physical Society	1975 - 1998
Santa Barbara Astronomical Unit	2007 – 2011
Santa Barbara Astronomy Club	1985 – 1990
Austin Astronomical Society	1974 – 1982

AWARDS & HONORS

Litton FY2000 Technical Innovation Award for Trade Secret (related to inertial resonators)
DSO Recognition Award for sensor analysis, debug, calibration, and field test support.

B.S. received Magna Cum Laude	Phi Kappa Phi (Interdisciplinary Honor Society)
Sigma Pi Sigma (Physics Honor Society)	Phi Eta Sigma (Freshman Honorary Fraternity)

PEER - REVIEWED PUBLICATIONS

Review of materials science for studying the Fleishmann-Pons Effect, V. Violante, E. Castagna, S. Lecci, F. Sarto, M. Sansovini, A. Torre, A. LaGatta, R. Duncan, G.K. Hubler, A. El-Boher, O. Azizi, D. Pease, D. Knies and M. McKubre, *Current Science* , **108,** 540, (2015).

Progress towards understanding anomalous heat effect in metal deuterides, O. Azizi, A. El-Boher, J.H. He, G.K. Hubler, D. Pease, W. Isaacson, V. Violante and S. Gangopadhyay, *Current Science*, **108,** 565, (2015).

Sidney Kimmel Institute for Nuclear Renaissance, Hubler, G. K., El-Boher, A., Azizi, O., Pease, D., He, J.H., Isaacson, W., Gangopadhyay, S. and Violante, V., *Current Science*, **108,** 562-564, (2015.)

Hydrogen Effect on Creation of Nanoporous Palladium by Palladium Hydride Wire Explosion, J. Baker, J. Gahl, P. **Time Resolved Two-Dimensional Imaging of Ground State Species Using Laser-Induced Fluorescence**, A. Dougal, P. Williams, and D.C. Pease, *Review of Scientific Instruments*, **54**, 572, (May 1983).

An Experimental Study of Ion Dynamic Effects on Helium Line Profiles, Roger D. Bengtson and D.C. Pease, pp.183-197 in *Spectral Line Shapes Vol. 2*, ed. by Keith Burnett, Walter de Gruyter, Berlin, (1983).

High Resolution ($\Delta\lambda$ < 0.08Å) Helium Line Profiles in a Low Density Linear Discharge, Dennis C. Pease and Roger D. Bengtson, pp.199-214 in *Spectral Line Shapes Vol. 2*, ed. by Keith Burnett, Walter de Gruyter, Berlin, (1983).

Production of a Cylindrical Plasma Shell, R.D. Bengtson, D.L. Honea, D. Pease, J.H. Degnan, R.A. Golobic, *Journal of Applied Physics*, 51, 4097, (1980).

CONFERENCE PROCEEDINGS & PRESENTATIONS

Final Report on Calorimetry-based Excess Heat Trials using Celani Treated NiCuMn (Constantan) Wires, Arik El-Boher, William Isaacson, Orchideh Azizi, Jinghao He, Dennis Pease and Graham Hubler, Journal of Condensed Matter Nuclear Science, **19**, 68, (2016).

Effect of Cathode Pretreatment and Chemical Additives on H/D Absorption into Palladium via Electrochemical Permeation, Orchideh Azizi, Jinghao He, Dan T. Paterson, Arik El-Boher, Dennis Pease and Graham Hubler, Journal of Condensed Matter Nuclear Science, **19**, 1, (2016).

Search for Low-energy X-ray and Particle Emissions from an Electrochemical Cell, Dennis Pease, Orchideh Azizi, Jinghao He, Arik El-Boher, Graham K. Hubler, Sango Bok, Cherian Mathai, Shubhra Gangopadhyay, Stefano Lecci and Vittorio Violante, J. of Condensed Matter Nuclear Science **19**, 257, (2016).

High Resolution ($\Delta\lambda$< 0.08Å) Helium Line Profiles in a Low Density Linear Discharge, Dennis C. Pease and Roger D. Bengtson, *Sixth International Conf. on Spectral Line Shapes*, Boulder, CO, July 12, 1982.

Helium Line Profiles in a Linear Discharge Plasma, D.C. Pease, A. Divatia, and R.D. Bengtson, *Bull. Amer. Phys. Soc.,* **24**, 1024, (1979).

High Frequency Plasma Wave Effects on Hydrogen Spectra in a Linear Discharge, D.C. Pease and R.D. Bengtson, *Bull. Amer. Phys. Soc.,* **23**, 774, (1978).

Generation of a Cylindrical Gas Shell Plasma, D.L. Honea, R.D. Bengtson, D.C. Pease, and J.H. Degnan, *Bull. Amer. Phys. Soc.,* **23**, 824, (1978).

CUSTOMER TECHNICAL REPORTS

MODI Validation Test, pp. 1-88, July 1 - March 1, 2012, Interim Report to the Leonard Wood Research Institute, PI: Randy D. Curry, PhD, University of Missouri-Columbia, Center for Physical and Power Electronics, Electrical and Computer Engineering

HRG HIRU Enclosure - Helium Diffusion Test Results of Helium Exposure Attenuation Achieved by 'Partial Sealing, D. Pease, pp.1-15, 19 September, 1996, Litton Guidance & Control Systems, Space & Launch Systems (LGCS), for Hughes Space & Communications Company (HSC)

Nitrogen Purge Testing of the HRG HIRU system after a Helium Exposure, D. Pease, pp. 1-34, 29 September 1997, LGCS for HSC

HIRU Helium Exposure GO/NOGO Analysis, D. Pease, pp. 1-75, 16 March 1998, LGCS for HSC

Silica/Quartz Radiation Responses, Section 3.3, pp. 3-6, D. Pease, "Assessment of HRG Materials, Processes, and Non-Electronic Components", Section 3.7.2, pp. 10-17, D. Pease, *Nuclear Radiation Assessment of the Litton Hemispherical Resonator Gyro (HRG) for the Trident D5 Life Extension (D5LE) program, Volume I. Final Report,* Litton Systems Incorporated, Guidance and Control Systems Division Strategic Systems, for Charles Stark Draper Laboratory, Inc.

30mm Resonator Finishing & Process Selection, D. Pease, Sections 3.2 & 3.3, pp 4-17, *Trident Guidance System, Hemispherical Resonator Gyroscope, Application Study III, Final Report, 1 October 1988 through 30 September 1989*, R89-75, 6-R89-75, Delco Systems Operations, for Hughes Aircraft Company, Electro-Optics and Data Systems Group

Space Chamber for Subscale Measurements (U), D. Pease, in *BREP X Semiannual Report No. 4*(U), R86-187, Aerophysics Department, Delco Systems Operations, (Mar. 1986). {CLASSIFIED}

Exoatmospheric Discrimination and Scale Modeling (U), D. Pease, in {BREP X Semiannual Report No. 3} (U), R86-75, Aerophysics Department, Delco Systems Operations,(Sept. 1985). {CLASSIFIED}

Intensity Interferometry and Reentry Vehicle Sizing (U), D. Pease, in *Ballistics Range Experimental Program (BREP X) Semiannual Report No. 2 (U)*, R85-146, Aerophysics Department, Delco Systems Operations, (Mar. 1985). {CLASSIFIED}

CUSTOMER TECHNICAL PRESENTATIONS

Thermal Scale Modeling of Reentry Vehicles and its Application to Infrared Signature Measurements in a Simulated Space Environment, D. Pease, pp. 1-38, 7 August 1985, for Ballistic Missile Defense Systems Command

30mm Resonator Finishing Process, Section II.4, p.19-23, *Trident Guidance System, Hemispherical Resonator Gyroscope, Application Study, Quarterly Program Review*, 26 September 1989, S89-116, 5-S89-116A, Delco Systems Operations, for Hughes Aircraft Company, Electro-Optics and Data Systems Group

Status of Metallization of Resonators and Measurement of Time Constant, D. Pease, Section XII, pp. 1-13, *HRG 158X Hemispherical Resonator Gyro - BSD and Trident Joint Technical Review*, 30 January 1990, S90-18, 1-290-18C, Delco Systems Operations, for Charles Stark Draper Laboratory, Inc. and Hughes Aircraft Company, Electro-Optics and Data Systems Group

FY00 HRG Nuclear Assessment Final Review, D. Pease, B. Pritchard, G. Johnson, D. Wright, *Trident HRG TIM #4*, 25 October 2000, Litton Guidance & Control Systems, Space Launch & Strategic Systems, for Charles Stark Draper Laboratory, Inc.

HRG Construction and Radiation Effects, pp. 66- 77, D. Pease, *In-Process Review of HRG Radiation Assessment & Enhanced Readout, Trident HRG TIM #2, **6 April 2000***, Litton Guidance & Control Systems, Space Launch & Strategic Systems, for Charles Stark Draper Laboratory, Inc.

HRG Resonator Lifetime Evaluation for the Hubble Space Telescope, D. Pease, A. Voros, B. Schwarz, 21 June 1995, pp. 1-16, Hughes Delco Systems Operations, *Technical Interchange Meeting #1*, for Lockheed-Martin (LMMS, LMTO) and NASA/GSFC

HRG Design Life Evaluation, Section 3.8, PP. 1-6, D. Pease, HRG/RGA PDR Presentation, 9 August 1995, R95-050, for Lockheed Martin (LMMS, LMTO) and NASA/GSFC

Trident Status Review, D. Pease, pp. 3-10, *Trident Guidance System, Hemispherical Resonator Gyroscope, Application Study, Program Review*, 27 September 1990, S90-133, 2-S90-133, Delco Systems Operations, for Hughes Aircraft Company, Electro-Optics and Data Systems Group

Trident Technical Task Reports, D. Pease, Section IV, pp. 1-11, *Trident Guidance System, Hemispherical Resonator Gyroscope, Application Study, Program Review*, 17 May 1990, S90-66, 2-S90-66a, Delco Systems Operations, for Hughes Aircraft Company, Electro-Optics and Data Systems Group

Metallization of Resonators and Measurement of Time Constant, D. Pease, Section XII., pp. 1-6, "Design Development and Checkout of Balancing Tooling", D. Pease, Section XIII., pp. 1-9, "Development of

Balancing Procedure", D. Pease, Section XV., pp. 1-3, *HRG 158X Hemispherical Resonator Gyro - BMO and Trident Joint Technical Review* , 18 April 1990, S90-57, 2-S90-57, Delco Systems Operations, for Charles Stark Draper Laboratory, Inc. and Hughes Aircraft Company, Electro-Optics and Data Systems Group, Section XII.

HRG Helium Permeation Simulation - An Analysis of the influence of external helium exposure(s) on the HRG's parametric drive for all of the Cassini Inertial Navigation Units, D. Pease, pp. 28-38, *JPL/Litton Cassini Test Incident Review*, 3 July 1997, Litton Guidance & Control Systems, Space & Launch Systems, for JPL

INTERNAL PRODUCTION PROCESS DOCUMENTS

Special Handling Specification: Non-Helium Environment for the Space Inertial Reference Unit, D. Pease, 2 November 2000, Rev. E, pp. 1-22, Litton Guidance & Control Systems, Space & Launch Systems

Qualification of Laser Balancing Process for HRG Tineless Resonators, D. Pease, May 24, 2000, PP.1-29, Litton Guidance & Control Systems, Space & Launch Systems

Resonator Laser Balancing Procedure, D. Pease, LMPD 0027, Issue 1.0, 7 July 1999, Issue 2.0 4 January 2000, & Issue 3.0 8 May 2001, pp. 1-69, Litton Guidance & Control Systems, Space & Launch Systems

INTERNAL TECHNICAL REPORTS

Preliminary Evaluation of an HIRU Go/No Go Criteria Based on HRG Parametric Drive Rate-of-Change Following a Helium Exposure, D. Pease, 6 October 1997, pp. 1-5, Litton Guidance & Control Systems, Space & Launch Systems, for Hughes Space & Communications Company

HRG Platform Heater Evaluation Using 8-12 Micron Infrared Imaging, D. Pease, 26 November 1996, pp. 1-16, for Litton Guidance & Control Systems, Space & Launch Systems

CO2 Laser Mass Removal of Fused Silica for Balancing of HRG Resonators, D. Pease, 15 November 1990, pp. 1-28, Delco Systems Operations

INTERNAL TECHNICAL PRESENTATIONS

Helium-Block Testing & Analysis, D. Pease, pp. 25-31, *HRG130T Resonator Balancing Procedure Development*, for Litton Guidance & Control Systems, Space & Launch Systems (LGCS) internal program review (IPR)

Engineering Project Review for Laser Balance, D. Pease, D. Wright, N. Hickox, R. Christel, PP.1-15, 26 January 1999, for LGCS IPR

Engineering Project Review for Laser Balance, D. Pease, D. Wright, N. Hickox, R. Christel, T. Jennings, PP.1-16, 10 December 1998, for LGCS IPR

ADDITIONAL UNLISTED WHITE PAPERS, PROPOSALS, PROPRIETARY, and / or CLASSIFIED ITEMS

Many additional monthly, semi-annual, and annual written reports, white papers, proposals, IRAD submissions, and oral presentations were completed in connection with my employment from 2002 – 2010 at Textron Defense Systems, IST Operations, and/or FLIR-Indigo Systems.

A complete and detailed listing of the above documents has not been provided in this CV due to their limited distribution as company proprietary or classified documents. In some cases, however, it may be possible to provide general titles and/or categorical descriptions upon request.

REFERENCES

David Wright 805-968-6787x158w 805-252-4884c dwright@toyon.com
Toyon Research Corporation, 6800 Cortona Drive, Goleta, CA 93117
Current Title: *Vice President and Director of Homeland Security Group*
Relationship: Former supervisor at Innovative Survivability Technology (IST) and Litton Guidance and Control Systems. Co-worker at Northrop Grumman and Delco Systems Operations.

Graham Hubler 571-641-1471c 301-854-0032w hublerg@missouri.edu
301 Physics, University of Missouri, Columbia, MO 65211
Current Title: Director, Sidney Kimmel Institute for Nuclear Renaissance
Relationship: Current supervisor at SKINR

Dr. Michael Mueller 415-412-6227c miketmueller@gmail.com
Spectral MD, 5831 McShann Rd., Dallas, TX 75230
Current Title: *Vice President of Research and Corporate Development*
Relationship: Former UC Berkeley graduate researcher I worked with on MEMS sensor project

Emel Bulat 617-373-4617w 508-954-5650c e.bulat@neu.edu
Northeastern University, 302 Stearns Center, 360 Huntington Ave. Boston, MA 02115
Current Title: *Sr. Consultant for Corporate & Government Partnerships, Gordon-CenSSIS & ALERT*
Relationship: Former co-worker who was in charge of Textron's university research and involved me in the joint Textron Systems – BSAC (Berkeley Sensor and Actuator Center) MEMS sensor development project

Julian Nott 805-708-8100c Nott@Nott.com
Nott Technology LLC, 4536 Carriage Hill Dr., Santa Barbara, CA 93110
Current Title: *President of Nott Technology LLC* (see http://www.nott.com/Pages/about.php)
Relationship: A friend and notable aeronaut who shares many of my aspirations for space exploration and the general pursuit of knowledge.

CURRICULUM VITAE

ARIE (ARIK) EL-BOHER

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Academic Degrees:

1989 Ph.D., Mechanical Engineering, Ben-Gurion University, Israel.
Thesis: "Investigation of a Magneto Hydro Dynamics (MHD) Generator at different Two-Phase Flow Patterns".

1980 M.Sc., Mechanical Engineering, Ben-Gurion University, Israel, with Distinction.
Thesis: "Single and Two-Phase Liquid Metal Flows in Solar Energy Facilities".

1978 B.Sc., Mechanical Engineering, Ben-Gurion University, Israel, with Distinction.

Professional Positions:

2012- Now Research Group Leader/Director at Sidney Kimmel Institute for Nuclear Renaissance (SKINR) of the University of Missouri, Columbia, MO, USA.
Responsible for the LENR R&D program. In the last fourteen years, working in this multidisciplinary field of LENR, gained vast experience in designing first class open and closed Helium tight electrolytic cells, high temperature gas loading cells and plasma-ion bombarding glow discharge cells with accurate isoperibolic, thermoelectric and mass flow calorimetry. Wrote all algorithms for data acquisition programs based on NI LabVIEW programs. Developed effective procedures for Pd cathodes/targets loading using variety of input signals, DC, Pulses and SuperWaves. Achieved outstanding excess heat results during Energetics and SKINR times. Excited Pd cathode/targets with ultra sound/ acoustic waves, RF waves and magnetic pulses.

2010-2012 Deputy to Chief Executive Officer of Energetics Technologies USA LLC, MIC, Columbia, MO, USA, Responsible for the LENR R&D program and operations. Directly Responsible to the Glow Discharge Research Program.

2002-2009 Deputy to Chief Executive Officer of Energetics Technologies Ltd, Omer, Israel. Responsible for the LENR R&D activity. Directly Responsible to the Glow Discharge Research Program. Energetics Replication Two Phases Successful Program was supported by DARPA at a total amount of $3.5 million in collaboration with SRI USA, NRL and ENEA Italy. Energetics outstanding results and Achievements were featured on April 19, 2009 edition of CBS 60 Minute's program "Cold Fusion Is Hot Again".

1998-2002 Chief Executive Officer, Founder and Director of Elecmatec Ltd., Omer Industrial Park, Israel.

Electro- Magnetic Technologies, Microgravity Casting of Metallic Composite Materials (registered patent worldwide), engine bearings with superior wear and anti-seizure properties, successfully tested by Ford and GM in internal combustion engines.

1997-2001 Chief Executive Officer and Founder of Gavish Ltd., Omer Industrial Park, Israel. Sapphire Mono-crystal Growing and Processing of products to the High-Tech industry. Built from scratch and run 40,000 ft^2 plant, selling products worldwide with total of 12 Million dollars.

1991-1997 Chief Executive Officer, Founder and Director of Ontec Ltd., Beer-Sheva,Israel.
Developed and commercialized Liquid Ice Machines (pumpable ice) for cooling and refrigeration, (registered patent worldwide). Company's products have been marketed and sold all over the world of machines, starting from 1 ton of Liquid Ice per day up to 15 ton per day, with total sells of 25 Million dollars and Metallic Micro-Gravity casting technology of Metallic Composite Materials for Engine Bearings, using MHD (registered patent worldwide).

1990-1991 General Manager and Director of Ofakim Center of Technological Incubator. Established as a model for absorption of over a million Russians who immigrated to Israel most of them holding academic Degrees, Patents and Technological ideas. The project was very successful and today there are about 30 such incubators in Israel.

1980-1990 Program and R&D Manager of Solmecs (Israel) Ltd. - Beer-Sheva, Israel.
Development of Method to convert Heat into Electricity by means of Liquid Metal Magneto Hydro Dynamics (MHD).

1985-1989 Lecturer at Ben-Gurion University, Mechanical Engineering Department and Material Engineering Department.
Heat Transfer, Fluid Mechanics, Thermodynamics and MagnetoHydroDynamics.

1977-1988 Research Fellow at the Ben-Gurion University Research and Development Authority.

Other Positions:

1981 – 1997 Delegate of the state of Israel to the International Liaison Group of Magneto Hydro Dynamics Power Generation.

1990 - 2010 Director of the Israel-Russia Bi-National Laboratory.

1992 - 2002 Member of Israel Prime Minister Committee for Immigrant Employment.

Contracts and Grants:

1977-1980 Contract from the office of Naval Research of the U.S. ($200,000) on MHD-Turbulence and MHD-Generator Studies.

1978-1979 Israel Ministry of Energy ($150,000) Solar Powered MHD Generators.

1980 U.S.-Israel Bi-National Foundation ($50,000) - Solar Collectors for MHD System.

1981-1991 Israel Ministry of Industry ($3,000,000) - Liquid Metal MHD Power Generation Systems.

1988-1991 U.S. Dept. of Energy ($229,825) – Development of Wet Vapor Homogenous Liquid Metal Power Systems.

1990-1999 International Lead-Zinc Research Organization ($450,000) – System with Volatile Fluids Boiling in Hot Liquid Metal (Lead).

Patents:

- Method and Device for producing Homogeneous Alloys.
- Method and Installation for Continuous Production of Liquid Ice.
- 8 patents and patents pending in the fields of LENR with SuperWaves, in Metallurgy and in Battery Charging.
- Patent pending with katti Kattesh on Pd Nano particles production technology and application in Electrochemical LENR field.

Publications in Scientific Journals:

1. Branover, H., El-Boher, A. and Yakhot, A., "Testing of a Complete Two-Phase Liquid-Metal MHD System", Journal of Energy Conversion, Vol. 22, pp. 163-169, 1982.

2. Branover, H., El-Boher, A. and Yakhot, A., "Testing of a Low Temperature Liquid-Metal MHD Power System", Energy Conversion and Management, Vol. 22, pp. 163-169, Feb. 1982.

3. Blumenau, L., Branover, H., El-Boher, A., Linn, G., Spero, E., Sukoriansky, S. and Greenspan, E., "Liquid Metal MHD Energy Conversion in Fusion Reactors", Trans of the American Nuclear Society, Vol. 52, Sept. 1986, In Fusion Technology, Vol. 10, No. 3, pp. 914-921, 1986.

4. Blumenau, L., Branover, H., El-Boher, A., Spero, E., Sukoriansky, S. and Greenspan, E., Walker, V.A., Bilton, J.R., Hoffman, N.J., "Liquid Metal MHD Power Conversion for Space Electric Systems", Space Nuclear Power Systems, 1987, Orbit Book Company Malabar, Fl., Vol. 6, pp. 267-279, 1988.

5. M. C. H. McKubre, F. L. Tanzella, I. Dardik, A. El Boher, T. Zilov, E. Greenspan, C. Sibilia and V. Violante, "Replication of Condensed Matter Heat Production," American Chemical Society Low Energy Nuclear Reactions Sourcebook, Washington DC , August 2008, p. 219-247.

6. Violante, V., Castangna, E., Lecci, S., Sarato, F., Sansovini, M., Torre, A., La Gatta, A., Duncan, R., Hubler, G., El_Boher, A., Azizi, O.,Pease, D., Knies, D., McKubre, M., " Review of Material Science for Studying the Fleischmann and Pons Effect" published in Current Science Journal, VOL. 108, No. 4, India, 25 February 2015, pp.540-558.

7. Azizi, O., El-Boher, A., He, J.H., Hubler, G.K., Pease, D., Isaacson, W., Violante, V., and Gangopadhyay, S., "Progress Toward Understanding Anomalous Heat Effect In Metal Deuterides" published in Current Science Journal, VOL. 108, No. 4, India, 25 February 2015, pp.565-573.

8. Hubler, G. K., El-Boher, A., Azizi1, O., Pease, D., He, J.H., Isaacson, W., Gangopadhyay, S. and Violante, V., "Sidney Kimmel Institute for Nuclear Renaissance" published in Current Science Journal, VOL. 108, No. 4, India, 25 February 2015, pp. 562-564.

9. J. Baker, J. Gahl, P. Norgard, O. Azizi, A. El-Boher, G. Hubler, J. He, W. Isaacson, and D. Pease, "Hydrogen Effect on Creation of Nanoporous Palladium by Palladium Hydride Wire Explosion", International Journal of Metallurgy and Metal Physics, (2015) 1:002

Publications in Books:

1. Branover, H., Borde, I., El-Boher, A., Leitner, A., "On the Possible Use of MHD Generators in Solar Energy Systems", in MHD Flows and Turbulence II, Israel Universities Press, p. 197, 1980.

2. Branover, H., El-Boher, A., Yakhot, A. and Claesson, S., "An Operating Model of Two-Phase Heavy- Metal MHD Power Systems", in Liquid-Metal Flows MagnetoHydroDynamics, Progress in Astronautics and Aeronautics, AIAA, Vol. 84, pp. 160-175, 1983.

3. El-Boher, A., Branover, H. and Petrick, M., "The ETGAR Liquid Metal MHD Project", In Single and Multi-Phase Flows in an Electromagnetic Field – Energy, Metallurgical and Solar Applications. Progress in Astronautics and Aeronautics, AIAA, Vol. 100, pp. 413-434, 1985.

4. Greenspan, E., Barak, Z.A., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "Liquid Metal MHD Conversion of Nuclear Energy to Electricity: Possibilities and Implications", Liquid Metal Flows, Magnetohydrodynamics and Applications, Progress Series of Astronautics and Aeronautics, AIAA, Vol. 111, pp. 129-157, Washington D.C., 1988.

5. Branover, H., El-Boher, A., Lesin, S., Unger, Y. and Petrick, M., "Testing of OMACON Type MHD Power Systems", Liquid Metal Flows, Magnetohydrodynamics and Applications. Progress in Astronautics and Aeronautics, Branover, H., Mond, M. and Unger, Y., (eds.), AIAA, Vol. 111, pp. 209-229, Washington D.C., 1988.

6. Greenspan, E., Barak, A., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "Liquid Metal MHD Conversion of Nuclear Energy to Electricity: Possibilities and Implications", in Liquid Metal Flows, Magnetohydrodynamics & Applications, Branover, H., Mond, M. and Unger, Y., (eds.) Vol. 111 Progress in Astronautics and Aeronautics, AIAA, pp. 129-157, Washington D.C., 1988.

7. El-Boher, A., Lesin, S. and Branover, H.," Liquid Metal MHD Generators in Two-Phase Flow Systems", Liquid Metal Magnetohydrodynamics, Mechanics of Fluids and Transport Processes, J. Lielpeteris and R. Moreau (eds.), Klumer Academic Publishers, pp. 111-118, Dordrecht, The Netherlands, 1989.

8. Marty, Ph., Leboucher, L., Alemany, A., Pilaud, A., Branover, H., El-Boher, a. and Kaplan, Y., "Recent Results on LMMHD Induction Generators", Progress in Astronautics and Aeronautics, AIAA, Vol. 148, pp. 244-260, Washington D.C., 1993.

9. Farchi, D., El-Boher, A., Lesin, S., Unger, Y., Branover, H., "Investigation of Two-Phase Gas Mixers for MHD Energy Conversion Systems", Progress in Astronautics and Aeronautics, AIAA, Vol. 148, pp. 678-704, Washington D.C., 1993.

Publications in Proceedings of Conferences

1. Branover, H., Yakhot, A. and El-Boher, A., "Solar-Powered Liquid-Metal MHD Generators and Some Peculiarities of the Performance of Two-Phase Generators", Proc. of the 7th International Conference on MHD and Electrical Power Generation, Mass. Ins. of Technology, Cambridge, MA, Vol. 1, pp. 165-170, June 1980.

2. Branover, H., Borde, I., El-Boher, A., Yakhot, A. Zilberman, I. And Lesin, S., "Experimental Studies of Liquid Metal MHD Systems for Conversion of Solar Energy", Proc. of the 7th International Conference on MHD and Electrical Power Generation, Mass. Ins. of Technology, Cambridge, MA, Vol. 1, June 1980.

3. Branover, H., El-Boher, A. and Yakhot, A., "Testing of a Complete Closed-Cycle Two-Phase Liquid-Metal MHD Power System", Proc. of the 19th Symposium of Engineering Aspects of MHD, pp. 7.7.1-7.7.7, Tullahoma, Tenn. 1981.

4. Branover, H., El-Boher, A. and Yakhot, A., "Solar Systems with Liquid Metal Magnetohydrodynamics Electrical Power Generators", Proc. of Solar World Forum, International Solar Energy Society, Brighton, England 1981.

5. Branover, H., El-Boher, A., Sukoriansky, S., Yakhot, A., Petrick, M., Pierson, E.S., and Smith, I.K., "Development of a low-Temperature Liquid-Metal MHD Small-Scale Pilot Plant", Proc. of the 21st Symposium of Engineering Aspects of MHD, pp. 7.7.1-7.7.13, Argonne, IL 1983.

6. Branover, H., El-Boher, A., Sukoriansky, S., Yakhot, A. and Smith, I.K., " A Liquid-Metal MHD System for Utilization of Low Grade Heat", 8th International Conference on MHD Electrical Power Generation", Moscow, USSR, Sept. 12-18, 1983.

7. Branover, H., El-Boher, A., Bardin, J., Lesin, S., Petrick, M., Pierson, E.S., Raveh, Z. and Sukoriansky, S. "ETGAR Liquid-Metal MHD Program at Ben-Gurion University and its Up scaling". Proc. of the 22nd Symposium on Engineering Aspects of MHD, pp. 7.6.1-7.6.10, Starkville, MI, 1984.

8. Branover, H., El-Boher, A., Sukoriansky, S.and Petrick, M., "Tests of Liquid-Metal MHD Systems", International Congress on Energy for Small and Medium-Sized Countries, May 14-17, 1984.

9. Branover, H. and El-Boher, A., "Review on Physical and Chemical Problems related to Liquid-Metal MHD Power Systems", 5th International Conference on Physical and Chemical Aspects of Hydrodynamics, Tel-Aviv, Israel, Dec.16-21, 1984.

10. Bardin, J., El-Boher, A., Lesin, S., Unger, Y., Zilberman, I. and Branover, H., " Void Fraction and Phase Velocities Ratio in Vertical Liquid-Gas Flows", 5th International Conference on Physical and Chemical Aspects of Hydrodynamics, Tel-Aviv, Israel, Dec.16-21, 1984.

11. Unger, Y., El-Boher, A., Branover, H., Lesin, S. and Sukoriansky, S., "Two-Phase Liquid-Metal-Gas Flows in Vertical Pipes", 19th Israel Conference on Mechanical Engineering, Beer-Sheva, Israel, June 1985.

12. Branover, H., El-Boher, A., Lesin, S., Unger, Y., and Sukoriansky, S., "Testing of 'Etgar 3' Liquid-Metal MHD Pilot Plant and Supporting Test Program at Ben-Gurion University", Presented at the 23rd Symposium on Engineering Aspects of Magnetohydrodynamics, Somerset, Pa, June 25-28, 1985.

13. Branover, H., El-Boher, A., and Sukoriansky, S., "Parametric Studies of Liquid Metal MHD Systems for Different Applications", Proc. of the 20th IECEC, Vol. 2, pp. 2.848-2.854, Miami Beach, Florida, 1985.

14. Branover, H., El-Boher, A., Lesin, S. and Unger, Y., "Two-Phase Flow Phenomena in Liquid Metal MHD Power Systems", Proc. of the 20th IECEC, Vol. 2, pp. 2.855-2.863, Miami Beach, Florida, 1985.

15. Blumenau, L., Branover, H., El-Boher, A., Sukoriansky, S., and Linn, G., "The Economic Viability of Liquid Metal MHD Power Conversion Combined with Distinct Heating", Proc. of

International Workshop on Fossil Fuel Fired MHD Retrofit of Existing Power Stations, Rome, Italy, CNR, January 27-28, 1986.

16. Branover, H., El-Boher, A., Lesin, S. and Unger, Y., "Study of Different MHD Systems with Liquid Metals Utilizing Solar Energy", Sede-Boqer, Israel, February 23-24, 1986.

17. Branover, H., Blumenau, L., El-Boher, A., Spero, E., Sukoriansky, S. and Talmage, G., "Studies of Liquid Metal MHD Power Plant Efficiencies and Prospective ", Proc. of International Specialist Meeting on mathematical Modeling of MHD Power Stations, Eindhoven University, Holland, April 28-29, 1986.

18. Branover, H., El-Boher, A., Lesin, S. and Petrick, M., "Tests of ER-4 and ETGAR-3 Facilities at Ben-Gurion University of the Negev", Presented at the 24th Symposium on Engineering Aspects of Magnetohydrodynamics, Butte, Montana, June 24-27, 1986.

19. Blumenau, L., Branover, H., El-Boher, A., Greenspan, E., Spero, E., Sukoriansky, S. and Talmage, G., "Liquid Metal MHD Power Conversion Systems with conventional and Nuclear Heat Sources" Proc. of the 24th Symposium on Engineering Aspects of Magnetohydrodynamics, Butte, Montana, June 24-27, 1986.

20. Branover, H., El-Boher, A., Lesin, S. and Petrick, M., "Testing of OMACON Type LMMHD Power Conversion Systems", Presented at the 24th Symposium on Engineering Aspects of Magnetohydrodynamics, Butte, Montana, June 24-27, 1986.

21. Barak, A., Blumenau, L., Branover, H., El-Boher, A., Greenspan, E., Sukoriansky, S., and Linn, G., "LMMHD Energy Conversion in High Temperature Gas Cooled Reactors", Proc. of 4th International Conference on Engineering Nuclear Energy Systems, ICENES, Madrid, Spain, July 6, 1986.

22. Unger, Y., El-Boher, A., Lesin, S., Ritz, D.J. and Branover, H., "Experimental Studies of Two-Phase Liquid Metal Gas Flows in Vertical Pipes", Proc. of 21st Intersociety Energy Conversion Engineering Conference, pp. 646-650, San-Diego, California, August 25-29, 1986.

23. Braun, J., Blumenau, L., Branover, H., El-Boher, A., Linn, G. and Sukoriansky, S., "The Economic Viability of Liquid Metal and Power Conversion Combined with Distinct Heating", Proc. of the International Workshop on Fossil Fuel Fired MHD Retrofit of Existing Thermal Power Stations, Rome, Italy, 1986.

24. Blumenau, L., Branover, H., El-Boher, A., Linn, G. Spero, E., Sukoriansky, S. and Greenspan, E., "Liquid Metal MHD Power Conversion Systems with conventional and Nuclear Heat Sources" SEAM 24, Butte, Montana, Proc. of the 24th Symposium on Engineering Aspects of Magnetohydrodynamics, pp. 33-41, 1986.

25. Blumenau, L., Branover, H., El-Boher, A., Linn, G. Spero, E., Sukoriansky, S., "Studies of Liquid Metal MHD Power Plant Efficiencies and Prospective ", Proc. of the Specialist Meeting on mathematical Modeling of MHD Power Stations, Eindhoven, pp. 117-129, 1986.

26. Branover, H., Blumenau, L., El-Boher, A., Linn, G., Sukoriansky, S., Greenspan, E., Barak, E., "LMMHD Energy Conversion in High Temperature Gas Cooled Reactors", Proc. of the 4th ICENES Conference, Madrid, Spain, 1986.

27. Unger, Y., El-Boher, A., Lesin, S. and Branover, H., "Two-Phase Liquid Metal Gas Flows in Vertical Pipes", Proc. of the 9th International Conference on MHD Power Generation, Tsukuba, Japan, Vol. II, pp. 743-751, 1986.

28. El-Boher, A., Lesin, S., Unger, Y., Branover, H. and Petrick, M., "Testing of OMACON Type Liquid Metal MHD Power Facilities", Proc. of the 9th International Conference on MHD Power Generation, Tsukuba, Japan, Vol. II, pp. 892-902, 1986.

29. Blumenau, L., Branover, H., El-Boher, A., Sukoriansky, S. Spero, E., and Greenspan, E., "Liquid Metal MHD Power Conversion Systems for Space & Unattended Aplications", Proc. of the 9th International Conference on MHD Power Generation, Tsukuba, Japan, Vol. II, pp. 920-928, 1986.

30. Barak, A., Beck, E., Greenspan, E., Szabo, J., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "Israeli Perspectives on HTGR", Proc. of the International Atomic Energy Agency Technical Committee Meeting on Gas-Cooled Reactors and Their Applications Conference, Julich, W. Germany, No. IAEA – TECDOC-436, pp. 343-368,1986.

31. Branover, H., Blumenau, L., El-Boher, A., Spero, E., Sukoriansky, S., Talmage, G. and Greenspan, E.," Liquid Metal MHD Energy Conversion in Fusion Reactors", American Nuclear Society 1986 Meeting, Reno, Nevada, 1986.

32. Blumenau, L., Branover, H., El-Boher, A., Spero, E., Sukoriansky, S., Greenspan, E., Walker, V.A., Bilton, J.R., Hoffman, N.J., "Liquid Metal MHD Power Conversion for Space Electric Systems", Proc. of the 4th Symposium on Space Nuclear Power Systems, Albuquerque, New-Mexico, January 1987, Trans. Of Conf. 870102 Institute for Space Nuclear Power Studies, pp. 361-365, 1987, and Symposium Book, February 1987.

33. Branover, H., El-Boher, A. and Spero, E., "Study of Liquid Metal MHD Rankine Type Systems Utilizing Parabolic Solar Collectors", The Jacob Blaustein Institute for Desert Research, Sede-Boqer Campus, Sede-Boqer, Israel, February 1987.

34. Branover, H., El-Boher, A. and Lesin, S., "Testing of OMACON Type MHD Power System", 21st Israel Conference on Mechanical Engineering, Technion, Haifa, Israel, June 1987.

35. Branover, H., El-Boher, A., Lesin, S. and Unger, Y., "Two-Phase Flow Phenomena in Gravitational MHD Power Systems", 21st Israel Conference on Mechanical Engineering, Technion, Haifa, Israel, June 1987.

36. Branover, H. and El-Boher, A., "Research and Development of the Liquid-Metal MagnetoHydroDynamics Systems; State of Art", 21st Israel Conference on Mechanical Engineering, Technion, Haifa, Israel, June 1987.

37. Barak, A., Greenspan, E., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "Liquid Metal MHD Energy Conversion in Nuclear Reactions", 21st Israel Conference on Mechanical Engineering, Technion, Haifa, Israel, June 1987.

38. Blumenau, L., Branover, H., El-Boher, A.and Spero, E., "Characteristics of the LMMHD Compressor and Potential Synergism with Closed Cycle Plasma MHD", Proc. of 25th

Symposium on Engineering Aspects of Magnetohydrodynamics, Bethesda, Maryland, June 1987.

39. Branover, H., El-Boher, A., Deckel, U., Spero, E, Petrick, M. and Pierson, " Development of a 15 MWe Liquid Metal MHD Power Plant in Israel", Presented at 25th Symposium Engineering Aspects of Magnetohydrodynamics, Bethesda, Maryland, June 1987.

40. El-Boher, A., Unger, Y., Lesin, S. and Branover, H., "Vertical Two-Phase Liquid Metal Gas Flows for MHD Power Conversion Systems", Proc. of the 22nd Intersociety Energy Conversion Engineering Conf. "Energy New Frontiers", Philadelphia, PA, Vol. 3 of 4, pp. 1450-1452, August 1987.

41. Greenspan, E., Barak, A., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "Liquid Metal MHD Conversion of Nuclear Energy to Electricity Revisited", 14th Symposium of the Nuclear Associations, Technion, Haifa, Israel, December 1987, Publ. In Transactions of the Nuclear Societies of Israel, Vol. 14, pp. 25-28, 1987.

42. Branover, H., Blumenau, L., El-Boher, A., Spero, E., Sukoriansky, S. and Greenspan, E., "Liquid Metal MHD Power Conversion for Space Electric Systems", Proc. of the 4th Symposium on Space Nuclear Power Systems, Albuquerque, New Mexico, 1987.

43. Greenspan, E., Barak, A., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "Liquid Metal MHD Conversion of Nuclear Energy to Electricity Revisited", The 14th Symposium of the Nuclear Associations, Technion, Haifa, Israel, December 1987, Published in the Transactions of the Nuclear Societies of Israel, Vol. 14, pp. 29-32, 1987.

44. El-Boher, A., Blumenau, L., Branover, H., Spero, E. and Sukoriansky, S., "Energy Conversion Systems Utilizing Two-Phase Flow Liquid Metal MHD Generators and Compressors", Proc. of the 22nd Intersociety Energy Conversion Engineering Conf. "Energy New Frontiers", Philadelphia, PA, Vol. 3 of 4, pp. 1459-1465, 1987.

45. El-Boher, A., Lesin, S. and Branover, H. "Liquid-Metal MHD Generators in Two-Phase Systems", IUTAM Symposium on Liquid Metal Magnetohydrodynamics, Riga. USSR, May 1988.

46. Barak, A., Greenspan, E., Blumenau, L., Branover, H., El-Boher, A., Spero, E. and Sukoriansky, S., "LMMHD Conversion of Nuclear Energy to Electricity", 2nd Int. Congress on Energy – "Energy 88", Tiberias, Israel, June 1988.

47. Branover, H., El-Boher, A., Lesin, S. and Unger, Y., "Development of "ETGAR" Liquid Metal MHD Energy Conversion Systems in Israel", 2nd Int. Congress on Energy – "Energy 88", Tiberias, Israel, June 1988.

48. Branover, H., El-Boher, A., Lesin, S. and Unger, Y., "Void Fraction Correlation in a Wide Range of Upflow Conditions", 22nd Israel on Mechanical Engineering Conference, Ben-Gurion University of the Negev, Beer-Sheva, Israel, June 1988.

49. Branover, H., El-Boher, A., Lesin, S., Spero, E., Sukoriansky, S., and Unger, Y., "Development of "Etgar" Liquid Metal MHD Energy Conversion Systems in Israel", 22nd Israel on Mechanical Engineering Conference, Ben-Gurion University of the Negev, Beer-Sheva, Israel,

June 1988.

50. El-Boher, A., Lesin, S., Unger, Y., and Branover, H., "Experimental Studies of Liquid-Metal Two-Phase Flows in Vertical Pipes", Proc. of First World Conference on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics, Dubrovnik, Yugoslavia, pp. 312-319, September 1988.

50. Branover, H., El-Boher, A., Farchi, D., Lesin, S. and Unger, Y., "Flow Pattern and Void Fraction Evolution in Medium and Large Diameter Vertical Two-Phase Upflow", 5th Miami International Symposium on Multi-Phase Transport & Particulate Phenomena, Miami, Fla., December 1988.

52. Branover, H., and El-Boher, A., "The Status of Israel's Liquid Metal MagnetoHydroDynamics Program", 25th International Liaison Group MHD Meeting, Sarajevo, Yugoslavia, March 21-22, 1989.

53. Branover, H., El-Boher, A., Greenspan, E. and Barak, A., "Promising Applications of the Liquid Metal MHD Energy Conversion Technology", Proc. 24th Intersociety Energy Conversion Engineering Conf., Washington D.C., August 1989.

54. Goldstein, J.R., Branover, H. and El-Boher, A., "Battery Storage Concept for MagnetoHydroDynamics Generator Systems", Proc. 24th Intersociety Energy Conversion Engineering Conf., Washington D.C., August 1989.

55. Branover, H., Deckel, U., El-Boher, A. and Lesin, S., "Research and Development of Single-Phase Liquid Metal MHD Generators", 27th Symposium on Engineering Aspects of Magnetohydrodynamics, Reno, Nevada, pp. 9.2-1 – 9.2-7, June 1989.

56. Branover, H., El-Boher, A., Lesin, S., Farchi, D. and Unger, Y., "Two-Phase Liquid Metal Gas Flow Characteristics in MHD Systems" 27th Symposium Engineering Aspects of Magnetohydrodynamics, Reno, Nevada, pp. 9.3-1 – 9.3-7, June 1989.

57. Branover, H. and El-Boher, A., "The Etgar Program for the Development of Liquid Metal MHD Energy Conversion Technology", Proc. 10th International Conference on MHD Electrical Power Generation, Tiruchirapalli, India, Vol. I, pp. 1.19-1.26, Dec. 1989.

58. Branover, H., El-Boher, A., Farchi, D., Lesin, S. and Unger, Y., "Experimental Studies of Mixers for Liquid-Metal MHD Energy Conversion Systems", Proc. 10th International Conference on Magnetohydrodynamics Electrical Power Generation, Tiruchirapalli, India, Vol. I., pp. 1.v.333 – v.39, Dec.1989.

59. Greenspan, E., Branover, H., El-Boher, A., "High Temperature Omacon Systems", Proceedings of the 6th Beer-Sheva International Seminar on MHD Flows and Turbulence, Jerusalem, Israel, February-March, 1990.

60. Farchi, D., El-Boher, A., Lesin, S., Unger, Y. and Branover, H., "Mixers for Vertical Two-Phase Upflow Systems", Presented at the 6th Beer-Sheva International Seminar on MHD Flows and Turbulence, Jerusalem, Israel, 1990.

61. Branover, H., El-Boher, A. and Lesin, S., "Liquid Metal Magnetohydrodynamics: A New Mode

of Power Generation", Pub. 10th International Lead Conference, Nice, France, May 29-31, 1990.

62. Lesin, S., El-Boher, A. and Branover, H., " Mercury Natural Circulation System with Internal and External Boiling of Thermodynamic Fluid", in Proceedings of the 6th Beer-Sheva International Seminar on MHD Flows and Turbulence, Jerusalem, Israel, 1990.

63. Branover, H. and El-Boher, A., "Gravitational Liquid Metal MHD System – The Etgar Program", in Proceedings of the 6th Beer-Sheva International Seminar on MHD Flows and Turbulence, Jerusalem, Israel, 1990.

64. Branover, H., El-Boher, A., Lichterov, L. and Baron, A., "Experimental Studies of Magnetohydrodynamics Turbulent Flows Simulating Geophysical Flows with Two-Dimensional Turbulence", 2nd World Conference on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics, Dubrovnik, Yugoslavia, June 23-28, 1991.

65. Branover, H., Lesin, S., El-Boher, A. and Merchuk, Y.C., "Experimental Study of Direct Contact Boiling in Superheated Fluid", 2nd World Conference on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics, Dubrovnik, Yugoslavia, June 23-28, 1991.

66. Zusman, M., El-Boher, A. and Branover, H., "End Effects in Liquid Metal MHD Channels", Proceedings of the International Conference on Energy Transfer in MHD Flows, Cadarache, France, September 30 – October 4, 1991, pp. 159-164.

67. El-Boher, A., Berezovski, L., Lesin, S. and Branover, H., "Etgar-5 and Etgar-7 – The Next Stages of Israel's Liquid Metal MHD Power Generation Program", Proceedings of the International Conference on Energy Transfer in MHD Flows, Cadarache, France, September 30 - October 4, 1991, pp. 305-310.

68. Greenspan, E., Barak, A., Baron, A., Branover, H., El-Boher, A., Cohn, A. and Lesin, S., "The "ETGAR" Energy Conversion Technology for Heat-Rate Reduction", International Symposium on Improved Technologies for Fossil Power Plant – New and Retrofit Applications, March 1-3, 1993, Washington D.C.

69. Branover, H., El-Boher, A., Gelfgat, Yu., Kopeliovich, D., Shapiro, A., "Microgravitation Casting Technology", Proceedings of the International Congress on Electromagnetic Processing of Materials, Paris La Defense, May 26-29, 1997.

70. Dardik, I., Branover, H., El-Boher, A., Gazit, D., Khachaturov, B., Krakov, V., Lesin, S., and Zilov, T. "Intensification of low energy nuclear reactions through SuperWave© excitation". 10th International Conference on Cold Fusion, ICCF-10, Cambridge, MA, USA, August 23-2003.

71. I. Dardik, T. Zilov, H. Branover, A. El-Boher, E. Greenspan, B. Khachatorov, V. Krakov, S. Lesin and M. Tsirlin, "Excess Heat in Electrolysis Experiments at Energetics Technologies," Proc. 11th Int. Conf. on Cold Fusion, Marseilles, France, 31 Oct - 4 Nov, 2004. World Scientific, p. 84.

72. I. Dardik, T. Zilov, H.Branover, A. El-Boher, E. Greenspan, B. Khachaturov, V. Krakov, S. Lesin, A. Shapiro and M. Tsirlin, " Report on Electrolysis Experiments at Energetics Technologies," Proc. of the ICCF13th, Int. Conf. on Condensed Matter Nuclear Science, Sochi, Russia, June 25- July 1, 2007. p. 325.

73. I. Dardik, T. Zilov, H. Branover, A. El-Boher, E. Greenspan, B. Khachaturov, V. Krakov, S. Lesin, A. Shapiro and M. Tsirlin, "Ultrasonically-Excited Electrolysis Experiments at Energetics Technologies," Proc. of the ICCF-14th, Washington, DC, August, 2008.

74. I. Dardik, T. Zilov, H. Branover, A. El-Boher, E. Greenspan, B. Khachaturov, V. Krakov, S. Lesin, A. Shapiro and M. Tsirlin, "On the Accuracy of Energetics Technologies Excess Heat Determination," Proceedings of the ICCF-15, Rome, Italy, October 5-9, 2009

75. V. Violante, E. Castagna, S. Lecci, F. Sarto, M. Sasovini, T.D.Makris, A. Torre, D. Knies, D. Kidwell, K. Grabowski, D Dominguez, G. Hubler, R. Duncan, A. El-Boher, O Azizi, M. McKubre, A. La Gata, "Excess of Power During Electrochemical Loading: Materials, Electrochemical Conditions and Techniques" Proc. of the ICCF-18th, Columbia, Missouri, July 21-27, 2013.

76. J. Baker, J. Gahl, P. Norgard, O. Azizi, A. El-Boher, G. Hubler, J. He, W. Isaacson, D. Pease, "Novel Calorimetry Technique For Pulsed Wires," 2014 IEEE International Power Modulator and High Voltage Conference Proceedings.

77. J. Baker, J. Gahl, P. Norgard, O. Azizi, A. El-Boher, G. Hubler, J. He, W. Isaacson, D. Pease, "Production of Nanoporous Palladium from Deuterium Loaded Wire Driven By a Low Energy, Fast Pulser" 2014 IEEE International Power Modulator and High Voltage Conference Proceedings.

78. O. Azizi, J.H. He, Dan T. Paterson, A. El-Boher, D. Pease, G.K. Hubler, "Effect of cathode pretreatment and chemical additives on H/D absorption into palladium via electrochemical permeation", Proc. of ICCF19, Padua, Italy , April 13-17, 2015, J. Condensed Matter Nuclear Science (2016), pp 1-9.

79. A. El-Boher, W. Isaacson, O. Azizi, J. He,D. Pease and graham Hubler "Final report on calorimetry-based excess heat trials using Celani treated NiCuMn (Constantan) wires" Proc. of the 19th International Conference, ICCF-19th, Padua, Italy, April 13-17, 2015, J. Condensed Matter Nuclear Science (2016), pp 68-87.

80. D. Pease , O. Azizi , J. He, A. El-Boher, S. Bok, C. Mathai , S. Gangopadhyay , Kat. Katti , Kav. Katti and G. Hubler, "Search for low-energy x-ray and particle emissions from an electrochemical cell", Proc. of ICCF 19, Padua, Italy, April 13-17, 2015, J. Condensed Matter Nuclear Science (2016), pp 257-263.

81. Sangho Bok, , Orchideh Azizi, Cherian Mathai, Keshab Gangopadhyay, Jinghao He, Arik El-Boher, Graham Hubler, Dennis Pease, Shubhra Gangopadhyay, "Fluorescence Based Temperature Sensor for Anomalous Heat from Loaded Palladium Electrodes with Deuterium or Hydrogen" , Proc. of ICCF 20, Sendai, Japan, October 2-7, 2016, J. Condensed Matter Nuclear Science (2017), pp 85-92.

82. Orchideh Azizi, Jinghao He, Arik El-Boher, Dennis Pease, Martin Di Stefano and Graham Hubler, " Effect of mercury on the kinetics and mechanism of hydrogen/deuterium loading into palladium in alkaline solution", Proc. of ICCF 20, Sendai, Japan, October 2-7, 2016, J. Condensed Matter Nuclear Science (2017), pp 289-296.

83. Arik El-Boher, Dennis Pease, Martin Di Stefano, Orchideh Azizi, Jinghao He and Graham Hubler, "Final report on SKINR replication experimental program to seek excess heat using Ni powders mixed with LiAlH4 and free Li under high temperature Hydrogen gas", Proc. of ICCF 20, Sendai, Japan, October 2-7, 2016, J. Condensed Matter Nuclear Science (2017), pp 297-303.

Letters of Recommendation will be given upon request.

Appendix C. Transcripts of Participants' Inteviews

The University of Texas at Austin
Energy Institute

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

Dennis Pease

Interview 1 of 4

Tom Grimshaw: Okay. This is Tom Grimshaw. I'm here with Dennis Pease. We're at his home in Columbia, Missouri, and the date is, I believe, January 11, 2019, and we're recording an interview about Dennis' recollections in his work for SKINR, S-K-I-N-R, Sidney Kimmel Institute for Nuclear Renaissance, from the period about 2012 to the date that it closed in December 2017.

And so, Dennis, I told you I have a few questions. We'll go on here for probably at least 30 minutes and maybe as much as an hour. We'll see how it goes. If you need to stop any time, just raise your hand and I'll hit the pause button. There's no problem with starting and starting 10 minutes later if we need to.

So, we'll start right off, Dennis. At the University of Missouri, you were on the faculty, or as a researcher, I mean, and Energetics Technologies had come to Missouri, to Columbia, Missouri, is about 2010, and then, about two years later, in 2012, Energetics Technologies was taken into the University of Missouri and was named SKINR, as I said before, well, S-K-I-N-R, Sidney Kimmel Institute for Nuclear Renaissance.

And so, my first question that happened in 2012, Dennis, we're going to avoid specific dates because we can always look those up later, but when Energetics Technologies came in under Rob Duncan in 2012, were you already working with Energetics Technologies? Or did you start working with SKINR after they had come into the university?

Dennis Pease: Well, I started working with SKINR, actually, after they were part of the university, although I became acquainted and associated with attending some meetings before that.

Tom Grimshaw: Okay. Good. And so, you started working with SKINR almost immediately after the transition and started doing experimental work and so forth?

Dennis Pease: Well, it was about five months from when they first formally formed SKINR and then they then transitioned in. The transition over was sort of gradual for a number of months and they were planning to get facilities in place to move from the business incubator over to the physics and engineering buildings. And so, that was actually, my first job was to work with the students and staff to move all the experiments from the business incubator to two separate locations, the physics building and EBW.

Tom Grimshaw: Okay. Great. That's exactly what I was expecting to hear, but we wanted to get it documented. So you said that the first thing you did was help with the move. When the experiments actually began, tell us a little about what you were doing initially in the lab, experimentally.

Dennis Pease: Well, that transition wasn't by any means an obvious one when that started, because we were running experiments during the whole time of the move, and Bill Isaacson was predominately responsible for keeping experiments going to the last minute through the completion of the move at the business incubator, while I was pretty much working to get the experiments wired up and in place in the new location. And so, it really was a very gradual process to transition into doing experiments again.

So, there was a dead time there for all the old experiments to get restarted of several months, because facilities, including the electricity for the 220 electricity we needed for many of our pieces of equipment from Israel had to get installed and work done in time for us to begin immediately. So, the first task that I had as far as, that I can clearly sort of remember, was to get the ultrasound experiment running, so that was the same set up that was used for the sort of flagship event 64 for Energetics, so they wanted to get that started first, so that's what I was predominately involved on as my first experiment. And so-

Tom Grimshaw: Okay, good. Yeah, so we'll ... we're going to probably, or I'll be talking to Arik also, and so we'll have a little bit more information on Experiment Number 64 which, as you called it, was the flagship and the one that really created a lot of excitement at Energetics Technologies earlier on. So, now Arik El-Boher was the manager, I believe, was he not, at Energetics Technologies before it was brought in to the university and then he continued in that role after it was in the university?

Dennis Pease: Yes. It changed a little bit because of busy ... When they changed to SKINR, it became more directly associated with the university, and hence, Rob Duncan, and so he initially played more a role, I'll say, in the sort of overall planning of things, but then he brought on Graham Hubler who was at the Naval Research Lab and had retired recently and so that sort of changed the role of Arik as well.

So, it became then more of a shared sort of ownership of what was going on between Graham and Arik and Rob Duncan, but Rob did not participate on a daily basis really, or at all, and so he was pretty much in the distance as far as my view of things. Right? I saw him, except we had like, gosh, I've forgotten the frequency, it was either weekly or twice monthly that we were having meetings and Rob would always be at those meetings.

Tom Grimshaw: Okay. Okay, good. And so the first experiments that were started up after, when SKINR was coming up, so to speak, were electrolytic cell, was electrolytic cell experiment with what's ... you said it was an ultrasound stimulation port.

Dennis Pease: Right.

Tom Grimshaw: And so was that the ... And you said that was the flagship from the earlier days of Energetics Technologies. What other kinds of experiments were started after that, after you got it up and running? Then they were starting to explore other techniques, other things?

Dennis Pease: Yeah. One of the things we got into, pretty earlier on, was trying to come up with a new way to do an experiment to create a new cell design that we could look at low energy x-rays if any were to be produced. And so, historically, the problem has been that the absorption of the electrolytic solution is sufficient and the vessel that it's in to keep you from being able to measure low energy x-rays, so things below maybe 50 or 100 KEB. So, what we did was to build a new cell design that had a thin membrane and put the x-ray detector as close as possible to the catho and try to look for x-rays. So that was, I'd say, the next thing that I got involved with. So-

Tom Grimshaw: Okay. So, the original experiment, the one that you started with SKINR, used excess heat for the anomalous heat effect.

Dennis Pease: Right.

Tom Grimshaw: It was in a calorimeter and you were using the heat signature.

Dennis Pease: Right. And Graham was really the person who thought that it made a lot more sense to look for x-rays because, if you look at the energy that you produce and the detectability of that energy versus what you can detect looking at x-rays, you are, I don't know, more than a million times more sensitivity looking at x-rays if those x-rays are in fact the source of the excess heat. So that was the driver behind this was the ... The belief was that

	we would be able to see very early indications of excess heat long before we could ever measure it calorimetrically. So, it-
Tom Grimshaw:	Okay. That makes sense. If it's a nuclear reaction, then there are certain non-heat related signatures that are much more diagnostic of the nuclear effect.
Dennis Pease:	Right.
Tom Grimshaw:	And so, let me ask this. When you were running the cell without the x-rays, the original cell, did you ever observe what you felt was the anomalous heat effect?
Dennis Pease:	There was one episode where we had a few percent of excess heat, in the midst of months, if not years, of having no measurable excess heat in the ultrasound system calorimeter, but we did have this one time period when, clearly, things were behaving somewhat differently, but we never got that to be large enough that we could clearly state that we felt confident that it was excess heat and not some little change in the calorimetric system. But, it did start and it did end in a period, as I recall, a few hours, and so it wasn't like a change that stuck, but it wasn't large enough. It gave us no indication that this was trying to be a replication of the 64.
Tom Grimshaw:	Yep. Okay, so when we think about 64 and the days of Energetics Technologies, the term that was used for the stimulation was super wave.
Dennis Pease:	Right.
Tom Grimshaw:	When you did the ultrasound, was that related to super wave? Was it another term for the same thing? Or was it a different stimulation?
Dennis Pease:	No, no. To explain a little bit, on the ultrasound experiment, because it was different than many other experiments that people were doing with ultrasound. We did not actually look for excess heat during the time we were doing this ultrasonic stimulation. We would use the ultrasonic stimulation for a period of time and the intent was to assist in the generation of, believed to be, surface features on the cathode, which then, after you've stopped the ultrasound stimulation and would be proceeding with, perhaps, some stimulation with super waves, that you then make use of these changed surface features of the cathode to interact with the super wave so as to produce the excess heat. But, it was fundamentally not possible to do calorimetry during the time of the ultrasound exaltation because it was like three orders of magnitude more heat output that it was producing than what you expected to get normally from just the electrolytic energy going in.
Tom Grimshaw:	Okay. Well, that makes sense. So in a sense, ultrasound was a preparation of the sample for the test for excess heat using super wave stimulation-
Dennis Pease:	Afterwards.
Tom Grimshaw:	Afterwards.
Dennis Pease:	Right.
Tom Grimshaw:	Okay. Alright. And so, yeah, did you continue to use the super wave technique with this electrolytic method for the rest of the life with SKINR?
Dennis Pease:	Well-
Tom Grimshaw:	For how much longer?

Dennis Pease: No. Actually, not. I mean, early on, I'll say, I entered into this field and it was a new thing to me and I really didn't know or understand Experiment 64 when I started working to run Experiment 64. And so, one of the things that I think I failed to appreciate there at the beginning was the difficulty of doing these kinds of experiments, in that, the least little change you make will probably make it something different as the results.

And so, there were a lot of little changes that I made or didn't implement again with starting the experiment that wasn't done originally, and if I had it to do over again, I would probably have gone to lot more trouble to try to replicate what they did, but that's all sort of, what they say, water under the bridge.

So, at any rate, we, later, when we had no success in doing what we were doing, we started to change things, and so, one of the things we changed was to change the way we were using the ultrasonic crystals so as to actually use them to produce impulses and actually do calorimetry during the time of the impulses. So rather than running the crystals in resonance and pumping in tens of watts, we were putting in, probably what would come to a few milli-watts of average power, but in terms of peak power, it would have been much, much higher than that.

And what were using was a high voltage driver for the pezos that put in pulses that was created by Peter Norgard. And so, that's what I was using, and at that time also, I started to do a different kind of data acquisition where I could record, at high speeds, the voltage and current continuously and do both real time FFTs and record, look at the recorded data later.

Tom Grimshaw: Okay.

Dennis Pease: So the intent was to try a different level of stimulation. Right? And watch it as we were stimulating it.

Tom Grimshaw: Okay. So instead of just using the ultrasound, you were, for sample preparation, you were actually using it to stimulate and were measuring using calorimetry at that time to measure excess heat during the ultrasound?

Dennis Pease: Right.

Tom Grimshaw: Okay.

Dennis Pease: And we also, for some of those experiments, which really was part of another experiment we haven't even mentioned yet, but we did at times put an antenna and used an RF spectral analyzer to look for any RF emissions that might be present as well.

Tom Grimshaw: Okay. I would like to close on the super wave of stimulation. Did that continue after you discontinued, went to the ultrasound stimulation as opposed to sample preparation? When you did that, did super wave then go by the wayside? Or did you ever ... Want me to say it again?

Dennis Pease: Well, I mean, it was being run on other experiments in the lab, both the closed cell and open cell intermittently, and that, I would have to go back and look at data to get a clearer picture of how many times we used super waves.

Tom Grimshaw: Right.

Dennis Pease: Of course, super waves is real generic term, and so there as many super waves as there are blades of grass, and we had several different experiments. We actually had different formulas that we might have been using to generate the super waves.

Tom Grimshaw: Okay.

Dennis Pease: And it might be worth mentioning as well that there were different methods used in the generation of the super waves in terms of how they were generated in lab view and then used, and that might have some changes that are noticeable as well, because it changed the rate at which the super waves can change depending upon the method that was used to generate them.

Tom Grimshaw: Okay, alright. So, super waves continue to be used as they had been in that first experiment and then it started to branch out to other kinds of experiments as well then. If I can-

Dennis Pease: Yeah, yeah. But, actually, I do not know whether super waves started with the ultrasound or not. I don't think so. I think they actually started, probably, in the open cell experiments, then were ported to the closed cell, and then were ported to the ultrasound.

Tom Grimshaw: Okay. Well, that's-

Dennis Pease: I believe that's likely how that happened. So, but it-

Tom Grimshaw: Interesting. Well, eventually, we're going to want to put together a timeline of things and we got interviews as well as the record.

Dennis Pease: Yeah, I'm sure Arik will likely recall how that happened too, so when you talk to him.

Tom Grimshaw: Okay. Alright. So, let's see. Well, I've already asked you some about the experimental procedures. Everything you've talked about so far was electrolytic cell.

Dennis Pease: Right.

Tom Grimshaw: And variations on the ... and it was deuterium and palladium were the prime ingredients as opposed to nickel and water, say.

Dennis Pease: Right, yeah. And I would say probably 90% of our experiments that we did were with palladium and deuterium.

Tom Grimshaw: I should have said deuterium oxide. Also, there'd be water. Yeah.

Dennis Pease: Yes.

Tom Grimshaw: To get the terminology correct. Okay. So 90%, and then later in the life of SKINR, you did some other kinds of experiments like gas loading and gas discharge, or glow discharge, I believe.

Dennis Pease: Well, we never really. There was a very short interval where we were doing a little bit with glow discharge with some students, but that really, that experiment was hardly run for any of the time that we were there. We just didn't have the staff to support running that experiment. It was complex enough it really didn't seem to be very amenable to turning it over to the students. And, I think, this is again one of those areas, if I had it to do over again, I probably would have spent more time and attention towards, but at the time, I felt occupied just trying to wrap my heads around these other things.

So, there was an experiment that I haven't mentioned that I think should be stated, because it constituted a substantial portion of my time, and that was, there was a second set of cells which were, the cell type was in the vein of what was the NRL cell, which was in a Peak container, so that's a special kind of corrosion resistant plastic, and so that experiment involved the insertion of antennas into the cell to do direct RF irradiation of the cathode, and also to look, then, with a second antenna at what might be coming out.

And the final thing in that was to have a pulsed magnetic field surrounding the peak cell and also that, then, was controllable, the pulsar, in concert with the RF exposure that was

	going in. So, we actually were putting in both voltage, RF and magnetic field, which is a large parameter space to do.
Tom Grimshaw:	Yeah, yeah.
Dennis Pease:	And so, we would scan, under computer control, these ... each of these methods of, what do I tell you, exposure, I guess. So, that was all sort of like automated and would run for days and collecting data, looking at the recording, the RF output, the RF input, the pulses that we were putting in with the electromagnet.
Tom Grimshaw:	Okay. So that work, then, began quite some time after the start of SKINR? Or-
Dennis Pease:	It was probably, yeah, at least three years after the start of SKINR.
Tom Grimshaw:	Okay.
Dennis Pease:	But, that sort of use, or most of my time, I'll say one foolish start at that, because it was something that had never been done before, so every facet of that, we took quite a long time. Peter Norgard designed that second pulsar that ran the electromagnet and to make it work reliably for thousands of pulses proved to be a considerable effort, but eventually, he did get it operating and we ran 20, 30,000 pulses.
Tom Grimshaw:	Okay. So let me jump in and ask this. That was over quite a long period of time, like 18 months, couple years that were you doing?
Dennis Pease:	I'd say closer to three years that we were doing some of those.
Tom Grimshaw:	Was there any calorimetry involved in this experiment?
Dennis Pease:	Yes, absolutely.
Tom Grimshaw:	Okay.
Dennis Pease:	There were in a thermoelectric based calorimeter system.
Tom Grimshaw:	Okay.
Dennis Pease:	So, it was in a big metal can surrounded by air, and then it had a water reservoir that the base was, the thermoelectric was attached to, and so it was, essentially, isothermal on the top and that metal can had water circulating at a regulated temperature through it, and so you would look at the differential output of the thermoelectric cell, as well as, we had thermocouples or RTDs measuring the temperature at various points in that system.
Tom Grimshaw:	Okay. So this was, in a sense then, during your time in SKINR, this was probably the experiment that you were the most involved in and most engaged with as far as the design and operation and data collection and all this?
Dennis Pease:	Yeah, yeah. I mean, ongoing, I had some involvement really in all of the experiments. I tell you, the least involvement I had was in the open cell experiments because that was pretty much kept going and run by Orchida Azizi.
Tom Grimshaw:	Okay. Well, that's a good segway for another question I wanted to ask. According to the records I've looked at, Rob Duncan continued as director until he accepted another position at Texas Tech University and that happened and he left the University of Missouri, I think, at the end of 2013 and Graham Hubler came in or-
Dennis Pease:	Well, he was already in and had been for ... Yes.
Tom Grimshaw:	Oh, so there was a what?

Dennis Pease:	Yeah, I mean, he was responsible for hiring Graham, but Graham was there and involved with this long before Rob left.
Tom Grimshaw:	Okay. So he was a member of the team?
Dennis Pease:	Right.
Tom Grimshaw:	And then what? Do you know?
Dennis Pease:	I don't think he ... Rob, I think, wanted to ... He always had it, I think, in the back of his mind, he knew of Graham's association with experiments in the anomalous heat effect sort of world, and I think he, from the very beginning, had in mind to leverage off of that in order to increase the visibility and viability and success of SKINR. So, he brought him on as early as possibly that he could get him, I think, is how I would say it.
Tom Grimshaw:	But after SKINR started, not prior with Energetics Technologist?
Dennis Pease:	Right, after SKINR started.
Tom Grimshaw:	Okay. Very interesting. So then, Duncan got a position and so he turned that reigns over to Graham who remained in Washington D.C. and Arik was kind of the local manager, would you say?
Dennis Pease:	Well, I would say it was more of shared responsibility between them and Graham would come here. We would have weekly, very reliable, weekly meetings for most of the history of SKINR. In fact, I would say, we had more reliability in those meetings and more frequent meetings after Rob Duncan left because it became sort of easier to schedule. Right? Because we were all around, and so we would then have, every week, a progress sort of status meeting that would last a couple hours and that was always, with few exceptions, attended by Graham as well by Skype.
Tom Grimshaw:	Okay.
Dennis Pease:	In a call back, but he said he would come here maybe once a month and be around for a week, and then the other three weeks, every week, he would be involved in the progress sort of meeting and planning meeting for the next, what we were going to do the next week.
Tom Grimshaw:	Was there any record kept during those meetings?
Dennis Pease:	There's notes. There's everybody's notes. I mean, I have a page of them. There is no-
Tom Grimshaw:	Nobody had the responsibility to capture the notes and distribute them?
Dennis Pease:	No. So, everybody was taking their own notes, and so, I mean, I have lots of little scribbled yellow pieces of paper that I can sometimes read myself that I keep hoping would be able to get that into some format that was like readable and searchable online. That would be nice, but-
Tom Grimshaw:	Yeah, It would be nice. Okay, so then, I think I'm going to ... We're at, now, 27 minutes. I think, usually, about 30 minutes is a good place to stop. Kind of take stock and so this is Tom Grimshaw here with Dennis Pease on January 11th, talking about the Sidney Kimmel Institute for Nuclear Renaissance.
Dennis Pease:	And if you think it's bad to say it, try spelling it.
Tom Grimshaw:	Alright. We'll come back in a few minutes.

Dennis Pease

Interview 2 of 4

Tom: Okay, Tom Grimshaw again. This is the second session of the interview with Dennis Pease about his days and his work at the Sidney Kimmel Institute for Nuclear Renaissance. Dennis, I think the first session went very well. I'd like to start this one with some question about staff. We talked about the directors ... started with Rob Duncan when SKINR was formed. Then it was handed over to ... well, Graham Hubler was brought on staff. Then the leadership was handed over to him, and then he shared it with Arik El-Boher. Graham remained in Washington D.C. Arik was the local manager. So I'd like to ask some questions about other staff. Who else did you work with while you were working at SKINR, and what were their responsibilities, generally? What did they do?

Dennis: I'll start with myself, and I guess I'll define my responsibilities a little better than what we have. I pretty much talked my way into the job. I was working three-quarter time instead of full-time, and that was a consequence of I had some ideas of trying to do work on the side that was started before I ever became part of the University of Missouri. I was trying to keep some time free there, as well as I had family obligations that were obviously occupying a fair amount of my time. Last but not least-

Tom: Let me just jump in there. That was when your wife started to become ill? Was that-

Dennis: Well, actually before that. More of what it was ... I was dealing with my parents.

Tom: Oh, I see. Okay.

Dennis: My dad was, at that time, in the nursing home and moved to a veteran's home. Any my mom then developed lymphoma. So I had a lot of things going on. My mom had five rental properties, so it was a busy time there, so.

Tom: Okay.

Dennis: And my son had a stroke. So in between all of these things, it was pretty clear that it was a major thing to keep things going, so. But I came on really for primarily ... I'll tell you. I had this wealth of experimental science experience in every sort of area of physics that you can probably think of, which was unusual for somebody with a PhD in physics, to have this sort of broad experience base. But I was always very much an experimentalist, and that's why it came about to be like that.

Dennis: So, it was sort of in leveraging off of that, that I talked my way into ... I really needed a job. It seemed a fascinating topic for me, because as a hot fusion person originally, a plasma spectroscopist at the University of Texas at Austin, I had an interest in the cold fusion thing for many, many years but had spent my time working in much different areas throughout my career. So this was a way to get back to my roots of fusion. So I made every deal I could to get myself included in this group that I had this interest in.

Dennis: I came on sort of as more of a ... almost a technician than as a principal investigator. That put me wearing many hats. But that's how it all got started, with my experience in the past of dealing with the moving stuff was the initial driver. I'm sure I paid for myself in that single thing because we were able to move for a tiny fraction of what money originally they had figured it was gonna cost to move. And so, I think that worked out real well, overall, for there. So that was my role, was this difficult thing ... well, I should mention ... I think Arik always had in mind that one of the main things to do was to [inaudible 00:04:31] over the [Lab-U 00:04:31] programs because I had done some Lab-U programming. Unfortunately, I certainly overestimated my ability to do Lab-U. When I encountered the Lab-U sophistication that Boris ... whose last name I don't remember right off ...

but the software person at [Energetix 00:04:52] was a very sophisticated Lab-U programmer. So I fell err to this Lab-U code that was just hundreds of levels of code.

Tom: Excuse me for interrupting, but this was the [SuperWave 00:05:13] code that you're primarily talking about?

Dennis: Yeah, it was both the data acquisition code and the SuperWave stimulation code. So the fundamental data that was taken by ... Well, essentially all of the data collection that was done by [00:05:33] and SKINR used this code or variance of this code. And it took data the following way: voltage and current were measured at 50 kilohertz, and then each one ... whatever that is ... 20 microsecond interval, the voltage measure during that interval was multiplied times the current measured in that interval, and then that number was stored in a register, it was added up and averaged for a period of two seconds, and then recorded; simultaneous with that voltage and current, there were temperature sensors, and those were being measured and recorded every two seconds.

Dennis: That was the fundamental sets of data that were created during the whole history.

Tom: Okay.

Dennis: The real exception to that came when I started to do other stuff.

Tom: Okay. Tom Grimshaw here with Dennis Pease. We had a brief stop in our course of interview. Dennis, I think let's not get quite so much in detail on the data taking. Let's stay at a higher level, please, on your responsibilities and how they evolved over time. You started as basically the mover of the equipment up to the university from the-

Dennis: And setting all that equipment to running again.

Tom: Right. And then you were brought in to help run with Lab-U. Take it from there.

Dennis: Right. So anyway, the Lab-U ... As we progressed in doing these other experiments, we needed to take lots of different kinds of data. And at that point, I started to create alternate programs in Lab-U to acquire fast data. That became an increasing amount of my time and responsibility was involved with that task of getting both for the x-rays ... to take the x-ray data, to do the Rf stimulation in an automated way, and the logging of the spectrum analyzer. So that was a different world because of the speed of the data acquisition that I was taking. Instead of recording data every two seconds, I was recording data at fifty thousand or twenty-five thousand ... became a popular number ... times a second for the channels.

Tom: Okay. So you continued with this Lab-U work. What came next?

Dennis: Right. Well, you had asked about other people, so I will now switch to some of that if you want me to continue there.

Tom: Well, no let's continue the train of the evolution of your involvement because a little while ago you talked about the work that you were doing with the magnetic pulse and so forth. Is there anything more to say between the time you were doing the Lab-U and when that started, or-

Dennis: Well, I mean, all of this was occurring ... There was no transition between them, really. All of this stuff was going on simultaneously. So the ultrasound experiment was running basically every day the whole time that I was there.

Tom: I'm sorry. The first ultrasound experiment that you described?

Dennis: Well, the ultrasound experiment evolved over time.

Tom: Okay.

Dennis: I left out a portion of the last evolution of that experiment was to essentially do away with the enclosure that had the ultrasound transducers in it, and to put it in a better designed, faster calorimeter. But we never got to the point of doing our intention, which was to then put the ultrasound stimulation back in through much smaller crystals.

Tom: Okay. And they never did that one.

Dennis: We were going to use a more direct stimulation insitu, but we didn't do that for lack of funding and time.

Tom: Okay. All right, let's pick up the thread, then.

Dennis: Okay. Well, I don't know if this is maybe the time to tell you ... because there's one thing that I did, a series of experiments, that we've not mentioned at all, and that was we went through a phase that we never really got finished in. But it started with ... I guess, discovery, I'll say, by Graham Hubler of a paper involving superconductivity changes in hydrogen and deuterium-loaded palladium, that under certain conditions of heat treatments, that you could increase the temperature at which superconductivity would occur in hydrogen or deuterium-loaded palladium from a few degrees kelvin to around sixty degrees kelvin. And so, we attempted to replicate that, which involved doing high-pressure gas loading. So one of the things that we did there was to instrument with faster speeds the resistance measurement as we were doing the gas loading. So I spent ... I don't know ... probably six months or more involved with setting that up because what we had to do was to do first the loading, then we had to heat it and cool it rapidly, all while maintaining it at a relatively high pressure ... as high as a hundred bar. I don't actually think we ever really ran it there. I should say more like 75, probably, bar that we were operating there.

Dennis: So anyway, I'll skip to the end and say we actually were not able to verify that effect, but we never really got it set up to do the complete experiment insitu at the university. We were instead preparing the samples and then shipping them to the naval research lab and having them make the measurements there. The problem with that was the shipping time and trying to maintain the samples at a cold temperature during that shipping. And so, that impacted our experimental results.

Tom: Now on that experiment, you were trying to duplicate what Graham had seen in this ...

Dennis: Well, it was a paper he saw.

Tom: A paper? Was there also an L-E-N-R, a LENR connection with that work?

Dennis: Well, no, I don't believe at that point. This work was originally done in way back like the 60s or something, but then there was a more recent ... 80s or something ... dissertation that was done by someone. And I don't know that either of those people were making a connection between this result and L-E-N-R, but certainly Graham was thinking along those lines.

Tom: Okay. So there was an intent for the experiment to evolve in a way to where you can look for LENR phenomena?

Dennis: Right. I mean, we were hoping to look for signs of excess heat. Well, we did, really. It's just that we were doing this ... We had temperature sensors within the tube and on the outside of the tube. And so, we were looking for signs of differential heating that would appear. So not really quantitative calorimetry, but qualitative calorimetry. The hope was that we would see some evidence that as we did these cycles, after we had done them, in a more quiescent phase, that we might see something that would be indicative of excess heat.

Tom: And you did not see that.

Dennis: Well, no. We certainly didn't see any gross indications of anything happening, but we did see, as always, a lot of unusual phenomena in places we didn't expect to see it. That predominately went back to the changes in the resistance that occurred during the gas loading that were not monotonic and involved transitions more rapidly than we were expecting.

Tom: Okay. While I'm on that subject, back to the ultrasound cell and the SuperWave cell ... the earlier one that we were talking about. I think you already answered this question, but I'll ask it again. Do you believe you saw the LENR phenomenon in that set of experiments?

Dennis: We certainly saw for periods of times ... I mentioned this fairly short interval where we had some fairly dramatic changes in both the fluctuations in the voltage and current that were occurring, as well as some indications of excess heat. But we saw for very long periods very small levels of excess heat that would continue along and then appear ... disappear. We never saw anything that stood out high enough like the 64 thing where you could just say, "Absolutely, there was excess heat." There's no accounting for it any other way.

Dennis: Certainly, we saw a lot of instances where for substantial periods of time we were getting more heat out than we were putting in, and there was no clear explanation for that. It's just that the level of that and the time constant of our calorimeter system was so long, it was really hard to be certain that you weren't seeing some sort of delayed response from some earlier fluctuation that was then manifesting itself as an appearance of a low-level, excess heat.

Tom: Were those observations ever written up in a paper, or ... ?

Dennis: No. I mean, there was maybe some ... Well, I don't think so. We oftentimes would talk about it and allude to it, but as far as actually being written up in a paper, I don't think so because it became just too difficult to understand. How do you document it? I mean, it's-

Tom: Excuse me. Just to be sure I keep things straight in my own mind, this was the original cell with the ultrasound and the SuperWave?

Dennis: Yes, but it was also true later. Even with our new improved calorimeter we saw that, the similar behavior. So a completely different calorimeter, and we still saw these indications that for certain configurations ... and in particular I'm referring to the changes in the electrolytic solution with the addition of nanoparticles ... that we saw clear indications in all of the vessels that we put it in. But that is still, I would say, an arguable and contested thing.

Tom: Yeah, okay. And the work you did with the gas loading, you never did see any indication there of excess ... of the LENR effect then? Because you never really got to that point, I guess.

Dennis: Right. Had there been some really large effect, I certainly would have seen it by the differential temperature measurement, but there was never any clear indication of anything there other than what I said, of this obviously anomalous behavior of resistance as a function of time.

Tom: Right. Okay. And then, going back to the work that you were involved in the last three years, did you see the evidence that you thought that was LENR at work?

Dennis: Well, the clearest thing that I ever saw was in the modified ultrasound calorimeter, where I saw fluctuations in voltage and current that were very similar to what occurred in 64.

Tom: Okay, I don't wanna get confused.

Dennis: But there was no heat associated with that.

Tom: Now I got confused. That set of experiments where you observed those, was that the work that you did later?

Dennis: Yes.

Tom: Okay.

Dennis: Right. That was work done in the last few months that we were there. And it was not documented because it never was replicated to be sure that it wasn't some odd thing that happened, so.

Tom: Okay. All right. I think we're gonna take another quick break here. Tom Grimshaw here with Dennis Pease ... January 11. We're at his home. We're gonna take a quick break.

Dennis Pease

Interview 3 of 4

Tom Grimshaw: Tom Grimshaw again here, with Dennis Pease 00:00:04. This is session number 3, I believe, and this session ... we started last time, didn't quite get there. We're going to talk about staff at Skinner. And we've talked about, of course, Duncan, Ari [Galmore 00:00:20], Graham [Hubler 00:00:26], Hoobler or Hubler? Either way, huh? And we've talked about yourself. Another name that I recall being pretty prominent, is Bill Isaacson. Tell me about him. He come from Energetics, Technologies?

Dennis Pease: No, well, he was a worker in the United States for Energetics. He was hired shortly after they came to Missouri. He worked in the Navy. I think he almost like retired. I think he worked 20 years in the Navy, and then he came back to the University of Missouri, got his masters degree in physics, and it was from there that I think is how he got acquainted with the Skinner group people. And he was on staff before I was ever cognizant of them, so while they were still at the business incubator, he started working shortly after they moved there. His role was essentially one of what I'm saying I sort of was hired on as a super-technician I'll say, because he had a masters degree in physics. But he was responsible for all the nuts and bolts of putting experiments together, as well as running some experiments and doing all of the ordering of stuff. He was the lab manager, had to deal with the hazardous materials sheets and stuff like that. He did all of the stuff that nobody wanted to do, he did. He was ... really enjoyed the work. I know that's true, and he was a very pleasant person to work with and around.

Unfortunately, after a couple of years, he suddenly died, and at that point that left us trying to live without him to get all this other stuff done that he used to do for us. That involved me then taking up some of that slack, and some of it was taken up by everybody that was there, the other staff, people were made more responsible for ordering their own stuff. We looked for a long, long time to try to find a replacement for him. He was tough shoes to fill, because of, again, all of the skillsets that he had. Eventually, we found a young guy that had gotten a degree from University of Missouri at Rolla, as well as had other educational ... was done up in Kirksville, which is where his family was. He started to work for us in, sort of, the capacity of Bill, but he had a lot of room to try to grow to fill the shoes of Bill. It was a tough order, as someone fresh from school.

Tom Grimshaw: And you told me his name was [DiStelfano 00:03:43]?

Dennis Pease: Yeah. Martine DiStefano I think that's the way it was pronounced. Unfortunately, about the time we got him really starting to become productive, he decided to go back to graduate school at the University of Missouri-Rolla, well now it's Missouri School of Science and Technology. I graduated there with UMR, so I have never got that out of my mind, to say that correctly but Missouri School Science and Technology is what it's called now. Where he's at, as far as I know, he's still there now. At that point, well, then it reverted back to us struggling to do our own purchasing and those sorts of things again.

Bill, when I first met him, he was busy working on the Chilani replication. He was just getting that started, put together and running. And he ran that during the transition time, as we were moving stuff and setting up new experiments. That was the heyday for that experiment, and as the experiment continued, he kept running that for probably another year and half or so, two, after that.

Tom Grimshaw: I'm familiar with that work because I made a visit to Skinner at that time because I was working with National Instruments, and talking to various people who were attempting to replicate Chillaney's demonstration that he had done at NI Week. Skinner was one of five

	or six entities that Stefano, Cassessie and LotharmWinsel and Ryan Glass were all supporting that offer for NI, had a very nice tour of the lab and saw the work being done during that time frame.
Dennis Pease:	Yeah. The apparatus was almost a comedy to thing to ... It was really a frustratingly delicate thing for Bill to work on that apparatus. I remember watching him struggling with reassembling it and at times. But ARC will be able to give a much better rendition of what happened in that experiment.
Tom Grimshaw:	Right. Yeah, and there are nice reports on it too. So another name we're going to stay with staff right was Mark Cyrlm, did you come with from LJ?
Dennis Pease:	Yeah, Mark was one of the few people like ARC that came and stayed for a significant time from Energetics. There were several people, other people. I want to say, I believe there were three other people, that initially, moved to Missouri, but they didn't stay for the time period, long enough to transition over to Skinner. But Mark, did and he was around for at least a couple years after they became Skinner. That meant he was here for probably four years or something in Missouri. And so Mark was a materials physicist and he was responsible pretty much for all of the microphotographs that were done as well as some of the ESCA analysis, I believe, that was done here at the University with universities equipment. He learned early on how to run that stuff and also ...
Tom Grimshaw:	ESCA means what?
Dennis Pease:	I'll have to ...
Tom Grimshaw:	That's all right.
Dennis Pease:	... Look it up to see, but basically, it's using an electron beam to knock off tiny bits of material and do a mass analysis, Mass Spec analysis.
Tom Grimshaw:	Okay, I didn't mean to get a diversion there. Was Mark running any experiments himself or was he just supporting other experiments?
Dennis Pease:	I believe he was just supporting other experiments. I don't recall him having any sort of experiment that he was running directly, but he was interacting a lot with Okada or [inaudible 00:08:02], who was supplying him both before and after cathode material. And so I guess now that I've said her name I might as well continue there. Okada is a electrochemist. She was started to work there ... I don't know how much before I did, but my understanding is she was hired after Bill. I was but not a long time after.
Tom Grimshaw:	At Energetic?
Dennis Pease:	At Energetics. And she was working there when I walked in the door. And she was responsible for running the open cell experiments was her primary thing, from beginning to end for the time she was there. She was also involved with all of the experiments. I'll say when it came to preparing the electrolytic solution, and materials the cathode materials for use the foils and Palladium foils for use in the experiment. She was involved across all of the experiments. And she prepared all of the experiments I worked on. She's the person that poured the solutions in, and mounted the foils, and did that, right, the aspect of the experiments, and then I would take over then from there running it, applying the currents and measuring the data and all of that.

	But that the open cells were her primary focus. And she kept all ... Well, I guess we had one, two, three, four, six of those running nearly continuously the whole time period that we were there.
Tom Grimshaw:	And they were different from the ones that you were running where you were using the Super Wave and ultrasound.
Dennis Pease:	No. No, no. That was part of the ones that she was running those. I'm saying with the Super Wave. The ultrasound, that was in the different room from open cells, and that was separate. And the thermoelectric experiments, where we were using thermoelectrics for the calorimetry. There were two separate units there, one we call TE1 and TE2. For most of the time, I was running TE1, and she was running TE2.
Tom Grimshaw:	Was TE1 the ultrasound that you described?
Dennis Pease:	No, no, no. No. The ultrasound was conventional water calorimetry.
Tom Grimshaw:	Okay. We have six cells, open cells. We had two Thermal electrics, and then we had the altrasounds ...
Dennis Pease:	Right, which changed over time, morphed into a different experiment with a different calorimeter.
Tom Grimshaw:	And what was the ...
Dennis Pease:	And then we had a close one ... Well, we had actually two close cells, but most of the time, we were only running one of the closed cells, but we did have to close cells running in two different separate incubators, as we call them for the temperature control Chambers. And for a while ... I don't know, maybe two of the six years, we were running two close cells.
Tom Grimshaw:	Two close cells plus the ultrasound that you ...
Dennis Pease:	Right, plus the ultrasound.
Tom Grimshaw:	Plus the thermalelectrics.
Dennis Pease:	Plus the thermal electrics plus the six open cells, and then there was several other experiments that were being run concurrently.
Tom Grimshaw:	Yeah, [inaudible 00:11:28] for example that Gilani experiment.
Dennis Pease:	Right. Yes.
Tom Grimshaw:	Okay. Well, that really helps to clarify things.
Dennis Pease:	And the [inaudible 00:11:33] replication experiment as well, that's another one. And then at this point, I'll transition over to yet another staff member we haven't mentioned, and that's Jing Hoa Hi. Jing Hoa Hi was a former employee of Graham Hubler at the naval research lab working in linear work, and he came to the university to work on a variety of sort of new experiments, which he pretty much put together from starting from scratch. So there was ... I'm not sure I know exactly the first one to say that he was working on, but certainly one of the things he was involved with as well as working with some students on this project was to create a experiment where we were stretching a cathode, and looking at the changes in resistance as the strain was put on it, cyclical strain was put on the cathode.
	That was called the Gorsky effect, I believe, is that. That's the experiment you would look for to learn more about that. And I was not directly involved with that. Peter Door

Guard, who was a ... Not a sort of official member of Skinner staff, but worked a lot of hours on Skinner related projects. He had helped with that experiment to make the instrumentation, to make the mechanical structure that did the cyclical stretching of the cathode. And it used piezoelectric strain [inaudible 00:13:26] for making measurements of that simultaneous with a motor-driven sort of thing to do the cyclical expansion, pulling on the cathode.

Tom Grimshaw: Did he work on others?

Dennis Pease: Well, I mentioned some of the other projects, right? He made these power supplies, the high voltage power supplies for the electromagnet on the post-experiment.

Tom Grimshaw: That you did that.

Dennis Pease: That I did, and he also did the piezoelectric driver for producing short pulses on the piezoelectric crystals on the ultrasound being used in this sort of alternate formulation instead of using the continuous 20 resonant, 20 some kilohertz excitation. It instead was applying very short pulses. That was part of his domain too. And I believe he may have been involved with some of the design work on the for the thin film window that we used on the X-ray experiment. It seems like there was some something he had to do with that experiment as well. So I don't remember for certain on that. But again, I'll defer to ARC his memory of other things because he I think had a better knowledge of what Peter was working on at any given time than I did. So the things that I interact with Peter on a lot was those two power supplies that were used. So that was the principal point of contact for me with him.

Tom Grimshaw: Other stuff you can think of? If not, we'll go on to Mark Prellis others on the faculty that were associated.

Dennis Pease: No, I think that's all I'm thinking of at the moment.

Tom Grimshaw: Okay. Well if you think ...

Dennis Pease: So Mark Prellis, he was a professor in the nuclear engineering department, and he had an experiment that involved doing hydrogen ... I think it was hydrogen loading. Oh, oh. I'm Blank. I may have to go back and to do this. But anyway, what he was looking ... He got results in an experiment 20 some years earlier that showed anomalous Neutron production in, I believe it was basically titanium ... I think it was hydrogen loaded titanium, not deuterium. And had found bursts of neutrons being emitted by that under a temperature change. So he wanted to replicate that experiment and we supported that at Skinner.

Tom Grimshaw: I believe that's called fractal Fusion, where there are cracks.

Dennis Pease: Well, I think his output were a lot higher than what you're saying ... I don't think this was classical fractal fusion because of the output was so much larger. But anyway, that started our connection with Mark Prellis, because we saw the results that he did. He was always wanted to go back and revisit those results because the experiment, in his mind, had been terminated in a very abrupt fashion. He got these early promising results, and it ended up his experimental equipment. There was some expansion that was needed into a lab space, and his experiment was thrown away without his knowledge, essentially.

And so he was understandably very upset by that especially, with the results he has been getting, there were so unusual. And so he had always wanted to replicate that, and so like all the people that apparently had done that have been gone by now. And so he took that opportunity, and he took it to get it leveraged into a new running of the experiment.

Tom Grimshaw:	Would you say that experiment was related to Eleonore or not?
Dennis Pease:	Well, I don't really know the answer to that at all. I think certainly, he believed that it was related.
Tom Grimshaw:	Yeah. Well, okay.
Dennis Pease:	I think so, but looking over those sort of broad view of the thing, it's clear that it was anomalous relative to the usual Eleonore stuff because, well, this was full-blown neutrons. So the question is though, I think the energy of the neutrons, it becomes the critical thing.
Tom Grimshaw:	What would you ...
Dennis Pease:	I think the energy of the neutrons that he was seeing were not fusion neutrons that they were lower energy.
Tom Grimshaw:	What was the outcome do you recall of his extreme?
Dennis Pease:	Well, it was ...
Tom Grimshaw:	Was it successful in ...
Dennis Pease:	I wouldn't say. Not really because it was not repeatable. He had some results. They look really exciting, and then he had some issues with the detector because he was trying to use a new kind of diamond detector at the time. And they had to [inaudible 00:19:00] with it. And so in the end, I think it was left in uncertainty, whether what he had seen was real or was it detector issues? But certainly, the magnitude of neutrons, which he was measuring was large enough. It wasn't a subtle thing, right? It was either a definite positive indication that neutrons were coming out, or alternatively, there was an issue with the ... A sporadic issue with the detector, But at least it wasn't like this borderline little signal thing. It was a big signal compared to background, thousands, millions of times background rates that he was seeing as count rates of neutrons. It's just it was never verified with multiple detectors of different types of that admission.
Tom Grimshaw:	Other faculty members.
Dennis Pease:	Well, was Sugar Gangopadhyay appears on many papers because she was the faculty member that basically gave up part of her lab space in the EBW building, now called NACA Hall, and that put her right next door in an office two ARCS and Orchid's office and sandwiched between and there and the lab. And so she provided as a lot of support, I'll say, at the political level, at the University, at the direct level of supplying the resources of space that we needed to move into, and participated to times on many meetings of reviews and stuff and even contributed some of her students at times to help with some of our projects and piecemeal thing. Her name appears on a lot of different papers from there.
Tom Grimshaw:	Did she do any investigations directly related to Leonore, and what were the results?
Dennis Pease:	I don't believe she herself did. The closest thing was the student I'd mentioned when we weren't recording, I think, that she had that worked on a novel kind of fluorescence measurement to measure localized temperatures from a cathode in air as it was deloading. And the thought was here that there might be some indications because of the very high temperatures that were found of Leonore occurring in a cathode after it's been extracted from the solution. So because we were seeing temperatures that were indicative in very localized areas of hundreds of degrees centigrade that were occurring.

Tom Grimshaw: Okay. What was his name? Do you recall that? I thought I just check it, it's fine we'll find that.

Dennis Pease: I'll have to look at her fall plan. No, I'm drawing blanks at the moment on that name.

Tom Grimshaw: It's all right. Other faculty members come to mind that you part of the scenes?

Dennis Pease: I'm drawing the blank on the name of the person that was involved in our nanoparticles research. But there were two people, him and his wife were both professors at the University. And so they were involved for a couple years with creating nanoparticles, [inaudible 00:22:34] nanoparticles predominately, although we also did some stuff with gold nanoparticles in solutions as a means to modify the electrolytic solutions that might produce more excess heat by providing a different kind of surface on the cathode. So the idea of fundamentally, I think was that we would dump nanoparticles into solution, they would be driven to the cathode, deposit on the cathode, create a surface there that might promote the conditions needed to have Leonore reactions.

Tom Grimshaw: So nuclear active environment.

Dennis Pease: Yeah, that would be an edge storms parlance, I guess, to say it that way. So that being the case, that representative large investment of time and open-cell resources for the investigation of different nanoparticles solutions to look for signs of ecstasy.

Tom Grimshaw: Did you see them?

Dennis Pease: And the early on and Orchidif is really the person to tell the story on that but Art as well. There was clear indications that nanoparticles solutions produced more heat, or maybe a more accurate statement is, it clearly changed your calorie metric measurements. As time went on, it became clear that there was some influence in the thermal conductivity within the cell that influenced the temperature distribution within the calorimeters. So in other words that the tops and bottoms of the cells were different in temperature with nanoparticles than they would other be. That distribution in temperatures led to some early maybe misinterpretation of the results that made it appear that they were producing more heat.

Once that was sort of understood and baseline cases were run using water instead of deuterium solutions. It still always emerged that these nanoparticles solutions seem to be producing excess heat. And we had a clear run, a very obvious and noteworthy excess heat for months only to find that then with a new batch of nanoparticles, after we'd had several batches, the next batch of nanoparticles it seemed to be gone.

Tom Grimshaw: So typical of [] weren't research?

Dennis Pease: Yeah, and so we basically didn't get it back but...

Tom Grimshaw: Other faculty members, were there any?

Dennis Pease: Oh, well, I will not bother to say the name for sure, but we did have another experiment at the very beginning of when I started there that was planned. This was to be done in conjunction with Myrrh, the University Research Reactor. I'm making use of facilities they had theirs for Neutron scattering. But unfortunately, that experiment never came to be, and it got to be a real sore point between the ARC and Graham and the person.

Tom Grimshaw: I see, okay. I better go with that.

Dennis Pease: Yeah, it just did not end well, it never really happened but it was a planned experiment and I'm sure Graham still wants to do that experiment. And I'm glad I didn't mention any of the collaboration with the experiment at CERN, and I don't know enough about that to talk of intelligibly about that, but I want to say something about it so you don't forget it, right because that is a experiment that was done.

Jing Hao Hi helped with that experiment more directly than myself at all. And that was set up some people that were at CERN. It operated for ... I don't know six months to a year, and is actually, I think still sort of ... I know I'm going endeavor at some low level for us to try to do, but it resulted in a vapor then and acceptance of the sort of importance of the phenomena at CERN. So that was, I think, a good scoring card thing for Graham in the whole area. Anyway, I never truthfully understood the physics of that whole subject. So I don't even want to begin to go down that path. So again, Graham's by far the best person for you to try to talk to you on that one. But that's really searching out there for another rather faculty, right? So I had to go off to another place.

Tom Grimshaw: That's fine. All right. You may think of others. So let's now think of all the students and graduate students and so forth without necessarily saying what they did. Right now I just want to capture their names because we're getting a little short on time. You remember graduate students or postdocs?

Dennis Pease: Well, first of all, I'll stay there was about 10 students that worked on and off for Skinner. So we had actually quite a few students. So my ability to remember names is way too poor without making a list and just checking them off. I'll name one person just because he remains associated with our family here, and I will grossly pronounce the name as Wienjii Wu but it not as in sound anything like that, but that's phonetically what it looks like. He goes by Harry Wu now and is a graduate student doing Medical Technology at Washington University in Saint Louis. But he worked in the lab for a couple years and played a part in reducing some custom Labview experiments and helped me out a lot within making x-ray experiment a program to review data automated.

That would allow me to look through many, many months of data to look for any anomalies that might have occurred transiently in the X-ray data. We had an x-ray machine. I mean, an x-ray detector running continuously or actually had two x-ray detectors, and we needed a way to parse through that data because you couldn't be there looking at it all the time. And in fact, it even took too much time to just scroll through the data looking at it after the fact. So he wrote a program that would scroll the data and look for oddities of emissions and then flag those and create an output file that recorded all of them, and then they can go back and look at this 50, 60 things that might be of interest in a month's worth of data in a few minutes instead of spending your days and weeks looking at it.

Tom Grimshaw: Great. Others that come to mind, other people? And [inaudible 00:30:24] had on the students?

Dennis Pease: One of the students worked with Jing Hao on the creation of this Gorsky experiment, and he played a critical role in getting the ATD card running on that. And again, my apologies. I'm sorry to not be able to state his name right this instant, but then we had some other students that worked for a much shorter period of time. And they helped Orchid at times with preparing electrolytic solutions and rolling cathode foils was another thing that the students helped a fair amount with. Trying to think if there's ... There were two students that were graduate students working for Mark Prellis, involved with the experiment that we mentioned this...

Tom Grimshaw: The titanium.

Dennis Pease: Yeah, titanium fracturing sort of releasing neutrons experiment. Again, I can't just write off ... Actually Owe, was the name of one person I believe is names that comes to me.

But I actually worked with them. It was sort of like scattered intervals I go over there for a day and help them with some instrumental issues or something. We never got working properly ... Well, we had it working for just a little bit of time and then he quit again. Mark Prellis is had a residual gas analyzer. And so, unfortunately, it had been abused its own phase in its life and wasn't really working quite properly. We almost had it working once and it fit but...

Tom Grimshaw: Okay, I think we're about ready to wrap this one up unless you can think of any other names that come to mind that they were working with Skinner or for Skinner.

Dennis Pease: Well, I think it's worth mentioning a name I mentioned once and that's Boris. So Boris, who did all the software for the experiments. He became involved three or four times during the course of Skinner. So he was hired remotely. He was over in Israel all this time, and he made modifications to support different experiments when it was clear that I was not capable of figuring it all out. About the time I sort of became possible for me to make changes in the code myself. It was like, "Well that was about the end of the six years that we were around." So he played an important role though and getting some of these, as we did, the different experiments including the Jelani and Kilani. It involved making of significant perturbations in the code for data recording and analysis. He became involved in that so.

Tom Grimshaw: Okay good.

Dennis Pease: So that was an important role for sure for us. So I think that's pretty much it.

Tom Grimshaw: Okay, good. All right. Yeah, we're out 33 minutes. That's just fine, again, Tom Grimshaw here with Dennis Pease. I think this was session number three on Skinner, and we'll pick it up again later.

Dennis Pease

Interview 4 of 4

Tom Grimshaw: Once again, Tom Grimshaw here with Dennis Pease. I believe this is session number four on Dennis's experience at Skinner. I think to catch up on some things. Dennis, on the other students or the other people who are working at the lab, you'd mentioned during our break here that there were three of them. You wanna go ahead and mention their names?

Dennis Pease: Yeah, so I had alluded to work done but I just couldn't remember his name. My apologies, Benjamin. Benjamin Davis was one, and he played a really important role with getting the data acquisition together for the [Gorsky's 00:00:40] firm with Janghow 00:00:43] Hee. Hee, I think was the person who found a low-cost data eCard and got the software going in order to acquire that data.

Also Hee helped some I think with the beginning phases of the data acquisition for another experiment that I did really talk about, but Janghow was running that involved a laser for direct stimulation in a [cuvat 00:01:11] for a miniature sort of electrolytic experiment.

That was following some of the work I think of Dennis Craven and Dennis Latz using a laser for stimulation. That work was done right before Janghow left, which was about six months before the closure of Skinner. That's when the data was collected with ... that was a replication of a previous experiment, or an attempted replication where the geometries and everything was really quite different.

But anyway, the similarity being it was a post-hundred picosecond laser that was being used for that.

Tom Grimshaw: Did you see any evidence of Lenner taking place in that experiment?

Dennis Pease: Well again this was one of the cases. There were certainly some indications of heat. The question was never clearly, I think, determined if it was excess heat or not. The difficulties of dealing with the source that's so brief in duration and not having any secondary way to measure the output of the laser. It was difficult, I'll say, to have a control experiment for that to know.

Again, one gets the impression it's running along. There's always these signs at some point where you think things should be constant and they're not. Conditions change, and then they change back, and as far as you're concerned nothing changed.

I'll tell you that seems to be a common thread in many of our experiments. What gives you, if you're doing the experiments, considerable confidence that there's something odd going on, because it just seems like this happens way too often.

I mean, I've done experimental physics all my life, and while I've encountered a few odd things, I don't think I've ever had anything that routinely behaved anomalously like electrolytic cells do with palladium and deuterium. There's just too many odd things that happened.

Tom Grimshaw: Okay. And then there was James, Benjamin, and Patterson.

Dennis Pease: Yeah, Dan Patterson and ... gosh ...

Tom Grimshaw: Benjamin Boleyn.

Dennis Pease: Benjamin Boleyn. Okay, so when I say those names they blur together for me as people because they were sort of always around together and they ... when we interviewed them, we discovered real early on that they were close friends. They had worked in high school, they had created a company together, they had run science award things together, and so they were pretty much a team.

They came up with an idea to try to run this glow discharge and started down that path, but then one of them in particular had just too much school work to keep up. That was our experience I'll tell you in general with our technicians, our student researchers or whatever to call them.

In most respects they varied between being researchers and technicians as far as how we interacted with them, but it was always difficult, because their first priority, rightfully so, was to do their school work. Unfortunately, oftentimes, that would turn into weeks of absence from our point of view. It made it really difficult.

Tom Grimshaw: Benjamin and Dan, Benjamin Boleyn and Dan Patterson, I think you told me worked primarily for-

Dennis Pease: Right, for [Orcada 00:05:17]. So they reported to her and they helped her with different facets of experiments. Certainly part of that was the routine mixing up of electrolytic solutions, and making foils that involved both heat treatments in our vacuum furnace and also rolling them out with our roller mill into giving dimensions of thickness.

Tom Grimshaw: Okay. So I'm gonna pause here just for a moment. Okay, we're back on again. Dennis, of the six years of work at Skinner, could you tell me the top three or so experiments or events that really stick in your mind as being clearly indicative that Lenner was taking place?

Dennis Pease: In some sense, I think I sort of mentioned on the side all of those already. The first one that comes to mind is in running the ultrasonic experiment in its original form. There was a few hours of clearly anomalous voltage and card fluctuations that occurred.

These started for no apparent reason at all. We were doing some sorts of stimulations that were not any different than what we had been doing, but for some reason it was behaving differently. It was responding differently. It did this for several hours.

During that time there was some excess heat, not phenomenal amount, but noticeable, like 30%, 40%. Just as mysteriously as it started, it quit. Totally tapered down over a period of days.

Tom Grimshaw: This is so characteristic of the field. It'll turn on and then it'll turn off unexpectedly or maybe even without stimulation. I think you told me earlier that this was not written up or recorded so there's no record of it.

Dennis Pease: No, I don't believe there's any record of that, because again it was ... even though it got up like 50%, 60% amount of excess heat, it was not something that ever repeated, so it didn't feel we could say too much about it.

Tom Grimshaw: What would be a second one?

Dennis Pease: The second one I think was when I was making scans with applied RF aud looking at RF out, and finding that there was some very unusual, sporadic occurrences of RF emission, and these were occurring in broad ... well intervals of tens of megahertz in the range of hundreds of megahertz.

They were appearing botb at a frequency, and then you would see the harmonic of the frequency as well. And they would persist for a few seconds and be gone, and appear again. That was a really exciting time for me to see these. Partially it was just because of the real time nature of the tools I was using to monitor.

So I first sort of became aware of this looking at it with our signal hound, RF spectrum analyzer, and then I hooked up a software-defined radio and started looking at it at much faster time response.

After watching this for several days and ... it became clear. Well, there was a lot of odd things about how this was initially done. I had first thought it was tied to the cell that I was looking at, and then as time went on I became more and more clear that no, it really wasn't.

It was actually seemed to be that when I would stimulate nearer Jinghow's cell, which he hadn't had much response from, well it turned out that me putting my antenna over by his cell produced a bigger response with my receiver in this other cell. Well that seemed pretty odd to me, but I looked at that for quite a while and there was no denying it was intimately correlated with that, and how I hung the antenna around would make a difference, but it needed to be over there by his experiment it seemed like.

Well, eventually I sort of moved out and hooked my software-defined radio up onto a laptop and started carrying it around and I found there was areas in the building where it was stronger, but as I kept looking at this, I finally kept moving back to our lab, but this time not that lab at all, but the open cell lab in the room next door.

At that point it became very clear that these emissions were coming from that room. Eventually I got it down and I found that it was clearly they were coming from a computer that the side of the case was off, and apparently the power supply was producing these sporadic pulses of RF.

The problem was it never did sort of make sense. The nature of those oscillations was clearly tied to the computer because of the clock frequency that it all came down as a base value to, but I still never felt very comfortable with it.

To this day, I guess I have this sneaking suspicion that it could have been that a cell was reacting to the noise on the power supply, and that there's more to this than what we ever really quite could figure. The complexity of it was such that it didn't seem it was just the power supply on the computer making the noise.

I take that as a hand-waving thing. Certainly to me, added to the bulk of phenomena, the little things that I witnessed as a really big thing, there's a lot of anomalous things that occur when you try to do experiments with these systems.

Tom Grimshaw: Right.

Dennis Pease: Then there's one last one to mention-

Tom Grimshaw: That's the third one.

Dennis Pease: Yes, the third one. And that is in doing the gas-loading, because I was taking data of resistance versus time at a higher data rate than probably anyone's ever done, so I was taking data at like 20 Hertz, people's expectations are that loading is going to change the resistance of the bulk material and they would do so based upon diffusion times, and that's very slow in gas-loading systems.

So the diffusion rate is vastly lower in gas-loading than it is in electrolytic-loading, because the affecting pressures in electrolytic-loading are just nothing but astronomical.

You get megapascals of pressure or gigapascals just with a few volts of electrolytic sort of current.

In gas-loading everything is expected to happen very slowly, but much to my surprise I found that things did not proceed in a linear fashion. Far from it, and that in fact there would occur what I ultimately came to call gas quakes in the foil.

These manifested themselves at certain regimes of loading that were very low. Never did we get the high levels of loading in the gas-loading using a 70 bar or something of hydrogen or deuterium. It was observed to occur in several instances, repeats with the same foil and also to occur in a couple of different foils.

Again, the primary thing that caught my attention was its sensitivity to ... you could be there static and there would be very gradual changes in the resistance only to make a little tapping sound someplace far from the cell, and have it suddenly make a large jump in its resistivity. It just didn't compute that it should have anything like that kind of sensitivity.

It became clear that the frequency of stimulation was important, that you could tap on it with your finger and it wouldn't change, but you could just take a hard object, and just as light of pressure as you could put to make it tap with something like that, even though you were thunking it with your finger and it wouldn't change, you could take this other thing, metal object to metal, and just go dink and it would ... the resistance would change by dramatic amounts, you know, three orders of magnitude higher than the noise in the system. Then it would settle down again.

Other regions of loading, you could do it and you would tap with this thing a thousand times harder and it wouldn't change the resistance at all. So this showed me it wasn't a consequence of the ... my connections being influenced by tapping or something. It was clearly tied to the state of loading of the foil.

Again this was never published because I didn't know ... how do you publish something? I mean, I didn't understand it at all. I didn't even ... I can speak of the characteristics it had, and the oddity of it, but we never got to do any controlled experiments just 'cause our time ran out.

What we wanted to do was to put a piece of electric crystal inside there so we could make quantitative sort of protobasens in the system right, by putting in different impulses or frequencies and see how that modulated the resistance changes, as well as to try maybe different kinds of foils, thicknesses, or ways we supported the foil.

Tom Grimshaw: Okay, well thank you. Those are the three main ones that stick in your mind, I guess.

Dennis Pease: Yeah, so certainly ... I'm sort of purposely not listing what would be considered by other people there to be the main ones. That would be the experiments that were done with the nanoparticles. That's what Orcada or Graham would certainly list those, not the things I'm saying.

I'm speaking of the clearly sort of anomalous things that I saw that I took as an indication that there is something very unusual going on in these palladium deuteride systems.

Tom Grimshaw: Okay, good. We're gonna move to another topic now.

Dennis Pease: Okay.

Tom Grimshaw: I think I'll probably do some of the talking here. Let's talk about the residual record of Skinner and its operations. When Skinner closed you were able to purchase a lot of the equipment and came into possession of a lot of the electronic files and hard copy files.

I think that if I understand correctly that what we've done so far captures almost everything that exists. I think in maybe the emails may have some information.

Dennis Pease: Wow, that's true. There's a lot, a lot and lot of emails that passed by, and then you mentioned something before and I ... we had these weekly meetings and people individually took notes, but there was no staff available to make it part of the thing to keep a real recording of the meetings and what happened, so to my knowledge there's no clear record of that.

Tom Grimshaw: It'd be nice if there were.

Dennis Pease: It appears that people took individual notes, right, because that's where we planned what we were gonna do the next week, and talked about the results we had gotten.

It's unfortunate ... that would be really invaluable to help with the computer records that we have of the raw data and all, to be able to go back and place those in the context of what we were really sort of, and at a higher level, trying to investigate.

Tom Grimshaw: What about laboratory notebooks?

Dennis Pease: Well, the laboratory notebooks that we've gotten through ... when we left Skinner, I got most of the notebooks that go back into the Energetics days that were available there in Missouri at the University, and then of course I had my own notes and some that were left by Bill and Mark. I think I have some notebooks of Mark Surland.

I did not have notebooks, I don't believe, any from Orcada, nor anything that might have been kept by [Aurick 00:20:31].

Tom Grimshaw: Okay.

Dennis Pease: So our notebooks situation is a little, still to this day, disorganized. There's a lot of notes ... I literally did not keep things in a notebook. It kept things either on random scattered sheets of paper which is not good protocol, but really the better way that I did most of the notetaking I did was online.

There are hundreds of pages scattered around in notepad files in directories of data that I took, so that's what I used as my method to record.

Tom Grimshaw: We should recover those for this project.

Dennis Pease: Yeah. Again they reside where the data is, so with most data files you'll find there will be associated notepad files, which will give the blowbug a little description of what I was doing.

Tom Grimshaw: That's very important to know. I did not know that, and so when we get to the next phase of this, we'll try to work that out.

Dennis Pease: I'm hoping maybe if we can learn more about the success of this, if I can come up with a fast way to transcribe my nearly illegible notes into a text form, that would help a lot to supplement our data records.

Tom Grimshaw: Next question for you, what are your future plans in this field? What would you like to do? What do you plan to do that you can talk about? Some of it's confidential I suppose.

Dennis Pease: Yeah, probably most of it is. I've always been an experimentalist sort of person. I've already had a good start on a lab in my garage here, so my hope is, first of all, to continue some of the experiments of things that I've mentioned in fact. These are the odd things. I wanna replicate some of these things if I can.

	I wanna see if I can see any of these odd effects if I set up the same conditions, or if they were in fact dependent upon the presence of other nearby cells running. Because I ... very came out with the opinion that the ... well for one thing I'll say, electrolytic cells clearly have an extraordinary sensitivity to RF fields.
	I won't say that there's any easy way that you can directly get excess heat from that, but it's obvious that they are influenced by external fields that you're not trying to apply, whether that be the harmonics of 60 Hertz and 60 Hertz that's present in every experiment as a ripple at a low level on any DC power supply or even battery.
	It was clear to me that the response of the ... if you measure the, at high frequencies, voltage and current from an electrolytic cell, the fluctuations that you see are disproportionately large for the level of your input fluctuations.
	I learned later that electrolytic cells were once used as actually RF detectors, if you go back far enough in time. So I think that says something right there. I think that is an important aspect of electrolytic cells that will play a part whenever people figure out how to make Lenner work.
Tom Grimshaw:	Right. Okay.
Dennis Pease:	So basically I'm saying I want to explore some of the past anomalies that I see, and see if I can repeat some of those.
Tom Grimshaw:	Right. I understood that. Now you have equipment in your garage, would you actually operate a laboratory in your garage under the right circumstances, or would you be looking for other space?
Dennis Pease:	Well, no, I mean initially I really don't have any choice because of the other demands I have on my time. I just simply couldn't operate anyplace outside my home.
Tom Grimshaw:	Yup, okay. Could be elsewhere in the house or something like that.
Dennis Pease:	My garage is not like a garage that most people think of. My garage is like a ... most people would call it a climate-controlled workshop I guess.
Tom Grimshaw:	Yeah, good. Let's see, I guess the last thing that I wanted to ask you about is tell us about your educational background. You've done that a little bit already, and then a few words on what you did from the time your education was completed until you started with Lenner.
Dennis Pease:	Well I don't know. This is something I really have to struggle to confine myself, because I did work on so many different things, but-
Tom Grimshaw:	Well, be brief.
Dennis Pease:	Yeah, I'll try to be brief.
Tom Grimshaw:	Start with your education.
Dennis Pease:	Well I grew up in a little town on a farm. Distinguished myself early on as the resident scientist of the town, and said I wanted to build fusion-powered rockets and go to another solar system. Best I could do starting out from that was, I went to University of Missouri-Rolla because I could go there really cheap. It was a good engineering campus.
	I studied physics there. Got my BS degree in three and a half years. All the time I was there I was working in labs. The last lab I worked in for a year and a half was for a Professor [Nyguard 00:26:37] there with a lithium atomic beam.

The sort of most notable thing though that I did there, was helped with the creation of an observatory, which we actually built an observatory out on the grounds of a farm and had two telescopes out there, and then we got a grant from the government, and me and three or four other guys that were working there interested in astronomy, and we got a 16 inch Group 128 telescope. I was the first person to look through it, and that's still there today. You can go and look through it on their observing nights. That was an achievement back in 1974. So when that telescope got cited at the University of Missouri-Rolla, now Missouri School of Science and Technology.

Anyway, from there my first introduction-

Tom Grimshaw: What year did you graduate?

Dennis Pease: I graduated actually in '73, but I was there as a student until '74, so I spent one semester of graduate school there working on this research project as well as taking graduate courses, which I think was very helpful to get started because it was such a big change to go to University of Texas at Austin, or The University as they'll say there, with 50,000 students. So from a school of 4,000 students to 50,000 is a pretty big jump in itself.

In terms of facilities and everything, it was awe-inspiring to do that. It was just the greatest time in my life to go to there and to have the lab equipment I did, and go to work in the Fusion Research Center.

I and two other guys, it was the first time they had ever done that. We started as research assistantships in the Fusion Research Center working on the Texas Turbulent Taurus, and so that was a big thing to do.

We were working at the time with a PDP-11/45 I think it was, and then we graduated up a little bit in computers there, but that was pretty much the world of computers we used, but we had the top-rated instrumentation, biomation, digital recorders. I had serial number two of the Princeton Applied Research Corporation's multichannel analyzer which I used to do optical spectra on a pulsed plasma, not actually the Texas Turbulent Taurus, but a separate plasma.

I was there just about eight years at the university, 'cause I really liked it. I had a little stint of time that I spent one summer at the observatory because I still had this strong interest in astronomy and was trying to decide whether to major in astronomy or in physics, but stuck in the plasma physics trying to get to my original goal of building a fusion rocket.

At last though, funding sort of died away in that time period for fusion-powered rockets, and fission-powered rockets for that matter. And so, when I graduated from the university there, which my degree was actually in Plasma Spectroscopy, so I was looking at fine details of helium and hydrogen line optical spectra from a pulsed discharge.

Tom Grimshaw: This was your dissertation?

Dennis Pease: This was my dissertation, yeah. So what I was looking for was the AC stark effect, so that is the protobation of spectra lines by applied external fields, which in this case, those applied external fields are being applied by the plasma waves within the plasma.

Anyway, you see that manifested both as satellite lines that appear around the main peak, and also broadening of the line itself that you'll see due to the electrical fields, and can be magnetic fields within the plasma. My magnetic fields were not strong enough to be a significant portion of the spectrum.

So from there, when I graduated I had a post-doc at Texas Tech University in work doing laser-triggered spark gaps, so this involved using a ruby laser to hit an electrode that was gapped to be enough that it would not break down by itself, but the laser would serve to break it down. This was all part of a long-term project in pulse fire to be able to make opening and closing switches that operate to very tight time powerages.

Tom Grimshaw: Who were you working with there?

Dennis Pease: Oh gosh, now you're giving me a name thing to get me.

Tom Grimshaw: Was there a professor?

Dennis Pease: Yeah, I worked with a professor there who is no longer actually there. He was only there for a few years, Tom's his first name. I'm losing it on his last name.

Tom Grimshaw: That's all right.

Dennis Pease: The other sort of odd thing that I did there, we were looking at doing optical diagnostics of the molecular species that formed transiently during the discharge of the laser trigger.

So, the idea was that by looking at this plume, you could watch it through this complicated laser fluorescence technique and see the way it evolved, and the hope was to figure out ways to manipulate that to improve the performance of the switch.

Tom Grimshaw: Were there any publications?

Dennis Pease: Yes, there was a couple publications that came out of that.

Tom Grimshaw: Okay. Wanna get those [crosstalk 00:32:39].

Dennis Pease: That was like an I triple A proceedings sort of thing at a conference that it was in.

Tom Grimshaw: Yeah. Then what?

Dennis Pease: So then I actually ... well onto another post-doc at Los Alamos National Lab. I was working on a high density z-pinch there, that was sort of out of the main stream of activities in the lab that was run by a couple researchers there.

That was like 600,000 volts and 800,000 amps discharge, so it had a capacitor bank the size of most people's living room. 10 feet deep or so filled with oil and high voltage capacitors, which were triggered, charged and parallel, triggered in series in what they call a Marchbank configuration.

So you would discharge all this current through a poor little tiny hollow gas shell of argon, and so it would instantly ionize and it would implode and produce this little three centimeters long, ten microns diameter wiggly current filament, and that would copious amounts of x-rays coming out of it.

This all started as part of a fusion-related experiment and was part of a bigger experiment that was a classified experiment, which by the time I got my clearance, it was about the time I left there, so I never really knew too much about that experiment.

Basically it was called Trailmaster for the big experiment, and involved explosive compression. I was like the ... this was like the prototype of that device that was used much higher levels of current and external compression by explosives in addition to just the current compression and cell magnetic field, generated magnetic field compression.

Tom Grimshaw: Were there publications?

Dennis Pease: Oh, there was lots of publications of dat ... not by me though, but on that machine.

Tom Grimshaw: I was wondering if you had any.

Dennis Pease: I think there was one that I created, which was not anything more than, I'll say ... what do I say, a phenomenological sort of description of what the discharge was like. Taken with an x-ray tube camera.

Tom Grimshaw: What was next?

Dennis Pease: Next, so left there and got a job at Delco Systems Operations out in Goleta, California. There I went to work for a group, the aerophysics department, which had a hypersonic ballistic gun range. What that was was this large battleship-size cannon laid on edge that went into a second stage and comprised what they call a two-stage light-gas gun.

So you would take this powder-driven charge and compress a plunger into a giant, solid, steel tube with a very small borer diameter that was tapered. You would extrude this plunger of polyethylene material into the end of it, so as to generate hundreds of thousands of PSI and it would then break a stainless steel disk that was like an inch and a half thick or something that was scored in places to be like half an inch thick, so when it would rupture as the pressure built up to this extraordinary value, and it would flare outwards in this neat little sort of hole.

Situated in front of it was a Lexan what they called [subbow 00:36:53], a Lexan cylinder that was close to the tube that it was in. Inside of that was a miniature replica of a nuclear reentry vehicle. That would that then be propelled out of the end of this at 16 times the speed of sound or something like that.

Then it would traverse a quarter of a mile tube of gas, and in the end impact into several steel plates making holes through two or three inches of them.

The role I played there was involved with, initially diagnostics of the in-flight projectile, so you would have to use things that had pulses of light, tenths of nanoseconds long. Anything much longer than that and it would just be blurry.

With tenths of nanoseconds, 10, 12 times the speed of sound, you get a ... it looks stationary. It's amazing. And so there was all sorts of other diagnostics doing signature studies of reentry physics they called it, looking at the radiation that's emitted from these projectiles in flight.

So from there, Starwares appeared, and the shift became less into atmospheric signatures, people realized you really don't want to intercept these things when they're on top of your head and blow up there. You want to blow them up when they're way out in space someplace.

And so that became the focus of [crosstalk 00:38:32].

Tom Grimshaw: Still at Delco?

Dennis Pease: Yeah, I was still at Delco, in the aerophysics department. So I helped with creating a conceptual design for a space simulation chamber with the intent of levering our ability to make these tiny little scale model reentry vehicles into something that you could use for signature status.

And so unfortunately I found early on that you can't do thermal scale modeling with factors of 12 or so reduction or more in size. Really you need like three or four if you want to have precision signature sort of replication.

Well that changed the whole cost and resources required to do this into a whole 'nother thing, so we never built the space simulation chamber.

The decision was made around that time by people in Washington, D.C. to move the Goleta gun range and consolidate it with another gun range that was in Huntsville, Alabama, so that happened.

And so that was ... sort of became my first experience at moving giant experimental facilities, but it took 80 transport trucks and stuff to move that stuff to Huntsville. That was the end of that.

So I looked around for other work there at the Delco Systems and was put into a program for C-17 that was just starting up and played a part for several months working on computerization of the airdrop function on the C-17 aircraft that was just being built.

It was sort of, for me, a fish out of water. I did do something very, I think helpful there, in coming up with a multi-dimensional way to do table lookup for parachute drop data, so whether than to actually look up tables, I created algorithms which replicated the tables, and that made it vastly more computationally in data and space intense, and they ultimately used something similar like that for the engine data as well, 'cause they ran into the same problems, right. That the historical ways, you just couldn't do it. It took too much data in your mission computer.

So, while I was doing that I came across another project that was going on there at the Delco Systems. It was called the HRG for Hemispherical Resonating Gyroscope, so this was a new kind of navigation system unlike a spinning gyro or ring-laser gyro, or fiber optic gyro, this used a vibrating mechanical hemisphere as the way to dissense rotary motion.

I helped with that project in many different ways from the measurement of different materials to evaluate the queue of the material so it would vibrate longer, to ways to balance the resonators better than ... you needed them to be done ... they needed to be mechanically more precise by a factor of a million to a billion than what you can fabricate them, and so balancing them individually.

So eventually that culminated in the development of a laser balancing system, which is still being used to balance HRG resonators today, that's 20 years later or something.

The HRG has been used on like 140 space flights for space navigation. When you see the pretty pictures of planets, many, many, many of those have been taken by spacecraft that were pointed and orientated by the HRG gyro system, inertial navigation system.

Tom Grimshaw: What's next?

Dennis Pease: So, from there I enter into a world of blackness. My time working on HRG was sort of split up by another thing that I can't say anything about other than it's a Department of Defense-related program and-

Tom Grimshaw: Still at Delco?

Dennis Pease: That was at Delco. So I worked on that in sort of two separate stints. That then actually did resurrect itself again later in life, a decade later. I'll sort of maybe come to that. I'm sorry, but I just can't say anything about it. This is one of the few projects that exist in the world today that there is no 20 year limits.

Tom Grimshaw: What was next?

Dennis Pease: So from there, the HRG, we got it all going. We went through about 15, 20 launches, and it was purchased ... we were sold from Delco Systems Operations, we were sold to Litton Guidance and Control.

Litton and Guidance Control was then purchased by Northrup Grumman. Northrup Grumman decided that they wanted to move the HRG production to Woodland Hills. Basically no one wanted to do that, including me, 'cause that was to me L.A. not Santa Barbara. Goleta's Santa Barbara.

So I spent a year to take over the care and feeding of the laser balance station and another couple guys helping them with other facets of different gyrotechnology I was involved with. They ultimately took all of that stuff and started doing my job there in Woodland Hills. I also helped with packing it all up, moving it all through this laser balance station and, two stations actually there were, to Woodland Hills. That all went very successfully, and actually the laser balance station was the first operational thing there. I was thrilled.

People made fun of me because I disconnected every cable, everything, took it all apart, but I got it working fast than anybody else got their equipment, 'cause they had problems with the cables broke the connectors on the equipment and they had to order equipment and stuff, so there's word to the wise and learned and all of that.

So anyway, next I had to find a job, so I created a consulting company and I started doing consulting at two places at the same time, sort of half time at one and half the other.

One was infrared detector company called Indigo, now it's Flair Indigo, and at the time we were working on sort of a closed lip project that's now very publicly known. It was a infrared microbolometer to be in an automobile, for BMW to be precise.

So I helped with the prototype vacuum, the vacuum life analysis of the prototype package. So the deal was you needed to have a 10-year lifetime they decided, so that meant you had to be able to hermetically seal this tiny, couple centimeter, maybe by half a centimeter thick package of the microbolometer in a vacuum, and it had that way for 10 years.

I was looking at seeing if that was possible, basically, on new packages using a residual gas analyzer as the primary means. So I helped build up a station to do the residual gas analysis and did that on that package and ran it through heating cycles and such.

I did that for about three years, and during that same time I was working for a small company called IST, Innovative Survivability Technologies. They were looking at a variety of different projects. Two that developed a fair degree into something. One was using a radiation portamonitors for the state of California.

So we installed at all of the major ports of entry on the freeways going into California, big white boxes on either side of the top where trucks would drive through looking for elicit nuclear materials entering the state. I helped with the development of that, which was a technology transfer agreement we had with Livermore National Lab.

The other thing that the company worked on was rocket-propelled grenade defense for op-hours Humvees. That ultimately transitioned into other investigations of finding ways to use our system on light armored vehicles and tanks.

Those projects were only done in a developmental sort of phase. To my knowledge they were never brought into fruition in any production sense. They worked well. It was just we could not meet the schedules that were needed by the army at that time.

Ultimately what happened with the rocket-propelled grenade defense is the threat changed. It became not that. It was that in Iraq, but in Afghanistan it was much more improvised explosives.

	I spent a lot of my time ... I did not work on a daily basis with these projects. I developed things that were used on a daily basis in connection with them, and I worked much of my time looking at other, too numerous to mention, ideas for new business.
Tom Grimshaw:	Okay, what then?
Dennis Pease:	So then, from there, well I mentioned that we missed the market on the rocket-propelled grenade thing. Well, that was the end of the company. We were purchased ... we were a little company, IST. We were actually purchase, I failed to mention that, by Textron Defense Systems, and we started down this road to productionize our system and actually do stuff with it, but we failed to get enough investment into the idea quick enough. We missed the market.
	At that point there was a change in the management at Textron Defense Systems and a decision was made at that level that they were not going to any further explore relationship at the beginning phases of projects. They were gonna wait for things to be a lot further developed along. So they closed us down basically.
	At that point I moved to Missouri and went to work for Randy Curry in the electrical engineering department for a year, and then became involved with Skinner.
Tom Grimshaw:	Oh, okay. What were you doing with Randy Curry?
Dennis Pease:	Well, so I was working with a RF remote detection scheme, I think is maybe the best way to summarize that. It involved using RF, which was sort of a little bit of a new area for me to be working in, although I had worked with RF some, because we used a microwave radar on this system that I mentioned for rocket-propelled grenade defense, so as a way for watching things coming towards you.
Tom Grimshaw:	Okay. Well that brings us up to the beginning of Skinner, which is where we started all this.
Dennis Pease:	Yes.
Tom Grimshaw:	And so I think we've come full circle. We may have another one of these, but I think this is a very complete picture. Thank you very mnch for doing that, and this is Tom Grimshaw with Dennis Pease.
	I think this is the end of session number four. I'm gonna go ahead and have these transcribed and you'll have a chance to look at them.
Dennis Pease:	Okay.
Tom Grimshaw:	All right. Signing off.

The University of Texas at Austin
Energy Institute

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

Arik El-Boher

Interview 1 of 6

Tom Grimshaw: Okay. Tom Grimshaw here with [Arik El-Boher 00:00:05]. We're talking about the Sydney Kimmel Institute for Nuclear Renaissance in SKINR, as well as its predecessor organizations, Energetics Technologies, Israel, and Energetics Technologies USA. Today is January 12th, we are in [Arik's 00:00:42] mobile home north of Columbia, and it's snowing beautifully, a wonderful winter day. So Arik, I do have some questions to kind of guide us. But a lot of this will be your extemporaneous reflections. One of the things we want to do is stay with just the actual facts, as opposed to some of the causes for the changes and so forth. We're after the actual events that took place, the experiments that were run, the results, and how they were reported and so forth.

And with that slight little editorial, I think I would ask you to start, if you would, with the beginning. When did Energetics start in Israel? When did you become affiliated with Energetics? And maybe even some of the reasons for the Energetics Technologies was formed in the first place.

Arik El-Boher: In 2001, I finished as a CEO of a startup company, and I was available, together with professor [Branover 00:01:48] that we worked together ... He was my mentor on my PhD, and we continue working for many years, more than 40 years all together. And we did a lot of good things together. One day he came to me and said, "Arik do you want to get into the cold fusion field?" And I said, "Let me think about it." And I start reading about it. I heard about it, but I wasn't there. So I start digging deep to understand what is going on, what was done, what is the status and where the so-called cold fusion community is at that time. So I'm talking about end of 2002 ... 2001, I'm sorry.

And then, professor Branover came to me and said, "There is a guy who is a physician, he is a surgeon, a vascular surgeon, who developed a theory on super waves. And that he believes that it can be applied to the field of cold fusion. And if we are interested, and that if yes, there is an already available angel investor who will invest in a company which will be established in Israel".

Tom Grimshaw: Let me ask a quick question. You were with Branover, were you affiliated with an academic institution or any other organization at that time?

Arik El-Boher: Yeah. I was affiliated with the Ben Gurion University. This is where I had my first, second, and third degree, together with him. And then we worked in all kinds of startups, along the years. He was the chairman, I was the CEO, of startup companies. And ... I mean, after I finished my PhD, I worked for another 10 years in the Institute of Research and Development of the university Ben Gurion University in the Nagev back in Israel, and then I started these enterprises together with him, and "Cold Fusion" was another one.

Tom Grimshaw: Yeah, okay. I was wanting to get a little more background there, so please continue on with the story.

Arik El-Boher: So, Irvin [Dardik 00:04:31] is a very interesting guy. He is an auto-didact. He is a scholar, he studied by himself physics, nuclear physics, and he came to the conclusion that everything we see on our planet and in the universe, it's all waves. And I think he's right. And by the way, Schroedinger is talking, not about particles, but on the probability of a particle to be in a certain place in a certain time. And [Irv 00:05:11] said, "It's not a particle, it's not the probability, it's a wave, and actually, a concentration of waves which are interpreted as a particle.

And he started developing these super waves for medical purposes, for bringing back the human body into harmony, by training it ... Increasing the heartbeat along a super wave that is higher amplitudes with higher frequencies, and the peak frequency at the peak amplitude. And this is the idea of the super wave. It's a nonlinear super wave, which is a superposition of many frequencies, wave frequencies. And then it starts slowing down and resting. So super waves are actually increasing of amplitude and frequencies, and then relaxing. And then again. So this was a method for body training, but also, he thought that, that will help a lot in the cold fusion field.

So in 2002, I would say mid 2002, we all agreed, and there were three people in the group in the beginning. It was Branover, Shaul Lesin and myself. And we decided that we are going for it. It was interesting enough to invest our efforts, and our vast experience, in research and development, in this field. We were all available, and we contribute ... We dedicated to that. And actually, the company was established in mid 2002, and actually we started after hiring a group of engineers and scientists. And in the beginning, it was 15 people, and it grew up, up to 35 researchers and scientists and engineers, and we started with electrolytic cells, and-

Tom Grimshaw: Let me jump in and ask a couple of questions. Branover, what was his-

Arik El-Boher: Branover.

Tom Grimshaw: [Branover 00:08:06]. What was his first name?

Arik El-Boher: Herman.

Tom Grimshaw: Herman, okay. Good. And the three of you started this company. Tell me, where were [Dardik 00:08:22] and Sydney Kimmel were they present there at the time you started the company?

Arik El-Boher: Branover was the chairman and Shaul Lessing was the CEO of the company. I was the deputy CEO and Dardik was the consultant, and Sydney Kimmel had a medical issue. And he tried all the classical treatments, nothing helped. And actually the clock was ticking and he approached Irvin Dardik, and Irvin Dardik, was training Sydney in this procedure that he developed with the super waves. He survived and actually he's still living. I'm talking about 20 years back. And as thanking Irvin. He said, "Anything you want, I will contribute to fulfill your dreams and so on". And one of them was the cold fusion. So we had an angel investor, the only investor, in spite of the fact that he asked us during the years to bring new investors. When we brought new investor he said that he doesn't need it, "I have my money".

It was just in order to know that someone else is interested. And when [DARPA 00:10:09] was interested in our results after the 60 minutes piece that I believe you saw, he was very proud and very happy and continue supporting energetics and in fact, if you are accumulating all the money that he gave to energetics over the years, it was over $25 million dollars. And then as you know, we moved to Missouri, and he continued to contribute another $5.5 million. So altogether it was more than thirty million dollars, which I think it's remarkable.

Tom Grimshaw: That's far exceeds any others that I know of in this field.

Arik El-Boher: Right? So we start from the beginning in September 2002 with 15 people. And I designed the first cells ... Actually, I designed all the cells during Energetics Ltd and LLC and during SKINR. So we started, as I said, with electrolytic cells, with Isoperibolic calorimetry which I designed, we built it and then I got in contact with this Eliezer [Blasberg 00:11:39] a specialist in LabVIEW programming . I thought at that time, LabVIEW was just in the beginning, it was just coming up and I felt that this is the future of programming and for Data Acquisition.

And so we went in this direction and he was very efficient, very professional, and he put together a very efficient and comprehensive LabVIEW program according to the algorithms I wrote, Eliezer fulfilled all what we wanted and asked him to do. What kind of data we need to store and process afterwards together with graphical ability, plotting all the graphs that are of interest with a lot of flexibility in changing the parameters and so on and so forth. So in the very beginning of our experiments, of course, we were seeing no excess heat. We were the first to apply the symmetrical double anode and one cathode sandwich method. Later on it was adopted by all the groups that we collaborated with, Vittorio Violante from ENEA and Mike McKubre from SRI and others.

We were the first, because in the beginning they were using spiral anodes and cathodes, or a film cathode, a film at the center surrounded by a spiral of platinum wire. So that was the first time that actually we were loading the Pd cathode from both sides symmetrically, not only that, as I mentioned, we applied the super waves, The super waves actually were developed by a wave generator subroutine embedded in the LabVIEW program and delivered to a Kepco amplifiers which were following the super wave constant current according with the set average current. So actually it was like loading and deloading. Loading and deloading, the loading or the ions influx to the Pd cathode was higher than the out flux, and as a result the cathode was loaded to a very high loadings. We checked all kinds of loading methods (DC, pulses, sinus waves etc. and we found that the super wave was the most effective method to load Pd cathodes to a very high loadings with relatively low current densities. Unlike Mike McKubre, which was loading with very high current densities.

We on the opposite, went with very low, relatively current densities, 6-10 mA/cm2. And that was actually gently loading of the cathode with controlled built up of stress levels into a very, very high loading.

Tom Grimshaw: As much as one to one.

Arik El-Boher: Yeah, we actually in few cases even we got higher than one (D/Pd atomic ratio).

Tom Grimshaw: Well.

Arik El-Boher: Slightly higher than 1.05 or 1.1.

Tom Grimshaw: Yeah. Just-

Arik El-Boher: We realized that the super wave is most essential not only for loading but also for providing dynamics to the system. You have now a packed cathode with ions /atoms of hydrogen or deuterium and they need to interact with the neighbor atoms. Now-

Tom Grimshaw: I'm gonna-

Arik El-Boher: Today we don't know if it's a fusion or not, but we came to the conclusion that dynamics is essential.

Tom Grimshaw: Just to be clear, maybe for the audience, what we're talking about is platinum anodes, palladium cathodes and deuterium oxide or heavy water.

Arik El-Boher: Heavy water.

Tom Grimshaw: And was there lithium hydroxide also-

Arik El-Boher: Lithium hydroxide.

Tom Grimshaw:	... in the heavy water. Okay. It was just-
Arik El-Boher:	In point one [inaudible 00:16:28] usually a concentration of the lithium [inaudible 00:16:33] in the heavy water.
Tom Grimshaw:	So you were designing your experiment somewhat along the lines of the original Fleischmann and Pons experiment with the parameters that they had set up for their electrolytic cells. Would you say?
Arik El-Boher:	Look, they worked with much higher current densities and we work with much lower current densities. And the configuration of the anodes and cathodes were different. As I said, we had these sandwich of two anodes and one cathode at the center, about five millimeters apart, (the gap between the anodes and the cathode). And of course we were just from the beginning measuring the resistance, the cathode resistance as it is being loaded continuously in-situ.
Tom Grimshaw:	Right. And just, again, when you were first doing your design of the cells in your thinking about how the cells should be designed and constructed, were you guided by the Fleischmann and Pons experiment and their way of doing it or were you using other ideas?
Arik El-Boher:	The calorimetry method of Fleischmann and pons had a lot of disadvantages, and it was very complicated. And if you follow the number of terms that was taking into account in order to get as close as possible to the reality of the thermal effect, it is very complicated. So we tried to simplify it, and this is why we selected the Isoperibolic calorimetric cells. It was a quite unique design that we made. With two concentric aluminum cylinders with alumina powder in between as a thermal resistor, we measure in the beginning many of pairs of temperatures, temperature elements around the cylinder in order first to see that we had an angular symmetry, of course we were averaging all those Delta T values in order to get the Delta T average. Once we saw that there is an angular symmetry there was no need for so many pairs of temperature elements and from that moment on we used only one pair of PT100 temperature elements, which gave us the Delta T value which is proportional to the input power.
Tom Grimshaw:	Right?
Arik El-Boher:	Of course, these cells have to be calibrated and the calibration data was part of the LabVIEW program. With the stored Delta T values, the LabVIEW program immediately was calculating the output power as K*Delta T. In the beginning, all of our experiments showed that the net input power (Pinet) was equal exactly to output power with no excess heat, until 2003, 2004, when we start seeing excess heat events. In the beginning we saw few tenths of percent of excess heat, but later on we saw thousands of percent, what we call COP (Coefficient Of Performance). In experiments #64, which was our champion, we got at peak, COP of 42, which is 4200% more output power than the input power and COP of 25 (2500%) on average over 17 hours of the first event (#64a). You see, the way we calculated COP, is different from others. We took Pout minus Pinet. Pinet is equal to the measured input power (Pin) minus the dissociation power (P_D , the amount of power which is needed to dissociate the heavy water). Certain amount of power is needed to dissociate the water, and the extra amount of electric power delivered to the cell, goes to heat the heavy water solution up. Right? So we were subtracting the Pinet from the output power (Pout), as all do for open cells, but we were dividing Pinet by the total input power (Pin), which is equal to the average of 50,000 instantaneous product of I*V every second. COP=[Pout- (Pin-P_D)]/Pin or COP=(Pout-Pinet)/Pin as

oppose to COP=(Pout-Pinet)/Pinet, as calculated by others. You see what I mean? So we were very conservative, unlike others.

Tom Grimshaw: Waving of course the super wave energy.

Arik El-Boher: Of course. We checked the cell calibration with platinum anodes and platinum cathode with the super wave just to make sure that our output power (Pout) equals exactly to Pinet with no excess heat (COP=0). We repeated this kind of calibration experiment many times to prove that our design allows accurate calorimetry. We proved experimentally that the cell linked to the LabVIEW data acquisition and processing system allowed very high accuracy of our measurements (better than 1% error). Only then we replaced the Platinum cathode with palladium and started loading cathodes. We saw that we can easily get to high loadings. Before starting any experiment with Pd cathode we had first to calibrate the specific open cell (we had 9 open cells), with Pt-Pt sandwich and stored the calibration parameters in the LabVIEW program.

In the very beginning we thought according to Mike McKubre that it is essential that we shall have a very high loading ratio and we easily got to 95% and more almost every time. Along the years, we came to the conclusion that even lower loadings can give excess heat events but we don't think that Ed Storm is right, I think Ed Storm went too far to 15% loading or so, we think that around 60, 70, 75% you can already get excess heat. And in fact in experiment #64, which was our champion, we were at about 80, 83% loading. And after the burst of heat, which lasted for 17 hours, the loading went down.

It didn't went down to zero, but it went down to 60% or 70% and kept generating huge amounts of heat. Such huge that we had to makeup heavy water from bottles connected to the cell through siphon, to make up. During electrolysis you lose some amount of water due to dissociation, at a rate which depends on the input current. So in order to keep the water level constant, sometimes running cells over weeks and months continuously, therefore you'll have to make up. So, excess heat event in experiment #64 happened overnight.

And the heavy water make up bottle has been dried off. Sorry. So you can imagine the amount of water which was boiled off, it was not because of dissociation it's because of boiling. And we saw the temperature.

Tom Grimshaw: Now did you have a recombiner to-

Arik El-Boher: No, we didn't at that time we didn't have a recombiner. Just much later we introduced to the same cells recombiners.

Tom Grimshaw: So when you did your thermodynamics and your calculations of COP and so on, you were losing massive water to the atmosphere deuterium atoms. Okay. And you were accounting for the loss of the mass it in your calculations and so on.

Arik El-Boher: Yeah, we took it into account.

Tom Grimshaw: Okay.

Arik El-Boher: Now. So we had 17 hours in which the temperature went up over boiling temperature and actually when we came in the morning the makeup heavy water bottle (containing about 1.5 liters) was dried off and excess heat stopped after 17 hours. We didn't do anything. We just fill the cell again with solution, keeping the same cathode, we deloaded and started loading again. After few hours from starting the second loading, we got a second excess heat effect with the same cathode for another eighty-something hours with COP on average of 15. You remember the average in the first episode was 25 on average, 42 at pick. In the second episode (#64b), after a few hours from starting, we got a somewhat lower COP but for much longer time. So the amount of energy was in the Mega watt range.

And in fact we had about one megawatt from the first episode and about three Megawatts from the second episode. Four megawatts together and we didn't account for the boiling. In spite the fact that we knew the amount of water which was boiled off and you could easily calculate according to the amount of latent heat, we wanted to be conservative.

Tom Grimshaw: Yeah.

Arik El-Boher: So that was-

Tom Grimshaw: So the energy lost to the boiling of the water wasn't included in your P out then?

Arik El-Boher: No. The latent heat was not accounted, it was only the sensitive heat that was accounted. In another words, we calculated the output sensitive heat as K* Delta T and that power was integrated over these 17 hours in the first episode (#64a) and during the 80 hours of the second episode (#64b) to give the total sensitive excess energy. The boiling, which is much, much higher amount of energy was not accounted for, although we calculated it, but we didn't report on it just to be in the safe side, to be conservative.

Tom Grimshaw: Have you ever calculated the COP and accounting for the energy lost due to boiling?

Arik El-Boher: Yeah, it was another 10 megawatts or so. It was huge amount of heat. And one of the temperature elements which was above the water level was at 120 °C. I mean it was really hot inside the cell. And just for you to know that after the first episode ended, all the temperatures came down and stabilize at the same levels as at the time we started the experiment #64.

So the calorimeter worked perfectly. And when we filled it in and was ready to start the second episode, the second trial with the same cathode, the same Palladium Cathode, we didn't change anything. And then all the temperatures were stabilized at the bath temperature level. Actually at the bath temperature because those three cells have been immersed in a temperature controlled bath. We had a refrigerator which was removing heat from the bath in order to keep the bath water temperature constant and stable over long time, the outer aluminum cylindrical wall surface was kept at constant temperature and was less than 0.1C higher than the bath temperature.

During these two bursts that I'm talking about, (#64a&b), the bath water temperature went up due to the burst of heat which was absorbed in the bath's water. This in spite the fact that heat was removed from the bath by temperature control refrigerator. We were measuring the temperature of the bath as well, and it was in complete correlation with all the other temperature elements which were inside the cell.

Tom Grimshaw: In the cell.

Arik El-Boher: In the cell. Three temperature elements were for indication and two for measuring the Delta T and calculating the output power/heat according to the calibration. So after these results, we start seeing much more events of excess heat [inaudible 00:29:20] and all together we were running about 1000 experiments from which we had a reproducibility rate of about 20%. Now-

Tom Grimshaw: Excuse me, 20% of the cells were-

Arik El-Boher: Were showing [inaudible 00:29:38].

Tom Grimshaw: Okay.

Arik El-Boher: Now, we were, as I said, conservative. Remember every COP number I give you is when we are dividing the denominator (Pout-Pinet) by P in, which is the total amount of input power, which was delivered to the cell, calculated as I times V. And in an open cell, you have to subtract from the input power the dissociation power, because this term (P_D) is not contributing to the thermal effect. So in the denominator we had Pout minus Pinet, but we were dividing by the total input power.

Tom Grimshaw: Okay. Let me ask this, we're at 30 minutes. I'd like to pause, and we'll start another episode. So I would say that this is Tom Grimshaw here with Arik El-Boher, and we're talking about the energetics technologies experiments. It's January 12, and we're going to start a new episode.

Arik El-Boher

Interview 2 of 6

Arik El-Boher: So 64 happened in 2003 and I reported, I gave a presentation in Marseilles in end of October 2004 in ICCF 11.

In Marseilles I showed the two episodes and the tremendous amount of heat which was generated, including the boiling and everything. I showed SEM images of the Pd cathode, in all 4 Pt Teflon insulated leads for in-situ current measurements as well as in the electrochemical current Teflon insulated lead, the Teflon leads were burnt off completely up to a distance of about 3 cm from the cathode foil edges, SEM images of the uninsulated/exposed Pt wires showed that along this 3 cm exposed wires many micro cracks due to the high thermal shock , this due to the very high temperature developed in the Pd cathode, much higher than the measured electrolytic solution temperature (Teflon is burning off at above 300C) . The SEM images of the Pt wires showed clearly several micro spherical droplets of Pd (analyzed by EDS), which were deposited on the Pt leads/wires. This tells us that Pd was melted, evaporated (at over 2900C, such high temperatures may be developed in local micro hot spots) and condensed on the Pt wires, (Pd melts at temperature above 1500C. After reporting our results in ICCF 11, the cathode was cut into many pieces and have been sent for analysis all over the world to laboratories we were collaborating with. [SRI, NRL, ENEA and others 00:01:44] and it was so difficult to find the missing controlling parameter, why it happened and why it didn't happen in such intensity, more.

We couldn't repeat these remarkable results since then. But we had hundreds of percent of COP and even thousands in other systems. First we had COP values of 4-6 in glow discharge cells in which Deuterium ion bombarded Pd films/targets, results reported in ICCF 10 in Boston/Cambridge in August 2003. We started experiments with electrolytic cells and a bit later with glow discharge (GD) cells, then with mass flow calorimetry, with ultrasound (US) excitation. In US systems, we saw excess heat of hundreds, and even thousands or percent, for a much longer time. Because, the ultrasound is not only vibrating/exciting acoustically, the cathode, but it also cleaning it. And you know, there is a build up of all kind of garbage on the cathode, with time, in the electrolytic cells, which are blocking. Some are calling it poisoning. The cathode.

The ultrasound was cleaning the surface, and keeping it active.

Tom Grimshaw: I'm going to jump in. We're going to come back to the ultrasound, 'cause that sounds very interesting. What I'd like to do, and I'm sorry to interrupt you, is talk ... you had 64, and you reported on it in 2004 at Marseilles. So there's a presentation that you gave. That should be on the record.

Arik El-Boher: It's in the list.

Tom Grimshaw: Okay. Was there also a conference proceedings paper prepared as well?

Arik El-Boher: Yeah, yeah, yeah.

Tom Grimshaw: Okay. Alright, and yeah I'm really tempted to let you go onto the future, but I would like to take a few moments to catch up from the period in 2002, until the 64 event. Were you working with just one cell, through that period?

Arik El-Boher: No, no, no. Right from the beginning, we worked with 9 open cells. It's an Isoperibolic calorimetry open electrolytic cells.

Tom Grimshaw: Okay.

Arik El-Boher: So we were running 3 baths full with 40 liters of treated water, in each bath there were 3 cells immersed.

Tom Grimshaw: Okay.

Arik El-Boher: All together 9 cells, and one computer with LabVIEW data acquisition program capable of dealing with 3 cells independently. [inaudible 00:03:45].

Tom Grimshaw: Okay.

Arik El-Boher: So, 3 computers, 9 cells, and each computer had a LabVIEW program capable of handling 3 cells independently, (having 3 independent wave generators and 3 independent data acquisition and processing capabilities). So that each cell could be run completely independently from the others. With 3 power supplies, and 3 resistance measurement devices and NI cards, independently, so that we could run, and we did run! 9 cells, and this is how we got through many experiments.

Tom Grimshaw: Of course.

Arik El-Boher: So, that was the beginning. These were Isoperibolic open cells in which we got many excess heat events. Unlike others, we said that if we have C.O.P. of less than 10%, we disregard it. So, everything above 10% considered as a successful experiment, because, the accuracy of measuring devices was less than 1%. So, we were in a good position.

Tom Grimshaw: Okay.

Arik El-Boher: Counting for those success, starting from about 10%.

Tom Grimshaw: Okay. So, 64, a seminal event. You had 9 cells running in parallel, from about late 2002, on up to the event in 2003.

Arik El-Boher: Up until Thanksgiving of 2017, those 9 cells were kept running.

Tom Grimshaw: Okay. I did not know that.

Arik El-Boher: Graham called them the horse cells.

Tom Grimshaw: Okay. Alright, so could you recall, assuming a top C.O.P. of 1.1, or 10% over, do you recall about how many events you observed before 64 took off? Was there a dozen, or so?

Arik El-Boher: Yeah, it was in the tens, I would say. But, not as violent and as intensive, as 64. There were 54 you could see in my summary of results presentation, in my results, you would be able to see some of those experiments before 64.

Tom Grimshaw: Okay.

Arik El-Boher: And then when counted, and numbered chronologically, so, you see 54, and even earlier. So, we had a few before. Before we left to Missouri, we had all together about 200 events of excess heat, out of about 1,000 experiments.

Tom Grimshaw: Okay, and this is all in the electrolytic?

Arik El-Boher: No, we had also an ultrasound electrolytic experiments counted in these 1000 experiments. All together-

Tom Grimshaw: All together.

Arik El-Boher: All together, the glow discharge, the ultrasound, and open electrolytic cells. Altogether, we run about 1,000 experiments, from which about 200 show excess heat.

Tom Grimshaw: Very good. Now, up until 64, you were only running electrolytic, and then after 64-

Arik El-Boher: GD experiments were started a little bit after we started with the electrolytic Isoperibolic open cells. GD showed excess heat before experiment #64. After exp. #64 we start adding other technologies.

Tom Grimshaw: Okay, can you tell us about that, and, maybe if you remember in what order-

Arik El-Boher: Yeah, we started with GD after the open cells. I developed a Glow Discharge (GD) plasma cells, which were in principle, very simple cells in which we had a palladium thin foil/coating/cathode, (connected to the ground) attached/deposited on a cylindrical horizontal inner SS surface of about 20 millimeters in diameter and 10 centimeters long. At the center there was thoriated tungsten wire (the positive voltage electrode, the anode), and we used deuterium gas. We reduced the pressure to a few millibars/Torrs and we ignited the plasma under constant current mode.

By the way, we work in all our experiments in a constant current mode. Which means that even if something is happening inside the cell. Either delivering excess heat and the voltage is going up, the current is being kept constant, which defines the influx of ions approaching the target/cathode constant, no matter what.

Constant on average, but fluctuating according with the super waves, all systems during Energetics times were operated with super waves. So let us take the glow discharge with mass flow calorimetry as an example, while we were setting the average current in the range of 10-250 mA actually, the instantaneous current will fluctuate according to the super wave configured, from current lower than the average set point and much higher at pick super wave. The voltage was following accordingly around 400 volts and fluctuating in the super wave form. At around 400 volts plasma is ignited the ionized plasma intensity is fluctuating according to the super wave, ions are bombarding the target, (a foil of palladium). After the experiment we looked at the surface of the target using SEM, (Scanning Electron Microscope), we saw pyramids, so that there was mass transfer of Pd, actually ions bombardment was so intense Pd was locally evaporated due to deuterium ions bombardment, condensing and recrystallizing in form of micro pyramids in the same Pd preferred orientation of the original palladium. We got very interesting surface morphology with active huge surface area.

In several GD experiments we saw very high excess heat COP values. One of the experiment was on Friday and I had to shut down the system, I didn't want to leave it running over the weekend while the system is producing excess heat, we kept the cooling water on and shut down the input power (there was no plasma). It took 12 hours for the system to cool down back to room temperature, actually we had heat after death. Usually when there was no excess heat, when input power is shut down usually it take the system only 1 hour to go back to room temperature.

The outer water cooling part of the GD cell had a jacket with spiral fins around the outer horizontal cylinder in which cooling treated water was flowing, we were measuring the mass flow and the inlet and the outlet temperatures. So output power was calculated as m*Cp *delta T, it's a direct first method calorimetry, there is no need for calibration. Of course, you have to calibrate the flows and you have to check that the temperature element are measuring correctly. It's the simplest and most direct method of calorimetry. We had COP values from 1 to 6 in few experiments, but then we couldn't repeat it. In the first experiment in which we had excess heat, we coated the inner stainless steel surface with palladium and after excess heat, all the palladium flaked off, and actually accumulated at the bottom of the cylinder. After shut down it was still active generating excess heat with infinite COP, since the input power was zero (shut down of power supply). As already indicated, it took 12 hours for the cell's temperature to cool down and to stabilize at room temperature.

These results have been presented by me in Boston in ICCF10 in 2003.

Tom Grimshaw: Whichever.

Arik El-Boher: In Boston, and...

Tom Grimshaw: So so far...

Arik El-Boher: Mike [00:12:36] when interviewed in ICCF 10 said that his jaw dropped to watch the results. Then we got into ultrasound excitation, with open-cell water-cooled calorimetry with 4 ultrasound transducers which were delivering ultrasound waves to the focus were the cathode was located. And we got tremendous long lasting (over months) excess heat events.

Tom Grimshaw: Yep. I have to stop us, you're... when you were talking about the... just keep it clear for the audience... when you were talking about the instrument that took a long time to cool down that was glow discharge that you were[crosstalk 00:13:25]

Arik El-Boher: Yeah.

Tom Grimshaw: Okay. So now you're gonna talk about the super wave [crosstalk 00:13:34]

Arik El-Boher: Ultrasound?

Tom Grimshaw: Ultrasound yes[crosstalk 00:13:32]

Arik El-Boher: All systems were running with super waves.[crosstalk 00:13:36]

Tom Grimshaw: Yeah okay.

Arik El-Boher: But in addition to the super waves, we add another mean of dynamics which was the ultrasound excitation.

Tom Grimshaw: Right.

Arik El-Boher: What we got and proved experimentally is that we had cavitation in the vicinity of the cathode. In other words, the cathode was actually impinged or hammered, like micro hammers, hitting the surface of the cathode, and as a result as I explained, it was cleaning the surface, keeping it active for a very long time, allowing getting excess heat over 2 to 3 months continuously. And...

Tom Grimshaw: I should also point out that this was still in electrolytic cells but what was different from the horse cells that continued alongside, this was a special experiment, not denying that ran in parallel, but this was a separate electrolytic experiment stimulated with super waves and by adding ultrasound waves.

Arik El-Boher: The cathode in US cell was actually put in such position that each transducer was in 45 degrees to the Pd cathode from both sides, so that all the four transducers are hitting the cathode at the same angle, of 45 degrees. "How do we know that we got cavitation?" because we replaced the palladium foil with an aluminum foil and it was completely perforated. Visually you could see tremendous amount of passing through pores along the cathode. The diameter of the membrane of the ultrasound transducer was about one and a half inches, which was more or less the length of the cathode so the whole cathode was covered with US waves. I mean, ultrasound waves were propagating through the cooling water jacket, through the quartz beaker's wall into the D_2O+0.1 M LiOD solution approaching the Pd cathode.

Tom Grimshaw: The electrolytic fluid.

Arik El-Boher: The anode cathode assembly was immersed in a quartz cell which was immersed in treated a water jacket circulated by magnetic stirrer, this jacket was water-cooled using a SS coil mounted close to the water jacket inner SS wall, immersed in the water jacket. This design allows having a mass-flow calorimetry, so the waves were propagating through the tap treated water, into the heavy water through the glass into the cathode.

The US waves were propagating and generating cavitation in the vicinity of the cathode.

I gave you summary of results' presentation in which you can see also the ultrasound results, in which you can see that there were huge amounts of excess energy, with large values of 600 percent, 3000 percent and even more. We also we got into gas loading of Pd and Ni alloys powders, but we never saw excess heat in these experiments, never. We tried all kind of excitation in gas loading cell experiments. We even introduced, (since it was a gas-loading systems), super-pressure waves, at different temperatures [inaudible 00:17:39]

Tom Grimshaw: And you said palladium powder was the...

Arik El-Boher: Yeah.

Tom Grimshaw: Okay.

Arik El-Boher: In the beginning we started with micro powder and then we moved to nano powders: we didn't see any excess heat. We even later [inaudible 00:17:57], tried to replicate Celani experiments with different Constantan alloy wires which were surface treated with different procedures. The wires were wounded on ceramic core, put in our water cooled mass flow calorimetry. We got no excess heat in all experiments conducted.

Tom Grimshaw: Right and were gonna get to that [crosstalk 00:18:07] as well

Arik El-Boher: We also replicate Parkhomov and Martin Fleischmann Memorial Project: **MFMP** experiments with Ni and Ni alloy mixtures, we saw zero excess heat

Tom Grimshaw: Bolson

Arik El-Boher: In Parkhomov cell he was just measuring temperatures to see if there was any change in temperature as compared to a reference cell under the same conditions.

Tom Grimshaw: Okay.

Arik El-Boher: In temperature.

Tom Grimshaw: So we're gonna hold those off we're gonna cover them when we get to SKINR.

Arik El-Boher: So after '64, after we felt so good, actually people were dancing in the lab, we published the results and at that time Sydney asked for new investors to come in. So we said in order to be able to find investors we need to publish our results in popular media.

Tom Grimshaw: Made... okay.

Arik El-Boher: So we went to 60 minutes and we suggested to have a program on what we were doing and you know that cold fusion has a very bad reputation so they were very hesitant to go for it, so they consulted with Rob Duncan, and Rob Duncan said "Look I'm an open minded guy, I can be a referee, and I can go with you to Israel, and let's see what they have." Rob came to Israel... I think it was already 2008 and he was with us for a week... and all this time 60 minutes were taking a lot of footage. The 60 minutes "Cold Fusion is Hot Again" was broadcasted on April 2009.

Tom Grimshaw: What was going on experimentally?

Arik El-Boher: Yeah, we explained to Rob what we are doing and how we are doing at every detail and he got into all details, he dug in very deeply and asked all the good questions, all the right questions, and at the end of this week he said "I'm convinced this excess heat is real." And this is what he said in the 60 minutes piece.

At that time, a professor named Richard Lawrence Garwin whom I met and presented the results and couldn't convince him. He said in 60 minutes "I will believe it if I could see that you can heat up a cup of tea again and again." And remember the #64 was at boiling conditions, not for minutes but for hours and hours. But he was not convinced and repeated it in the 60 minutes piece, he couldn't find any fault or an artifact in our experiments but kept saying what he said with the "cup of tea" Okay? Fine!

Tom Grimshaw: What was going on in the laboratory during Duncan's visit? What experiments were under way [crosstalk 00:21:51] that he observed?

Arik El-Boher: All the experiments, he saw excess heat [inaudible 00:21:54] while he was there, he saw excess heat, not at that level of #64 but it was 40 or 50 percent in one of the open cells, and also another excess heat in the ultrasound system and he checked everything and he said "look... I must admit it looks real. The excess heat looks real" and he said "I don't believe that I'm saying it, but this is what I must say as a physicist"

When he came back to the University of Missouri as a vice-chancellor for research, he preached about what we are doing and about our achievements, and he convinced Sydney Kimmel to move Energetics to the United States, to Columbia Missouri.

Tom Grimshaw: Why did he want that? What was the reason that he...

Arik El-Boher: He was so convinced that he wanted it near him and to be involved in it, he was preaching, he gave presentations, in physics and in other departments in the University conveying his confidence in what we were doing. When we arrived to Columbia scientists were ready for us and wanted to collaborate with us. [00:23:40] and [00:23:40] the team from the nuclear reactor MURR and others.

Tom Grimshaw: Prelas comes to mind

Arik El-Boher: Mike Prelas and Mike Prelas was working on cold fusion...

Tom Grimshaw: When you came...

Arik El-Boher: And the University killed it, I mean, he had very interesting results, but they stopped his program...

Tom Grimshaw: Before any of...

Arik El-Boher: Before we arrived, I mean years before we arrived. We also worked with Katesh, Kathy Katesh a professor for radiology who developed nano-particles for medical applications. I came and said to him: "Let's work together! You will prepare solutions of Pd nano-particles for us". Originally Kattesh conducted research with Gold irradiated nano particles solutions which have been injected into cancer prostate tumor with good results in animals. So I said "Can you prepare for us palladium positively charged nano-particles and we charge these solutions in our electrolytic cell. Think about charged particles which are actually migrated toward the palladium cathode and precipitated on it. Nano-palladium, so you get a very highly developed surface. We got very interesting results.

Tom Grimshaw: Okay.

Arik El-Boher: Very interesting results.

Tom Grimshaw: Now this was during the 2 years that the Energetics Technologies USA LLC was at the Incubator

Arik El-Boher: In the Incubator and on. I mean I worked with Kathy Katesh right from the beginning as we arrived to Columbia [inaudible 00:25:26]. We worked [inaudible 00:25:33] with nano-particles, solutions for 7 to 8 years. Not only 2, when we moved to the University we continued working together.

Tom Grimshaw: Right.

Arik El-Boher: We got very interesting events of excess heat, but lets go back. So when we had the #64 results and after proposed to DARPA to independently replicate our results. A two phase program approved by DAPA with a 3.0 million dollars budget. The DARPA replication was successful and with all these achievements [inaudible 00:26:00] we applied to 60 minutes and we suggested to have a program/piece on our technologies so that others will show and judge if this is real or not. In the first phase of the replication program 2 groups were involved, (SRI and ENEA). [inaudible 00:26:19] Mike McKubre got 3 cells from us all the necessary hardware together with a computer and full LabVIEW program, we educated them how to use the equipment and from that moment on, they continued by themselves independently.

Tom Grimshaw: In their own facilities in Italy and McKubre in SRI.

Arik El-Boher: Yes and eventually there was a SRI report, that summarized the results in the first phase of replication, a report in which he, Mike, claimed that they achieved 75 percent reproducibility, in other words he conducted about 30 experiments over 2 years, half-year he was dealing with calibration only, just to make sure that our open cell colorimeters, , these Isoperibolic cells, were accurate. And after half a year he said "It is accurate and now I can work on it" and in some experiments he worked with super waves in some experiments he worked with DC, and he did whatever he wanted with the facility we delivered. Actually we got much more money than what it cost us to deliver the facility, that was about 10%of the 3 million dollars of the two phase program. 3.5 actually

The phase one replication program was very successful and as a result the second phase was approved.

Tom Grimshaw: Oh, excuse me. ENEA [inaudible 00:28:05] also had successful replication?

Arik El-Boher: Not only that he saw the same effect as we did. When there was excess heat, everything start being fluctuative, you know, the resistance measurement start fluctuating, and the voltage went up, there was a buildup of voltage. Usually we were working with 3 volts, in #64 it went up to 15 volts. He saw the same thing. And then we start thinking "Why it is happening? What is happening? Is it a double layer? Is it because you get boiling and as a result the cell resistance goes up?" And so on and so forth.

So after success of phase 1, we went into phase 2 with NRL and SRI got into the picture. They also got facilities from us but they did whatever they wanted with it. We didn't even see the final report of phase 2.

Tom Grimshaw: You were still in Israel at that time.

Arik El-Boher: Yes. Yes. And with all this Rob Duncan came to Israel with the 60 minutes team, he knew about DARPA program. That gave him a good background and overview of what we are doing. DARPA is a very respectful and prestigious agency that selected to work with us with a budget of 3.5 million dollars. It is a lot of money.

Tom Grimshaw: Do you recall who the program manager was at DARPA?

Arik El-Boher: Yes, Judah Goldwasser was the project manager in the 2 phases Energetics Replication program.

Tom Grimshaw: Okay. Okay so now would be a good time to take another break. So this is Tom Grimshaw. This is the completion of the second phase. I don't think I had a chance to say that this was the second phase at the beginning. So we'll fill that in on the transcription. But I'm here with Arik El-Boher it's January 12th and we'll stop here and start another one.

Arik El-Boher

Interview 3 of 6

Tom Grimshaw: Okay, Tom Grimshaw here again. This is the third episode of Interview with Arik El-Boher here in Columbia, January 12th. And in our last session Arik, you were talking about the work that Energetics Technologies was doing with DARPA sponsorship while Energetics was still in Israel and you collaborated during phase 1 with SRI International. Mike McKubre and also with Vittorio Violante from ENEA in Italy.

And then in phase 2, the naval research lab, NRL, got involved. So why don't you pick it up there, Arik, and tell the story, and what's ... particularly the experiments that were being run at the time you made the transition to the United States.

Arik El-Boher: Okay, but before, at that time, after we got the money from DARPA, which by the way, about 90% of it went to the American institutions. We got only the 10%. Although we were the initiators, and so on. Because we were not Americans. And so, we had to have collaborators in America. And they got most of the money, which is okay. For us it was important enough to have the approval by DARPA and so on and so forth.

Tom Grimshaw: NRL?

Arik El-Boher: At that time--

Tom Grimshaw: SRI, and then NRL were the American part collaborators.

Arik El-Boher: Yes, at that time, Sidney asked us to find investors for Energetics with these results and the approval of DARPA, he said "I believe that other investors will contribute as well."

Alright. So we had very good background, DARPA and results and everything so we approached two wealthy Israelis. One is Mr. Yitzhak Tshuva [Tshuva 00:02:16] and the other one is Mr. Stef Wertheimer. Stef was the owner of Iscar which was acquired by Warren Buffet for about 4 Billion dollars. Two huge entrepreneurs, Tshuva in the field of energy, discovered few years ago offshore huge natural gas reserves and Werthheimer, is a real entrepreneur in a variety of technological fields. His career was in manufacturing facilities all over the world for cutting tools, high-speed cutting tools. They were both very interested in investing in Energetics. Energetics was located at Omer Industrial park,which is close to Beersheba. This industrial park was established by Mr. Wertheimer and is the owner of this park.

We talked to Wertheimer and he was interested in investing. As well as Tshuva. Tshuva was in the energy business and he just discovered, the huge gas fields in the Mediterranean, close to the Israeli coast. So you can imagine, the amount of money that they both have. And they were interested, very interested, and actually we brought Tshuva to New York to the office of Sidney Kimmel in his apartment building in Manhattan New York, in front of Central Park.

Tom Grimshaw: Central Park?

Arik El-Boher: Central Park, yeah. So, we were sitting there. He said, "I'm interested, I'm going to invest 50 million dollars in Energetics technology Yeah. He opened the check book, and was ready to sign the check book 50 million dollars, but before was asking "What is the value of Energetics?" Sidney without hesitation said "One billion dollars." Tshuva said "Thank you, bye-bye" and left. That was the end of it.

Tom Grimshaw: Why did he ... I don't understand, what was the dynamic that caused him to change his mind?

Arik El-Boher: Who? Who changed his mind?

Tom Grimshaw: Well, he was ready to write a check for 50-

Arik El-Boher: He was ready to write a check, he thought that he would get 50 percent of the company.

Tom Grimshaw: Okay.

Arik El-Boher: Alright? But Sydney gave him an evaluation of one billion dollars.

Tom Grimshaw: Oh, so his [crosstalk 00:05:00]

Arik El-Boher: So he said "Thank you very much." And left.

Tom Grimshaw: Yeah. Too small a percentage.

Arik El-Boher: Tshuva said "I wish you all success," and went out of the office. And after he left, we asked Sydney "Why you gave such an outrages evaluation? One billion dollar? Where did you bring this figure from?" He said "No, I just wanted to check if he's interested. For me to know. If he's interested, I will keep investing. I don't need his money."
Then, we brought Stef Werthheimer

Tom Grimshaw: The guy with the Iscar.

Arik El-Boher: Yeah.

Tom Grimshaw: The company that Warren Buffet bought.

Arik El-Boher: Stef said "I will put 50 million dollars, but on one condition that the company will stay in Israel and I even don't ask for 50 percent for me. But together with the options that the workers have, we want to have together, 51 percent." Sydney came back and said "no". Because he was an entrepreneur producing jobs all over the country. All kinds of projects. He was tremendous entrepreneur. Very bright, smart guy. And Sidney said "No, I will not give majority, even not together with the employees." And that was the end of it. And he continued financing. He said again, "I don't need this money. I see that it's interesting and people are interested so I'll keep financing Energetics"

Tom Grimshaw: He was testing the water.

Arik El-Boher: Right.

You know, we were claiming that we have such and such results, and our technology is very interesting and very promising and it can become a big business in the future and so on and so forth. Sidney Kimmel came from the apparel business, so he didn't understand anything about science.

Although we tried over the years in meetings, to explain and to share with him all the information and background. Energetics Ltd and LLC reported to Sidney annually, after we moved to the university, Rob did it and then Graham did it in meetings and in written reports.

He continued financing and in 2009, we were in ICCF 15 [ICCF 00:07:59] in Rome in 5-9 of October2009. Rob was there for the first time after being in Israel. Only then during lunch with Rob, we realized that he convinced Sidney to move to Missouri, to Columbia. Rob said "I talked to Sidney and Sidney and Sidney decided to move everything to the United States".

What? How come? And so on.

We were, at that time, about 35 people on the payroll. It was huge operation already, Sidney's financial adviser asked us: "Tell me who are the key people to move to America and who wish to move to America?"

The idea was to move first for seven months. We didn't know if there will be a continuation after the 7 months. Rob told us that that lunch, that if we shall move to the States with a group of Israelis, then probably the company will be located in the incubator of the university.

Since Energetics USA LLC is a private enterprise, so the incubator is the right place for the company, of course if we agree to move.

It took us some time to digest this news and eventually we we're ready to move. Seven key persons were ready to move to Columbia, Missouri. We looked in the internet, where is Columbia Missouri? And what is Columbia? We found out that Columbia was the third of the top best cities to live in America, so we gave our agreement to move.

Knowing about the top class facilities the university is offering and that groups of scientists are ready to collaborate with us after Rob's preaching we realized that after all, Columbia is a good place to move to and we gave our consent.

Tom Grimshaw: May I jump in at this point and clarify a few things and then pick up the story.

What was Energetics Technologies doing experimentally during that time when you learned that you would be coming to the U.S.? You still have the nine horse cells operating?

Arik El-Boher: Yeah, everything was running. We were running experiments in all the systems, including the gas-loading, we did conduct at that time experiments in the glow discharge, in spite the fact that we stopped seeing excess heat but we continued running the GD cells and on which I was directly in charged on.[inaudible 00:11:24] in addition to my position as the R&D manager and deputy CEO.

Tom Grimshaw: And the acoustic, or ultra sonic ...

Arik El-Boher: And the ultra sound as well as the gas-loading with the powders, all was running.

Tom Grimshaw: Okay, good.

And my second question is, who were the seven that were to make the transition?

Arik El-Boher: The group of seven were: Tanya Zilov [Zhilov 00:11:55] which was our electrochemist, which was with us from the beginning. There was [Dr. Boris Khatchaturov 00:12:03] who was a nuclear scientist. There was [Dr. Mark Tsirlin 00:12:08] who was our material scientist. There are presentations which I gave you that Mark prepared.

Tom Grimshaw: And I met Mark one time.

Arik El-Boher: He's a very brilliant scientist, a forth degree Doctor.

Tom Grimshaw: Russian?

Arik El-Boher: Most of them are Russian?

Tom Grimshaw: Yes.

Arik El-Boher: [Dr. Shaul Lesin00:12:27] the CEO, myself. So let's see, [Tanya Zilov 00:12:31], [Boris Khatchaturov 00:12:31], Dr. Sasha Shapira, who is a data acquisition specialist.

Tom Grimshaw: Mark.

Arik El-Boher: No, no. I didn't say Mark?

Tom Grimshaw: I don't think so.

Arik El-Boher: [Mark Tirling 00:12:54], then [Dr. Vitaly Ikrakov 00:12:56] who is a chemo-physicist. And [Dr. Shaul Lessin 00:13:12] and myself. Seven people.

I moved with my wife Ora. Mark Tsirlin also moved with his wife [Mark Tirling 00:13:23]. All the rest came alone and they were married or [Shaoul 00:13:32] had a girlfriend back in Israel. It was very difficult for them. Therefore after 7 months Tanya and Boris returned to Israel and after 21 months Shaul, Vitaly and Sasha left to Israel. Only Mark and me moved to the University, as SKINR, we hired local scientists, technician and engineer.

We came to the incubator. Actually, half a year before, I have been, together with Shaul [inaudible 00:13:43] in the the incubator, to see the infrastructure. What is needed? We designed the lab, together with the architects from the university and MU facilities and the whole project was put together with all the infrastructure on September 2010 together with the labs and the offices and everything, it cost more than one million dollars.

Just to build the labs, the infrastructure, and very excellent air conditioning system with an accuracy of plus minus half degree centigrade stability. Temperature is stable all year round. Doesn't matter if it's freezing outside, or hot summer it was kept constant and it is very important for a good calorimetry [inaudible 00:14:35]. How we did it in Israel, with a lot of split AC units for cooling and heating which were working continuously and independently so that there were no fluctuations in temperature, better than plus minus 0.5C.

Here in the incubator, there was a sophisticated system, very expensive, very unique. It is still there. Nobody is using it because it is overkill.

They built the Labs and offices according with our design, by the way, the labs and offices were designed by my wife, Ora. She's an architect. They promised that it would be ready by July, for the time the crew will arrive in 2010. It didn't. They finish it by September 2010. By the end of 2009, actually we started to disassemble the facilities in the beginning November 2009, we shut down everything in November 2009 and we started disassembling and knowing that we have to reassembled it again in Columbia, so everything was tugged and documented, we prepared disassembly and assembly procedures followed by many pictures.

Which part of it I sent you, in the files that I gave you.

Everything was packed by the end of December in two 40 feet containers. All our life, everything, was there. Equipment which worth more than two million dollars for sure pack professionally in this two containers.

Tom Grimshaw: Large shipping containers?

Arik El-Boher: Yeah, 40 feet long each. They were shipped via sea to Columbia. The two containers arrived already in January 2010 in Columbia in a storage warehouse waiting for us. Now, the facilities were waiting in Columbia, but the incubator labs were not ready, so we had to wait. We were waiting from January to July 2010, in order to move to Columbia. Eventually in July 5th we arrived 5 people for the first time. Shaul and me visited Columbia two times before July 5th 2010, in order to meet with the designers, to meet the architects in order to convert our architecture drawings into the American standard, they did a terrific job exactly according to our designs of the labs and offices.

There was a dedicated lab for each technology, for the Glow Discharge, for the open cells, for the ultra sound, for the gas-loading and so on. Also room for the preparation of Pd cathodes we were rolling it, we were annealing it, we were sometimes polishing it, so we had preparation and cells assembling lab.

We had also workshop for all kinds of mechanical works. Everything was part of my detailed design and they built it exactly according to our design. I don't know if you visited our incubator's Labs it was top class and unique Lab worldwide. I know that you have been iu our University's Labs, right?

Tom Grimshaw: I've been only in the SKINR lab, not in Energetics Incubator's Labs [crosstalk 00:18:26]

Arik El-Boher: So the SKINR lab was 10 times lower standard than the incubator's Labs standard. In the incubator it was first class lab of course with 220 and 110 volts, because most of the equipment was coming from Israel.

By end of November 2010, in two months, we finished the assembly of all our facilities and they were fully operational. Every system that was operated in Israel, was operational in the incubator. The seven months passed from July and we got extension up to almost two years until end March 2012. In which Sidney said, "That's it, I'm leaving."

And he said "But, I will give everything, the labs, the know-how, the people, as a gift to the university including the IPs." intellectual properties which were registered as patents in Europe, in China, in America, at least in America they were pending aud we couldn't succeed registering them in America. But in Europe and China in some other countries, in England, Germany, France and so on, patents were registered.

Those were patents on the super waves and all our technologies that we were using.

All this was given as a gift, (equipment, people, actually everything), to the university plus 5.5 million dollars for five years of research which was enough till the mid-December, 2017.

We started SKINR's operation in the university in April 1st, 2012 after Energetics LLC ceased to operate and we moved once again to the university.

Now, this time, there wasn't enough space so we had to split our labs and we got a space in electrical engineering and another space in physics, so we put the glow discharge and the gas-loading [inaudible 00:21:25] experiments in physics. We had the machine shop there. And our warehouse for equipment that we didn't use, and the open cells, the ultra sound, the thermoelectric [inaudible 00:21:43] as well as all the cells which we developed in SKINR. Close cells with internal recombiners and 4 open cells have been converted into like close cells. They were not helium tight close cells since hydrogen could be released, but most of the hydrogen was caught by the recombiners. We had very nice results also with these internal semi closed cells, (those were the same open cells, but with internal recombiners).

Tom Grimshaw: Okay, I'm gonna stop just for a moment here, because I wanna pick up the SKINR part. There are some things that I'd like to cover during the two years or so when you were in the incubator.

During those two years you had these parallel efforts going on with the different experiments, did those continue throughout the life of Energetics USA?

Arik El-Boher: Yes.

Tom Grimshaw: Okay, and so you were generating experimental results and making reports and so forth throughout that time?

Arik El-Boher: Right. And you have the files, you have the presentations and the results.

Tom Grimshaw: Right. Okay, then can you tell me or give any insight, was Sidney Kimmel, I mean he was the catalyst that caused the change from the LLC to the gift to the university. Anything you can say? I don't wanna ask you anything that is really experimental, but people would naturally wonder, do you why he made that decision?

Arik El-Boher: He believed that if we will be successful, it will be right for him to have the business in America and not in Israel. I think it was a mistake.

Tom Grimshaw: I see.

Arik El-Boher: I think it was a mistake because we lost quite a bit of know-how because people left. We became seven, we were 35 people, all those engineers and scientists gained a lot of experience and they vanished. We tried to explain it to him until we saw that there is no merit in it.

We tried to fight it, to stay in Israel.

But it was his idea that if we will be successful and we shall solve all the scientific and engineering problems and [inaudible 00:24:28] if we will be in full control of the heat process and with full reproducibility (having heat on demand at commercial level) so that can lead to industrial production of heat source for power conversion or for domestic heating or to any other application, then the right place to have such a business is in America.

That was his idea.

Tom Grimshaw: Okay. And then at the end of the time when he decided to withdraw and gift it to the university, what was his thinking do you think at that time?

Arik El-Boher: Look, he didn't want to kill it. He wanted to give it a chance, because even with our moved to the university, he still kept 50% in the technology rights and the university got also 50%. Sidney would get 50% of the fruits if there will be a commercial success. He was interested in continuation of the research. He wanted to keep it going because he knew that there is a potential but it's not for a small private company to solve all the problems. We told Sidney and he knew that our technology deserves much more fundamental research which only can be conducted in the University having the required instruments and groups of scientists who were willing to collaborate with SKINR.

We told Sidney very clearly that our technology is really deserving much more research, fundamental research, to be able to understand what is going on. Why we don't have control of heat process and why it is not happening on demand when we want it to happen.

Tom Grimshaw: It was during those two years that these problems of reproducibility became salient, I would say.

Arik El-Boher: Yeah, but he didn't lose hope. He hoped that it will be successful so he put another 5.5 million dollars given to the University as a gift. Sidney said: "If you will be successful, fine, if not, that's it". And this is how it was.

Actually, by the end of the period (end of March 2017), we found financing for our activity for another few months and he said, "If you will raise money, I will match it." And he did. We found $150,000. He matched it. In another with additional $150,000 in addition to the 5.5 million and this is how we could carry on till mid December 2017, instead of stopping after five years.

Tom Grimshaw: Is it public information who the contributor was? Can that be disclosed, or is it confidential?

Arik El-Boher: At this point, I can't disclose, who was the investor, not because I don't want, but because the investor doesn't want.

Tom Grimshaw: Okay. That's fair. I had to ask.

Arik El-Boher: I didn't mention another cells which I developed, the closed cell. I took the open cell which needs calibrations, kept the same dimensions. [inaudible 00:27:45] I modified it into a real closed cell keeping exactly the open cell dimensions. The design allowed Helium tight closed cell with mass flow calorimetry which doesn't need calibration. In this cell we got excess heat events with Pd Nano particles solution, with [inaudible 00:28:12], Single Wall Carbon Nano Tubes (SWCNT). In this system we got many events of excess heat. There was no question anymore about the validity of the excess heat events simply because there is no need for calibrations which always raise questions, the calculation of COP is simpler, because you don't need any more to subtract P_D from Pin (since P_D the dissociation power dissociates the heavy water molecule in to deuterium and oxygen which are then recombined inside the cell back into D_2O with release of heat in an exothermic reaction, this heat is equal exactly to P_D). Therefore in closed cell there isn't such thing Pinet and COP is simply calculated as (Pout-Pin)/Pin, where Pin is calculated as I times V and Pout is calculated as m*Cp*(Tout-Tin), where m is the mass flow of the cooling water measured by very accurate Porter mass flow controller, Cp is the heat capacity of the cooling water which depends on the water temperature and Delta T is measured by inlet and outlet PT100 accurate temperature elements. Cooling water is flowing in a jacket surrounding the cell, the cell is well thermally insulated and being put in a constant temperature controlled incubator with stability of +/- 0.1C. We could go with this system above boiling point because it's a closed system and you can elevate the inside cell pressure. The run the cell at 120C and even 150C. Since the cell is a Helium tight, we wanted to detect an increase of ^{4}He concentration during excess heat events, but unfortunately we didn't find Mass spec. which is sensitive enough to distinguish between ^{4}He and D_2 without using a gutter to remove the D_2 from the system.

As well known, an increase in 4He concentration during excess heat event is the ultimate proof that Cold Fusion/LENR is really caused by fusion of deuterium atoms!

Tom Grimshaw: Now was this still in the incubator or after you got into the university?

Arik El-Boher: We had these Helium tight close cells fully operational, already in Israel. We moved them here. We had them fully operational in the incubator as well as in SKINR [inaudible 00:29:53].

Tom Grimshaw: Okay. Good.

Okay, I think this is another good stopping point. We're at 30 minutes. This is Tom Grimshaw with Arik El-Boher on January 12 we're talking about energetics technologies and SKINR and we'll pick up again here shortly.

Arik El-Boher

Interview 4 of 6

Tom Grimshaw: Okay, this is Tom Grimshaw here with Arik El-Boher, and we are talking about energetics technologies and Sidney Kimmel Institute for Nuclear Renaissance. We completed the part of the story for energetics technologies in Israel and then in the incubator at the University of Missouri. Arik, I'll ask you to pick it up here. It's January 12th and we'll take off from there. Let's talk about mostly, what happened at Skinner this time please.

Arik El-Boher: Okay. So we moved in end of March 2012. We moved from the incubator to the University. We got split spaces. We had the electrolytic cells in electric engineering and the gas cells in physics. Gas cells means the Glow Discharge and the gas loading, powder loading, Celani's wires, etc., all this was done in physics. We worked with seven different scientific groups University of Missouri. We worked with Mark Prelas, who worked, on gas loading and thermal shock with powder and sponges of palladium, he had some interesting results, but they were not conclusive.

Eventually we stopped the program with Mark, but we continued with John Gahl in the cyclotron, a high intensity ion beams bombardment of deuterium and hydrogen. High focused ion beam on palladium targets, target was water cooled but we didn't see excesses there. We worked with Shubhra Gangopadhyay on Meta materials. Meta Pd metals with variety of nano structures on it [inaudible 00:02:48]. We worked on nano palladium solutions where the particles are positively charged and as you apply positive potential it will push the nanoparticles and they will precipitated on the palladium cathode. This precipitation of Nano particles caused a development of actually very high and very active surfaces. With these solutions developed and prepared by Kattesh Katti we got tens of events of excess heat, in the Lab located in electric engineering. We got, good results with Shubhra, positive results with nano structures, with Single Wall Carbon Nano Tubes (SWCNT). We got spontaneous bursts of heat with SWCNT of up to 5,000% and 7,000%. This corresponds to COP values of 50 and 70 with a lot of excess energy. As I mentioned before, when we measure the cell port voltage with a multi-tester we change the impedance and that caused the burst to collapse and stopped.

Then few days after we had another a smaller burst [inaudible 00:04:30]. So altogether, we had tens of positive results in SKINR. That event in which we changed the impedance of the system while measuring the cell voltage, told us that probably when excess heat occurs, RF at certain frequencies are emitted, affecting the cell impedance. The loaded Pd deuterium system can be excited by RF at a proper frequency, which may bring the system into a resonance state and to trigger excess heat. <u>You may excite the system with RF, but when you have excess heat, RF frequencies are being induced/emitted from the Pd cathode.</u> [inaudible 00:05:13]. We have some other groups all over the world which are in agreement with us about this RF phenomenon. Therefore, we continue our work with our facilities that came from Israel to the incubator and from the incubator to SKINR but we apply all kinds of different excitation means. Electromagnetic pulses, laser, RF, ultrasound, local ultrasound and in some of them we got very interesting results. Positive results, excited events. The process is uncontrollable and it's not happening on demand. Although, we have no doubt that dynamics has to be applied to the system in terms of exciting the system, (that is palladium hydrogen or palladium deuterium system), much more fundamental research work is needed to try to understand the proper role and mechanism of loaded systems with excitation in order to achieve eventually full controllability on the generation of excess heat in huge amounts.

I have no doubt that these huge excess heat events are real, but there's a long way to go to be able to commercialize it.

Tom Grimshaw: Yes. Okay, so I would like to back track a little bit and we'll pull three threads here. We'll start with the work that was done internally by your own staff at SKINR and the experiments and then we'll do the collaborations with the other members of the university. Then third we'll do collaborations with other entities outside of the university. Okay?

Could you please kind of reel back from the time when the move was made from the incubator to the University? You were split in two parts in the physics building and the engineering building and the gas related experiments were in one location and the electrolytic experiments were at the other location. However you want to do it. I'd say start with the maybe the electrolytic work. The cells that were operating at the time. You had indicated that there were nine cells that were carried through, but I think you said you converted them from open cell to closed cell.

Arik El-Boher: Open cells which were modified into a Semi- closed cells. They are not Helium tight, but they recombine successfully oxygen and deuterium back into heavy water using an inner recombiner, (this recombiner is simply a thin foil of Teflon impregnated with carbon particles and platinum, this catalyst was purchase from the fuel cells industry).

Tom Grimshaw: Okay, so talk about those cells and then talk about the other electrolytic cells please. The various experiments, ultrasound and so forth. And then we'll cycle back to the gas related experiments.

Arik El-Boher: Okay, so first of all, it was very simple to upgrade the open cells to become semi-closed cells. So energetically wise it was really like closed cells because the inner recombiner kept the heavy water electrolytic solution at constant level for a very long time with no need for makeup. Which means that most of the hydrogen or deuterium and oxygen dissociated was already combined back into water. We had also to modify the [inaudible 00:09:36] LabVIEW program with the help of Eliezer Blasberg our LabVIEW programmer (I wrote all the necessary algorithms for this modification), to allow calculations of powers, energies and COP values as in case of closed cell. The program allows to run the Isoperibolic cells in two modes, as an open cell by pulling out the recombiner or in a closed cell mode (with the internal recombiner). Of course each mode requires a new calibration. We had about 20% of reproducibility. So in other words, 80% of the experiments were not successful. In these non-successful experiments we got Pin exactly equal Pout. That was a good indication that our calorimetry in a semi-closed cell mode, worked perfectly.

Tom Grimshaw: What were the COPs you were getting after that modification?

Arik El-Boher: We got few tens of percent. With the [inaudible 00:11:06] Nano Pd particles solutions, we got in some cases even COP values of over 100%. The results were presented by me in the Erice's meeting in which you also participated.

Tom Grimshaw: So back then you were still continuing the ultrasound cells along side the-

Arik El-Boher: Yes. We run some of the experiments with the ultrasound excited electrolytic cell with internal re-combiner. So it became as a semi closed cell with mass flow calorimetry. Again, here it's even easier to prove that you work accurately because it's a first method of calorimetry and it doesn't need calibration. You don't need to reference the data accumulated to the calibration curve. You just measure the input power, I times V, you measure the mCp Delta T and mass CP is just a constant which depends on the cooling

	water temperature, the program is calculating the Cp, the cooling water heat capacity, as function of the arithmetic average of the Tin and Tout, the average of the inlet and outlet temperatures of the cooling water. Where Delta T= Tout-Tin of the cooling water stream.
Tom Grimshaw:	So, the ultrasound cells. Did you see COP?
Arik El-Boher:	Yes. We saw COP values of a hundreds of percent. As I told you before. We work with google, and we showed them excesses with the ultrasound excitation. Not only that we got excess heat, but we got heat after death. That means that we started decreasing the cell's input current step by step, the electric input power was decreased by us step by step until we reached zero, as we reduced the input power step by step, Pout decreased only slightly and at some level of reduced input power it stabilized and didn't drop to zero for hours with Pin=0, that means that we have infinite value of COP. Google claimed that it's an offset. So we took out the Pd cathode and we put instead a platinum cathode instead' without changing anything else. We rerun the system. At any electrical DC input power level Pin and Pout were exactly the same, identical, which means that the temperature elements and the calorimetry worked perfectly, within accuracy of less than 1%. When we put the back the same Pd cathode (that was producing excess heat and heat after death), the system generated excess heat once again. In spite of everything we did to prove to google that the excess heat they saw is real and that there is no off set, we couldn't convince them. We showed them so many excess heat events in different independent cells also in the open and semi closed cells as well as in the electrolytic closed cells and in the miniature open cells with thermoelectric calorimeters and laser excitation with substantial COP values, we couldn't convince them.
Tom Grimshaw:	It had to do with, one of their had a model that he was using-
Arik El-Boher:	Doctor Fork developed a simulation model in which he claimed the excesses is auxiliary power which is dropped on an imaginary resistance, somewhere between the power supply and the cell, out of the insulated cell. We proved them that there isn't such thing because there was no voltage drop on the leading wires, from the power supply ports to the cell. So there wasn't such thing as imaginary parasitic resistor which consumed power out of the cell. But you know when people come with a fixed idea, you can't do anything to change their minds. By the way, Graham did a comprehensive analysis and wrote several reports regarding the results of the ultrasound cell in order to convince google that the excess heat is real. Graham did a terrific job in trying to convince them in what they saw is real. I'm talking about four, five reports with very detailed simulation analysis. It didn't convince them. Approval by google could save SKINR. That was critical because if we could convince google then SKINR was still alive. That was in a critical point in time in which we knew we have just few more months to go and then our budget will be exhausted. You can ask Graham for these reports!
Tom Grimshaw:	I think you told me that the five year funding would have ended in the summer or-
Arik El-Boher:	In the spring.
Tom Grimshaw:	In the spring of 2017, but you were able to get funding from a confidential source that was matched by Sidney Kimmel. Another-
Arik El-Boher:	Dollar against dollar.
Tom Grimshaw:	Dollar against dollar 150,000 I think you said.
Arik El-Boher:	And he gave another 150,000. So that was $300,000 altogether.

Tom Grimshaw: That kept you going until the middle of December of 2017. Alright, so I want to step back again and kind of do inventory of the experiments being done internally, at SKINRr. You had the converted cells, the horses-cells

Arik El-Boher: Including the closed cell, that's helium tight close cell with mass flow calorimetry.

Tom Grimshaw: Yeah, they had been... Was that the one that was ultrasound?

Arik El-Boher: No, that was without.

Tom Grimshaw: Keep me straight. So you had the converted, the horse cells, were they converted to this, or were they continued as open cells?

Arik El-Boher: Yeah not all of them, if I'm not mistaken, four of them have been modified to become semi-closed cells with Isoperibolic calorimetry.

Tom Grimshaw: Okay. So you had those two and you had the... Wait you said something about thermo-electric.

Arik El-Boher: Yeah, those have been developed in SKINR based on NRL design. So it was basically a aluminum sleeve with a face flange at the bottom. To that flange we attached a thermo-electric unit. So heat was flowing from the cell to the aluminum cylinder and from there down to the bottom aluminum flange. The cold junction of the thermoelectric unit was water cooled and kept at constant temperature. The cooling system was connected to a thermal control temperature bath having accuracy of +/- 0.01C. The thermoelectric calorimeter is in principle like the Isoperibolic calorimeter, since both have to be calibrated, Isoperibolic calibrated by input power versus Delta T and the thermoelectric by input power versus Delta V. You see the delta V. Where Delta V is the thermoelectric voltage develop between the steady constant cold junction temperature and the hot junction which is affected by the heat flowing from the cell down to the hot junction. The higher the input power, or in case of excess heat the Pout the higher is the hot junction temperature and the higher linearly the Delta V. Which is generated by the thermal electric unit. The thermoelectric Delta V is directly proportional to the temperature difference between the hot junction and the cold junction temperatures. We saw many excess heat events in these calorimeters. We had two cells like this and another micro or miniature cell that Jinghao developed. Graham worked for years with Doctor Jinghao He in NRL and convinced him to move to SKINR. [inaudible 00:19:12] The micro electrolytic open cell with thermoelectric calorimetry and with laser excitation developed by Jinghao was a very sensitive and highly accurate and sensitive.

Tom Grimshaw: So you had two kinds of calorimetry cells then?

Arik El-Boher: Yeah.

Tom Grimshaw: Okay,

Arik El-Boher: But based on the same principle. In miniature cell the cold junction was air cooled and the cell was put in a small incubator. The cell itself contained 40ml to 50 ml. The incubators inner temperature was kept constant and stable within +/- 0.1C degrees centigrade. Of course the cell output power was proportional to the thermoelectric voltage. It was so sensitive, that we could sense micro watts. If we didn't supply current to the cell and we just shined a laser on it through a quarts wall, which had power of few tens of micro-watts you could sense it, with no electrolytic current or power input supplied to the cell. Just shining it on the [inaudible 00:20:39] cathode and it could be sensed. It is very sensitive calorimeter.

Tom Grimshaw: Okay, and then the ultrasound cell was separate from any of the others we discussed so far right?

Arik El-Boher: Yeah.

Tom Grimshaw: Yeah. So tell me about the ultrasound experiment.

Arik El-Boher: The ultrasound cell is basically composed of a quartz beaker in which we put the heavy water plus 0.1MLiOD and the assembly of the Pd foil/cathode [inaudible 00:21:10] with 4 Teflon columns in 4 corners, on which Pt wires are spiraled on. There are four ultrasound transducers. Four spirals of platinum serving as four anodes, so that the four transducer emitting the US waves who penetrates in between those fonr columns with spiral platinum wire. So the idea is to have the cathode mounted by 45 degrees to each transducer's face, in such a way that the cathode will be exposed to the US waves coming from the four transducers symmetrically [inaudible 00:22:18], the cathode is mounted at the focus of the four transducers and at the center of the circular cell. The US waves will excite the loaded Pd cathode, creating micro cavities in the vicinity of the cathode. The transducers are emitting US waves at frequency of around 25-27 kilohertz. On a later stage at SKINR, I modified the design by adding a tightening spring and changing the end supports of the Pd cathode, to allow stretching of the Pd foil and keep it stretched and straight during deuterium loading, (as it is well known Pd is elongated during loading).

Now, how do we know that the US waves are generating cavities in the vicinity of the cathode? First, we know from theory that according to the power level and frequencies we were working with, cavitation should be occurred. Second, we replaced the Pd cathode with a very thin aluminum foil, having the same dimensions as of the Pd foil and it was perforated with micro through holes all over. We could control the intensity of the USand the higher intensity, the higher perforation density. So there was no question that we are one, cleaning and leaving the surface active. These cavitation is vibrating the cathode with micro-hammers. So the not only we could clean the surface (a known effect of Ultra Sound), but also to excite the cathode with these local vibrations that allowed us to get excess heat events for a very long time (even months continuously) and with very high COP values, we got thousands of percent of COP values for two and sometimes even three months and with quite nice reproducibility, still not 100%, we were producing the Pd cathode from Pd wires rolled down to 50 micron thick and annealed, from 5 cm long wire of 1 mm in diameter, one can get after rolling 1000 cm long foil of 50 microns thick. From one of the lots, we got 75% reproducibility. These levels of excess heat over long time, accumulatively generated huge amounts of energy, (results can be seen in the summary of results' table in the Summary of Results presentation, I forwarded to you). This is the difference between the open cells, (the horse cells) and the ultrasound cells, because in the open electrolytic cell, cathodes were "poisoned", with time there was precipitation of all kinds of impurities on the cathode while in the US, the US effect cleaned the surface and allow for much longer excess heat events to occur.

This poisoning of the cathode was one of the reasons for the excess heat effect to stop. Unlike in the ultrasound, we could see excess heat events for very long time. Now how we applied US excitation, we applied it in sequences. We were applying the ultrasound continuously for 24 hours, then stop it for seven days. And then again. Every week we were running the ultrasound for 24 hours and then stop it. And you could see the effect when you are applying the ultrasound. You see that all the parameters are jumping up and then after stopping the US, it was stabilizing over few hours, back to the real excess heat level. We were disregarding the calculation of COP values during the24 hours in which ultrasound was applied.

[crosstalk 00:26:17]. After we took out the cathodes which were loaded and excited with US, we analyzed the Pd cathode surfaces very carefully using among others the Scanning Electron Microscope (SEM). The surface of the cathodes was covered uniformly with micro pitting due to the cavitation generated by the US transducers emitting US wave at frequency of 25 to 27 kilohertz as I mentioned before. Just huge number of micro-pitting all over both cathode surfaces. This effect tells us really that there were like micro-hammers created by micro bubbles collapsing on the Pd surface, hitting it and vibrating it. As I mentioned earlier, the cell beaker which was made of quartz, was immersed in treated water and the 4 transducers' SS membranes were in direct contact with the treated water. So that the US waves were propagating through the treated water into the quartz beaker's wall and then in to the heavy water and from there directly to the palladium cathode mounted in 45 degrees to each transducer membrane's surface, which was excited by those waves, creating cavitation and pitting.

Tom Grimshaw: Of the ones that we just described that are in the electrolytic area, I'm gonna review them just one more time. You had the horse, which some of the nine cells were continued as before. Some of them were modified to-

Arik El-Boher: To become what we call semi-closed cell.

Tom Grimshaw: Semi-closed cell. You had two kinds of thermo-electric. One that was really small, two that were not. And then, what did I miss?

Arik El-Boher: And two cells with design based on NRL with Thermo-electric, calorimetry.

Tom Grimshaw: And of course the ultrasound of these cells-

Tom Grimshaw: Right, so which of these were you using super wave? Any of them?

Arik El-Boher: In all of them. I must say that during SKINR time, we worked less with super waves (SW), because Graham wanted to test other things. So, not all the time we run with SW. In energetics, we always run with SW, in all the cells whether it's the helium tight, closed cell, open cells or US cells. Semi closed cells with thermoelectric (TE) calorimetry were developed and built here in SKINR. Not in energetics. At Energetics time it was just plain open cell. Same thing with the ultrasound, we modified the open cells and the US cells into semi-closed cells during SKINR time including the modification of the LabVIEW programs.

Tom Grimshaw: Did you use super waves in any of the electrolytic cells? Did you use the super wave in the horse cells?

Arik El-Boher: No, no, in all of them.

Tom Grimshaw: All of them okay.

Arik El-Boher: All of them. We worked with super waves and with DC and with all kinds of pulses. You see the LabVIEW wave generator allowed us to generate all kinds of signals. This signal (0V-10 V), or even 0 to -10V, it was Bipolar), was delivered into the Kepco Bipolar amplifier. The Kepco amplifier is amplifying these voltage analog signals proportionally to the average current level required by us as set it digitally in the wave generator, it could be DC, SW or any other wave form.

Tom Grimshaw: Okay now let's turn our attention then over to the other part of the lab where the gas was being done. What were the experiments that were running? I'm aware of a few of them but can you kind of give me a run down of what all was being done over there?

Arik El-Boher: We brought from Israel the [inaudible 00:30:59] Glow Discharge and the Gas Loading facilities [inaudible 00:31:01]. As I mentioned, in Israel we run 3 low temperature Glow Discharge (GD) cells we continued to run 2 cells in low temperature cells mode with super waves. We modified one GD cell into high temperature mode (over 600C), with air cooled mass flow calorimetry in which we were bombarding hydrogen ions on Nickel thin foil target. No excess heat was achieved, we were heating it up in a super wave ion bombardment. In Israel we run Pd and Nickel powders with super waves (SW) thermal heating and gas pressure which was oscillated according with SW. No excess heat was observed. We continue in the incubator and later in SKINR with Gas loading experiment with facilities brought from Israel as well as with newly designed and modified systems.

Tom Grimshaw: Okay this is Tom Grimshaw. We're at our 30 minutes and we're gonna pick up with the gas part of the laboratory in our next session which will start soon. Tom Grimshaw here with Arik El-Boher. It's January 12th. We're talking about the Sidney Kimmel Institute for Nuclear

Arik El-Boher

Interview 5 of 6

Tom Grimshaw: Okay. Tom Grimshaw here again, with Arik El-Boher. We're talking about the Sidney Kimmel Institute for Nuclear Renaissance. Let's see. It's January, what'd we say, the 12th?

Arik El-Boher: 12.

Tom Grimshaw: I think this is episode number six, if I'm not mistaken. I kind of lost track there. Arik, when we ended the last session at 30 minutes, you were about to talk about the gas-related experiments in the other part of the SKNIR facility at the University of Missouri.

Arik El-Boher: Yeah. So, as I said, we brought from Israel two facilities. The glow discharge cells, which by the way, I explained before, it was basically a horizontal cylinder with a thoriated tungsten wire at the center, that was the anode, and the cathode was connected to the ground. It was grounded. The 20-millimeter cylinder was either coated with palladium, or we inserted a palladium thin foil, which was attached to the inner cylinder surface. It was 2 centimeters in diameter and 10 centimeters long.

We modified the cells, so that in one end of the cell we put a sapphire window so we could look inside. As the plasma was ignited, since we work with SuperWaves, you could see the plasma waving, according to the SuperWaves. We were using amplifiers which were amplifying the SW analog signal according with the set point. In the LabVIEW program, there was a wave generator subroutine, which was generating the analog 0-10V signal. This signal was amplified and in this case, up to 200 milliamps of current. and up to 5 kV. So very high voltages could be developed if necessary. Those were very powerful power supplies/amplifiers. We were working with constant current mode.

You deliver current, and in order for the currents to cross from the anode to the cathode, you have to ionize the gas. The voltage is built up until ignition. After ignition, you get stabilization, and then the voltage is also fluctuating according with the SuperWaves. It was a mass flow calorimetry.

But unfortunately, after the very nice effects that we saw in Israel, very nice COPs and very nice excess heat events, we couldn't replicate them. I reported in ICCF 10 conferences about our positive results. I also reported in later ICCF conferences without playing games, admitting what we couldn't reproduce these positive results. Of course that again, gives confidence in our calorimetry, because when you don't have excess heat, Pin and Pout are equal. And it's a mass flow calorimetry, so, no calibration is needed and there is no question about the results.

We also brought gas loading cells. In these cells, there was a powder - initially a micro-powder of palladium, and later on nano-powder - with mixtures, with nickel, and all kind of mixtures as recommended by Aher from Boston are. The guy who worked with powders and gas loading, claimed that he saw excess heat, he did not have any direct calorimetry, only indirect as all other researchers in the field. We also had in Energetics Ltd a gas loading facility which allowed to load different types of wires (Pd, Nickel and alloys of them). The cell allowed to heat up the wires with DC or SW applied directly to the wires, high temperatures could be achieved with deuterium or hydrogen. The cell had water mass flow calorimetry. We never ever saw any excess heat event in the gas loading of powders experiments!

Then, after we gave up, Celani approached us and said, "Can you replicate my experiments?" We said, "Yeah." So, he sent us wires which were treated by multiple cycles of heating and cooling the wires in oxygen atmosphere, oxidizing the wires surface in a secret procedure, so that you get very developed surface of the Constantan wires with micro/ nano multi layers structures combinations. All of those wires sent by Celani have been tested in our wires gas loading system, which was modified, by changing the spiral ceramic wire's support into a ceramic wires holder in which the wires were fully exposed to hydrogen in an hexagonal spiral shape (see our reports submitted to you). The cell has water-cooled mass flow calorimetry, so you can't fool the calorimetry, and we didn't see any excess heat.

When we had the ICCF here in Columbia, in 2013. Celani came few days before the conference started. I worked with him for a week. He said, "Try this," and "Try this," and "Try that," and Pin was equal to Pout, period. He was very disappointed. He said, "I don't know why I see excess heat and you don't." He didn't have, in his system, calorimetry. He was just calculating, back-calculating, according to the temperatures that he measured, that there was excess heat. When I said that we have mass flow calorimetry, he said, "Maybe because of that you don't get excess heat."

Tom Grimshaw: I would like to jump in at this point and see. I'm familiar with those experiments because I was working with National Instruments. Celani had given a demonstration at NI week, and then he gave a second presentation in South Korea ICCF.

Arik El-Boher: I was there.

Tom Grimshaw: You were there?

Arik El-Boher: Yeah.

Tom Grimshaw: And he gave a second demonstration at ICCF 17.

Arik El-Boher: In South Korea.

Tom Grimshaw: In South Korea.

Arik El-Boher: I have been there.

Tom Grimshaw: You were there as well. And I was working with NI then to see whether there had been replication, and of course, SKINR was one of the four or five labs that we talked to. The materials he was using was Constantan, which is a copper-nickel-zinc alloy of constant proportion, its unique property is that resistance is kept almost constant in a wide range of temperatures.

Arik El-Boher: He delivered the treated wires, and we used them as he delivered them. Together with him, we conducted the whole procedure, and he said, "Let's try SuperWaves." I said, "Okay, let's go with SuperWaves." We applied SuperWaves. Nothing gave excess heat. DC, AC, pulses; nothing gave excess heat. Then we conducted another replication of Parkhomov.

Tom Grimshaw: Before we get off Celani, I wanted to mention that I spoke to him at ICCF-21, just this last spring. He said that they had had an error in one of their measurements, and that's why he was ...

Arik El-Boher: I didn't know that, but okay.

Tom Grimshaw: It's an interesting afterthought, or aftermath, if you will, that there was an error in the Pout that caused the apparent excess heat. As you noted, he didn't have a calorimeter; he

	was using the Boltzmann equation to do the calculation. That's kind of an afterthought for you to consider. It's not surprising you didn't see any positive results, because of his error.
Arik El-Boher:	There were lots of weaknesses in his method of calculation, and I told him it very frankly. I was sorry that I couldn't replicate it. Because of that and in order not to create a lot of noise, we presented our results in poster sessions, you know? So that that he would not be humiliated.
Tom Grimshaw:	I present my results of our survey as well as a poster session. Okay, so moving on to Parkhomov.
Arik El-Boher:	Yes. We were in ICCF-15 in Padua. It was 15, or ...?
Tom Grimshaw:	19. ICCF-19.
Arik El-Boher:	19, right. We presented our work including Celani's results, and at that time, Parkhomov presented his work.
Tom Grimshaw:	I remember it well.
Arik El-Boher:	It was very intriguing and very interesting. There was almost no doubt that the very high temperatures achieved may lead to something interesting , you know, the cell was glowing ... applying input power, and eventually, the cell was glowing. We built this cell in SKINR from scratch. We didn't have such a cell before.
Tom Grimshaw:	I would jump in and say that Parkhomov was replicating the work of, um ...
Arik El-Boher:	Yeah, I know ... Rossi!
Tom Grimshaw:	Rossi. Thank you. Andrea Rossi was working with industrial heat to get his system going, and that did not end well. But Parkhomov, meanwhile, as well as others in China and elsewhere, were attempting to replicate Rossi's very dramatic claims, and so forth.
Arik El-Boher:	Also at that time, that group, the nonprofit foundation of ... I don't remember how they're called ... I remember there was a young guy Bob Greenyer, who built a group of scientist and engineers around him.
Tom Grimshaw:	Yeah, that was the Fleischmann ...
Arik El-Boher:	Fleischmann nonprofit - I don't know - association, or ...
Tom Grimshaw:	Yeah. I'll think of it in a minute. Martin Fleischmann Memorial Project (MFMP).
Arik El-Boher:	Right, right. They said that they also started working in this direction, trying to replicate Parkhomov. We said it's interesting and intriguing, and we want to see it. As I said, up till that point, we never saw gas loading excess heat. So we built a system, at first phase, without calorimetry. We didn't like not having calorimetry, the idea was just to see if there is any effect in first phase, then we will invest in having high-temperature calorimetry as we had in the GD. By the way, we modified the glow discharge into a high-temperature glow-discharge, and instead of water cooling, we were air-cooling it. We reached temperatures of 500 and 600 degrees centigrade, but with no excess heat. We could do the same thing in this cell, but we said we will do it in the next phase if it would see promising results. So we built a ceramic tube which is sealed with SS Swagelok connectors.
Tom Grimshaw:	The way Parkhomov had done it?
Arik El-Boher:	No. The way MFMP did it.

Tom Grimshaw:	Oh, the Martin Fleischmann Memorial Project.
Arik El-Boher:	Yeah. The cell was really holding pressure and vacuum under very high temperatures. [inaudible 00:12:57]. We applied the powder, and it was nickel and all kind of mixtures, with hydrogen, and with a coil heater wound on top of the alumina tube, we could reach easily to 1,000, 1,200 degrees and even 1,300 centigrade, very stable cell. Dennis worked on this cell in physics.
Tom Grimshaw:	Dennis Pease.
Arik El-Boher:	Yes Dennis Pease. We built a very nice system. We wrote a LabVIEW program dedicated for this system, which Eliezer Blasberg programed according with the algorithms I wrote. It was a very nice data acquisition system. We measured temperatures everywhere, since this was the only thing we could measure, because there was no calorimetry at that time. We applied DC, we applied AC and we applied SuperWaves. We applied everything. We changed pressures. The cell was glowing but we didn't see excess heat. The Martin Fleischmann Memorial nonprofit association sent us a procedure, on how they fluctuated the temperatures with a specific sequence and everything: "Do it five times," and "This and this sequence," and "For this and this period of time." Everything we did, we never saw excess heat. Not according to the Parkhomov procedure nor according to the MFMP procedures.
Tom Grimshaw:	MF Memorial Project. Yeah.
Arik El-Boher:	We reported on our results again in a poster session and left it. I think Dennis took it. I think he has this cell, and of course it had few generations of modifications, and it was improved from one generation to the other, and the system was very stable, and every time it could reach 1,200 degrees centigrade and even more. With hydrogen, you can imagine, under these temperatures and pressures and so on. We built a thermal protection with thermal bricks surrounding the cell for safety and for temperature stabilization, if there will be an explosion or whatever, but it was very safe. Good system. We didn't see any positive results.
Tom Grimshaw:	So you had gas, discharge ... glow discharge, gas loading, and then the Celani and the Parkhomov.
Arik El-Boher:	Yes. By the way, the high-temperature glow discharge cell that we developed, was modified from the water cooled low temperature GD cell into a high-temperature calorimetry with air-cooled calorimetry. We put nickel foils and nickel alloys with hydrogen with really high temperatures, with SuperWaves, without SuperWaves, and magically, every time, Pin was equal to Pout, and we never saw excess heat!
Tom Grimshaw:	Another failure to replicate the Andrea Rossi claims. Were there other things in the gas part before we move on?
Arik El-Boher:	There was another project in the end that Dennis was playing with, which was a gas loading of a foil of palladium which was put in a stainless steel tube, and was heated by a furnace up to relatively high temperatures, and then immersed in liquid nitrogen so that thermal choke was applied. We measured continuously the foil's resistance while the foil was gas loaded at different levels of deuterium pressures. Resistance was measured during heating and abrupt cryogenic cooling. You could see not only how the resistance ratio is changing during loading, but also the phase change as the Pd foil is being loaded (from Alfa, Alpha+Beta and Beta Phase). We could plot the resistance ratio versus the atomic ratio loading. We knew at any instance what was the loading, and what happened

to the loading after you immerse it in liquid nitrogen. You can imagine the thermal shock the Pd foil was going through.

We were hoping that we'll see some excess heat effects, but we didn't. We did see not only the loading, but also the frequencies/vibrations of the foil while being loaded or deloaded. [inaudible 00:18:23]. The system was very sensitive, and the data acquisition system was tailored for this purpose, and it could measure not only the resistance ratio, but also the frequencies developed as phases are changing.

It was a very nice experiment. We had hopes. We wanted to add ultrasound to it, as excitation, but SKINR stopped its activity, and it's still our dream to continue this interesting work. This study helped us to understand the loading mechanism in much more details than we had before.

By the way, these fluctuations, we believe are also due to induced RF while it is being loaded ... It's interesting. You could even hear it acoustically using sensitive microphone.

Tom Grimshaw: When it was loading.

Arik El-Boher: Yeah.

Tom Grimshaw: Yeah. He showed me one of his recordings of the acoustic waves.

Arik El-Boher: Yeah. We worked for days and days, with huge collected databases. We analyzed the recorded data with [inaudible 00:20:21] with spectrum analyzer.

Tom Grimshaw: He mentioned that he thought that the effect was due to secondary effects from the power supply in a computer, but not directly from the power supply, but induced in one of the cells somewhere.

Arik El-Boher: Yeah. We tried to isolate it so that we will see the real effect, and it was hard.

Tom Grimshaw: Yeah. Okay, so I want to take a few minutes and talk and just review again the investigators at MU that you worked with. It was Mark Prelas.

Arik El-Boher: Yeah, Mark Prelas and Katti Kattesh, Shubhra Gangopadhyay, John Gahl, Dave Anderson from MURR, who is a chemist and specialist in mass spectrometry. All are professors. With John Gahl, we worked on the cyclotron with deuterium and hydrogen ion beam bombardments of palladium and nickel targets respectively. We didn't see any excess heat. There was another professor Helmut Kaiser, from MURR with whom we wanted to work in the reactor with beams of neutron, that will allow us to try to understand the electrochemical and gas loading mechanism in high locally resolution along the Pd foil. [inaudible 00:22:31], but that didn't work out Helmut didn't deliver and as a result we had to fire him after several months.

Tom Grimshaw: What was his name?

Arik El-Boher: Helmut Kaiser.

Tom Grimshaw: It's okay.

Arik El-Boher: With Katti Kattesh we worked on development of Pd nanoparticle solutions. It was a solution with heavy water and positively electrically charged nanoparticles. We precipitated the nanoparticles on the palladium foils, and we got excellent results in experiments carried out in SKINR.

Tom Grimshaw: Including excess heat.

Arik El-Boher: Of course, many excess heat events. When I say excellent results I mean that we have positive results of excess heat. Also with Shubhra on nanostructures of Pd on Pd substrates. By the way, now I work with Shubhra on nanoenergetic materials, for rockets, propulsion, for combustion of nano-aluminum and some other alloys.

Tom Grimshaw: She was also using nano ...

Arik El-Boher: She has a nano center, nano technology center.

Tom Grimshaw: Using it for prostate cancer.

Arik El-Boher: No, no, no. That was Katti Kattesh.

Tom Grimshaw: Oh, okay. Sorry.

Arik El-Boher: Shubhra is not working on medical applications, although she is developing nano sensors for biological diagnostics, human biological diagnostics. The nanomaterials, energetic materials are being developed for combustion, for propulsion, (rockets propulsion and for ammunition). [inaudible 00:24:35]

Tom Grimshaw: Who were you working with where you had the sandwich that was very successful?

Arik El-Boher: The single-walled carbon nanotube? With Shubhra.

Tom Grimshaw: That was Shubhra. Okay.

Arik El-Boher: We worked with her and her brilliant group of past Docs, and graduate students. She has a wonderful top class lab nano center with outstanding abilities, instruments and so on. Mass specs plasma coating facilities and everything one need to diagnose and analyze materials, she has it. [inaudible 00:25:14] optical microscopes, SEMs, everything you need, she has it, including of course plasma chambers for coatings and creating these nanostructures. She is doing a terrific job.

Tom Grimshaw: So we'll come close to the end, and then I'll have one more session after this, please. Let's take a few minutes at the end of this session and talk about the other entities that you've collaborated with. I know one of them is confidential. You'd mentioned NRL I think, you'd mentioned SRI.

Arik El-Boher: Yeah, we've worked with NRL, SRI, Enea and others

Tom Grimshaw: Enea being the Vittorio, the Italian ...

Arik El-Boher: Yes, he and his group. By the way, Vittorio now has stopped his activities in cold fusion, or LENR. He is now working for Eldor [inaudible 00:26:06]. It's an Italian, international huge conglomerate which is developing and producing, among many other things also products and technologies for the car industry. They also developing fuel cells. Vittorio is an electrochemist. He is working with his group in Frascati, in the same lab, but for this company. He took leave of absence from Frascati, and they are renting the labs and the equipment. He's already two years or so with Eldor.

Tom Grimshaw: I see. Using private money to do the similar kind of investigations then.

Arik El-Boher: It's not exactly the same. It's not cold fusion, but it is electrochemistry. By the way, the recombiners that we were using in the closed cells, the helium tight and the semi-closed cells, are from this fuel cell industry. We found it and we sold it, (so to speak), to Enea, to NRL and to Coalescence. For years they were using the same recombiners we gave them because they were regenerating it in an oven, heating it up and regenerating the recombiner.

Tom Grimshaw:	What was the nature of the collaboration with Enea, with Vittorio? That goes back to energetics.
Arik El-Boher:	Yeah. Actually, I met Vittorio for the first time in the ICCF-9 conference in China, in Beijing. We had lunch together and we decided to collaborate. In the beginning he was developing and producing cathodes for us. He was rolling and annealing, and he had his own procedure for doing it. He shared everything with us, and exp. #64 was with his cathodes.
Tom Grimshaw:	Ah, okay. Very interesting.
Arik El-Boher:	But he kept producing, under the same known, controlled parameters, the same cathodes, which sometimes didn't show excess heat at all [inaudible 00:28:30] and sometimes with lower amounts of excess heat events. Some of them gave much lower amounts, and some of them not at all. That was the collaboration. We worked with him on gas loading, we worked with him on electrochemical cells. He was analyzing our cathodes before and after experiments (pre and post experiments. He had a very nice lab to work with. [inaudible 00:28:52].
Tom Grimshaw:	And also with SKINR?
Arik El-Boher:	Yes, yes. It continued also during SKINR, and at that time, he found some morphology with scattering of optical beams, (light beam), he found some interesting picks of cathode 64, as an indication for the surface morphology. (As I told you, we cut the 64 cathode into so many pieces and we sent it all over), and he thought that this is the key for preparing right cathodes. He produced cathodes for him and for us and we both tested them, but they didn't produce excess heat with reproducibility rate higher than 20%.
Tom Grimshaw:	Did any of the others that used pieces of 64 produce excess heat?
Arik El-Boher:	No, no, no. It was just for analysis; they never used the cut pieces for other purposes just for analysis. NRL investigated our cathodes for months, trying to understand what is the secret behind those. They did, together with David Knies [inaudible 00:30:10], terrific job. In analyzing the grain size, the grain size distribution, the morphology, the orientation of the grains, and the impurities. I really think they did a terrific job, but the bottom line was we don't know what really caused 64 cathode to work so well.
Tom Grimshaw:	Coalescence was another entity you worked with.
Arik El-Boher:	Yes, many times. We visited them, they visited us. By the way, when Google was here, they worked together with them, and they were very critical as well, together with Google. They were just about to close Coalescence, and they wanted to prove that if they didn't get excess, heat, nobody will [inaudible 00:31:07]!
Tom Grimshaw:	That's terrible.
Arik El-Boher:	Yeah. You know, there were sometimes arguments with David in a very high levels of energy, you know?
Tom Grimshaw:	David [inaudible 00:31:23]. Yeah.
Arik El-Boher:	Yes.
Tom Grimshaw:	Yeah, I remember him very well.
Arik El-Boher:	But it didn't help us. They wrote a report that they think it was an offset. We proved that it wasn't offset, but they didn't accept it. Sometimes I thought to myself that they are following Google attitude in order to get finance from Google. I didn't know, but

eventually they closed, they shut down the operation, so it seems that the reason wasn't to be financed by Google. David now works for the government as a research engineer.

Tom Grimshaw: When you were collaborating with him, what kind of experiments were you doing?

Arik El-Boher: First of all, loading. They found that if they add ppm levels of lead into the electrolyte solution, it will help to reach high loadings. We knew that, because we did it with mercury. Mercury is covering/blocking or coating the surface, but not completely. Why it's hard to reach high loading: it's like you are trying to fill perforated bucket with water. The coating is blocking these perforated holes, so to speak, from which ions of hydrogen or deuterium are escaping.

Yes, we saw it with mercury. When we had mercury, we saw a jump in loading. When we added an addition portion - and I'm talking about ppm levels; don't understand me wrong. There was one cell that they always saw good loading, and when they analyzed the content of the electrolytic solution using a mass spec., they found lead, and this is how they start adding lead on purpose. We did it the same with mercury after we collaborated with Mike McKubre, who had together with Peter Hagelstein a company, called Cobalt.

I don't know if you know about this company in which they loaded discs of palladium and coated it with mercury, like sealing it, keeping the loading, those discs were disconnected from the current source, and they were kept loaded for a very long time, and we know that. We saw it. Because of this idea, we add mercury to our solution a dissolved mercury salt, and we saw exactly the same phenomenon every time. Cobalt's idea was to take these loaded discs and to shine a laser on it to excite it, and to get excess heat. The loaded discs were kept on the shelf, waiting for the right moment to excite it.

They failed, but the idea of the mercury came from there, and we tested it and we got even better results than Coalescence, and we went to Coalescence with our systems to let them show us that they get good results of loading. They failed during this visit, but they were serious and honest and good scientists to collaborate with, beside the fact that they didn't accept our last results of excess heat.

Tom Grimshaw: Well, they had this propensity to brag that they were the largest lab, or the longest-lived lab never to have seen the effect. I remember that. I saw them in Erice [inaudible 00:35:47]. Were you at [inaudible 00:35:49]?

Arik El-Boher: Yeah. I was there. I gave a presentation there. By the way, Shubhra was there, as well as Katti Kattesh, and I gave a presentation on our results, positive results, excess heat results, in a lecture.

Tom Grimshaw: I remember that. And you included 64 as I recall.

Arik El-Boher: Yeah. I gave an overview. David [inaudible 00:36:15] was there as well.

Tom Grimshaw: Yeah. I had dinner with those guys. Olga was there, McConnell was there. We all had dinner together one night. They were convincing themselves that they were using the right approach to investigate this during the dinner. It was interesting to watch.

Arik El-Boher: They did good work, scientific work, to understand the material science, but they never saw excess heat. And they had good calorimeters, thermoelectric calorimeters.

Tom Grimshaw: What about ... You collaborated many times with Michael McKubre at SRI. Can you tell me about a few of the kinds of experiments?

Arik El-Boher:	Yeah. First of all, after his jaw was dropped in ICCF-10 in Boston, he approached us and wanted to become a consultant in energetic. Sidney Kimmel accepted him as a consultant. He was getting paid at that time. He was coming every few months to energetics in Israel, and we were sitting and discussing all kinds of experiments to be conducted and the results achieved so far. Peter Hagelstein also came. Together with him sometimes, and even without him. Peter at that time had an idea that the mechanism for achieving excess heat requires existence of helium atoms in addition to deuterium in the lattice to excite the effect.
Tom Grimshaw:	Oh, I didn't know that. I knew that it was a product of the ...
Arik El-Boher:	So we conducted such an experiment. He came and we discussed all kinds of possibilities, and as a result, I prepared in the GD system [inaudible 00:38:11] a mixture of deuterium and helium in proper ratio, and bombarded these ions so that helium will be absorbed in the lattice in addition to deuterium, but nothing came out of it. That was his idea. I did it.
Tom Grimshaw:	Didn't work. Okay.
Arik El-Boher:	Mike McKubre's claimed that in order to load the cathode to loading ratios of above 95% which he believed it's a necessary condition for achieving excess, you need to have high current densities (over 250 mA/cm^2), he also showed experimentally that he was getting higher excess heat values as the power density was higher, and we claimed the opposite, we usually worked with current densities of 6-10 mA/cm^2, (#64 was with loading ratio of about 80% and 6mA/cm^2. Eventually he admitted that what we have is real. He called his mode A and ours mode B, (low power density, or low current density).
Tom Grimshaw:	Interesting. Were there others that you can talk about? I know there was one other larger one that's confidential. You had mentioned that he had granted $150,000, which was matched by Sidney Kimmel. Other collaborators come to mind as we wrap this one up?
Arik El-Boher:	For some times, we collaborated with [inaudible 00:39:32] Lets and Cravens, (he visited us in Columbia).
Tom Grimshaw:	Cravens?
Arik El-Boher:	Yes, Cravens.
Tom Grimshaw:	D1 and D2.
Arik El-Boher:	Right. We tried to replicate Cravens unsuccessfully. By the way, this is how we developed the miniature thermoelectric calorimetry with the lasers excitation as suggested by Lets. We shined lasers in an angle pointing the cathode, we used all kind of lasers with different wave lengths, into a miniature rectangular quartz glass cell with thermoelectric calorimetry.
Tom Grimshaw:	Single, dual. Yeah.
Arik El-Boher:	Yeah, single laser. By the way, I was in NI annual conference few times. [inaudible 00:40:06] in one of them Cravens demonstrated his working cell , with his two spheres 2/3rd submerged in heated aluminum pellets maintained in constant temperature. One sphere was filled with sand and the other with Pd, gold and carbon particles he measured in both spheres the temperature. The second sphere with the Pd mixture, showed during the days of the conference continuously higher temperature than the one filled with sand which had the same temperature as of the Al pellets temperature. By the end of the conference Cravens cut both spheres, right on the spot, to show that one sphere was full with sand, and the other one with palladium, gold and carbon. [inaudible 00:40:31].

Tom Grimshaw: I visited him in his laboratory in New Mexico this past fall. He has a Model A car waiting to receive his cold fusion engine. Okay, I think we're about ready to wrap this up. I have one more tape I'd like to do looking at the long term, okay? This is Tom Grimshaw with Arik El-Boher. We're talking about the energetics technologies and SKINR experiences. It's January 12th, and we'll sign off until the next session.

Arik El-Boher

Interview 6 of 6

Tom Grimshaw: Okay Tom Grimshaw again here with Arik El-Boher, this will be I think session will be session, well I've lost track actually, I think it's number six but I'm not sure. Arik, we've been talking about energetics technologies and we've talked about SKINR that grew out of that organization and I think we've done an excellent job of covering the landscape of the various things that were done, what experiments were done where there were some successes and so forth. I'd like to talk now about your recommendation for future work plan, after your many years of exposure and investigations in this field, what observations would you care to make about cold fusion, LENR, what causes it? Why we have so much trouble with reproducibility? Getting an adequate explanation? Whatever thoughts you might share about the big picture with cold fusion.

Arik El-Boher: Okay. First of all, I can say honestly to the best of my knowledge, what I saw in more than thousand experiments, from which we saw those positive results. [inaudible 00:01:27] I have no doubt that the excess heat events are real. And unfortunately I, even today after what is it? 16 years since I started being active in this field. I can't tell whether it's really fusion or not. It may not be fusion, it may be some kind of resonance, which is excited by dynamics of all kinds of excitations from [inaudible 00:02:07] magnetic, to acoustic, RF, laser or combination of excitations which are affecting the material hydrogen/deuterium, palladium systems. Generating excess heat.

Now, as I said, I'm not sure that is fusion. I am positive that it's real. I have no doubt that lower level of loading than 95% can generate excess heat, not necessarily 95% or more as McKubre claims. I saw excess heat at 70% and 80% already. But I never saw excess heat at 15% or 20% or 30% or even 50%.

It is a dynamic system, you need to apply dynamics to the system in order to excite it. If there will be a continuation in which SKINR will be able to resume its activity, it will be in the direction of dynamics excitation, (laser, electromagnetic, RF acoustic and combination of them). I think that this is the way eventually to achieve reproducible generation of excess heat.

I don't know how many years it will take, I cannot even say how much money is needed in order to do it, but if we will continue, it must being done in a professional way, the same way we did it in the last 15, 16 years.

That's all I can say. I came into this field where there was a big disagreement about the theories behind these extraordinary effect or event or phenomenon and after 16 years I am in the same position and unfortunately, the whole field is in the same position.

Tom Grimshaw: I had a recent conversation with Rob Duncan and he was referring to this as a catalytic effect.

Arik El-Boher: Well, maybe.

Tom Grimshaw: What would you do if you could start again in this field with a good adequate funding?

Arik El-Boher: But let me say something with regards to catalytic effect. Catalytic effect or any catalyst will not generate more heat than you put in. It's chemistry and chemistry is not excess heat. Maybe he means that some kind of catalysis is exciting some effect that we don't know yet, we don't understand yet.

Tom Grimshaw: I think he was referring to the broader sense of the term catalytic in that if ingredients are brought together and something is added that will then allow the reaction to take place.

Arik El-Boher: [crosstalk 00:07:07] a reaction, okay. Alright.

Tom Grimshaw: And nuclear. And perhaps nuclear.

Arik El-Boher: Perhaps and perhaps not, I don't know.

I don't know if you heard Brown's theory, he presented it one of the ICCS.

Tom Grimshaw: Well I was gonna get to that last actually, after this.

If you were to be able to open a lab and design, as you have before, the experimental program, the individual cells and the data acquisition and the decision on the signals or signatures, what would that look like?

Arik El-Boher: It will be definitely much local [inaudible 00:07:50] it will be probably closed cells, or semi-closed cell, it doesn't have to be helium tight. Only if you wish to measure helium, , as a product of the fusion if it is fusion reaction, then you need helium tight cell, which we have.

But if not, if it's just for [inaudible 00:08:26] purposes generating excess heat, you don't need helium tight but you need semi-closed cells with mass flow calorimetry, just to remove any doubt when you get positive results.

Tom Grimshaw: You use palladium and deuterium? You'd use electrolytic. Would you use glow discharge?

Arik El-Boher: I will not go with glow discharge, I gave up glow discharge. I will not go gas-loading because, again, I never saw excess heat, in electrolytic cells I saw excess heat and I must say that gas-loading or glow discharge are easier to commercialize if it was working because you can reach much higher temperatures and power conversion is function of temperature. The higher the temperature, the higher the efficiency.

Tom Grimshaw: [crosstalk 00:09:26]

Arik El-Boher: Of course. And glow discharge allows you to reach higher temperatures, in the hundreds of degrees level, as well as gas-loading, if it works. Electrochemical cells are much difficult to commercialize. They are more sensitive and so on, but in order to understand, the principles and the mechanism behind this generation of excess heat, this is the way I would go. With applying dynamics to the system in terms of miniature localized acoustic transducers with high resonating frequency, electromagnetic pulses, RF and laser

Tom Grimshaw: What about the materials question and the actual palladium itself? Would you be looking at parameters there, directly structure, the alloys? I've heard boron, for example, is an effective add on.

Arik El-Boher: We looked for years to try to find the controlling parameters of the material and that was our collaboration with Enea and NRL [inaudible 00:10:59] and we did all kinds of investigation and analyses, including boron and other ingredients in the Pd metal, alloys and doping and we couldn't get reproducibility. We got some excess heat events but we were far from getting heat on demand.

In the very beginning, we thought that the material is the key. But it didn't prove itself. I'm not sure. And by the way there are groups who claim that it doesn't really matter.

Tom Grimshaw: That was Fleischmann who was among those.

Arik El-Boher: Yeah. Fleischmann but also others. And I don't know. I really don't, all I know is that we tried tirelessly and you saw it in the presentations of [Mark Tsirlin 00:12:04], we investigated endless time and effort to investigate the grain distribution, grain orientation, grain orientation distribution, grain size, typical grain, impurities etc..

Different procedures for annealing. Creating specific morphologies on the surface of the cathode. Embedding carbon like islands, as hot spots for chemical jumps, potential jump, because we saw in 64 carbon embedded in the cathode. We tried all kind of morphologies together with Vittorio and without Vittorio. But we failed in identifying the controlling parameters vis-a-vis material science.

Yes, we got all kinds of materials, nano structures, which worked. But not every time.

Tom Grimshaw: Perhaps it's fair to say that there are too many parameter spaces, too large with respect to materials to be able to zero in on the key parameters.

Arik El-Boher: And if you are talking about palladium, people tried to purify it, people tried to get from a specific vendor, a specific procedure, but it was never the same from one lot to another. we analyzed it and proved it. We bought Pd from the same source, asking for the same specification, and it was never the same from one lot to the other. And even in within the same lot.

Tom Grimshaw: Within the lot.

Arik El-Boher: For example, I'll give you an example.

We took the same lot. We cut it, it came as a one millimeter sheet, 10 by 10 centimeters. We cut it to 7 mm wide and 50 mm long, we roll it down to 50 microns and the strip became 1000 mm long, we cut our cathodes (each 7 mm by 80 nm long with 50 microns thick) and we etched it chemically. We tried also ultrasound etching, which is considered to give more uniform etching. We took cathodes from the same strip, I mean, number one and number two or five from the same strip and we etched them, and it was not etched uniformly.

One was etched nicely, the other one, partially. You could see the difference visually, even without using a microscope.

Tom Grimshaw: Let me back up again. You would use excess heat or would you use other signatures as the indicator?

Arik El-Boher: Definitely other signatures. Followed the excess heat. For example we want to measure high RF emissions while cathode is generating excess heat. We failed to do it, but we, as I told you, in one of the excess heat events, when we changed the impedance [inaudible 00:16:00] we killed the excess heat.

There must be some RF activity taking place and whether it's in a very narrow window of frequencies, or not, I can't say. But I believe that when excess heat is generated, RF emissions can be detected. By the way, when we had 64 and not only in 64, also in another experiments, in excess heat, all the parameters fluctuated. The voltage, the resistance and the temperatures. We always run in a constant current mode, but the voltage is free to respond. When the excess heat event stopped all those fluctuation disappeared and the parameters are stabilized. So voltage was fluctuating and not only that it was fluctuating, its level was increasing by a factor of five. From three volts to 15 volts, with a lot of fluctuation. When the excess heat stopped, all those fluctuations diminished and the voltage dropped back to three volts. This tells you that probably RF frequencies are emitted and causing this fluctuations that we witnessed. By the way in this gas-loading experiment of loading the Dennis was conducting. We measured these frequencies as well.

We wanted to measure the RF effect and even the acoustic effect. We didn't do it, because SKINR closed and stopped its activity. But if we will go back, I would go and continue these studies.

Tom Grimshaw: Two things -

Arik El-Boher: Which will help us to understand what is going on.

Tom Grimshaw: Yeah. A couple of things of interest. As you know, Dave Nagel is now using a laboratory.

Arik El-Boher: Yeah, we are collaborating with him, [inaudible 00:18:25] we were communicating and instructing him on how to build a cell which will allow for acoustic [crosstalk 00:18:35]

Tom Grimshaw: Acoustic and RF excitations. He's got a full spectrum of signatures.

Arik El-Boher: And how to stretch the cathode with springs and so on, which we did.

Tom Grimshaw: The other thing I would note is that RF, of course, is photons and that's what [Storms 00:18:58] claims is photon emission that he says it can be phonon, photon in his model. And so what frequency is the question, but it has to be able to interact with the lattice to develop heat.

Okay, I'm gonna -

Arik El-Boher: The idea is to introduce RF at a certain frequency which will resonate and excite and give you back RF emissions in a kind of feedback.

Tom Grimshaw: In your scheme of things, then, excess heat remains as a prime signature but also other signatures, particularly RF and others, loading, at least 50% or more.

Arik El-Boher: Exceeding 50%.

Tom Grimshaw: Exceeding. For materials, who knows? In other words, particular alloys, particular structures, you would probably, what, go with the purest of palladium or some selected?

Arik El-Boher: Purest is only if you pure it yourself, otherwise you can't trust anybody. Any producer, not to speak about the fact that they use recycled palladium and it has all kind of junk, even in the PPM level, but it's there.

Only if you use moving melting zone, vacuum melting zone purification, only if you do that you can purify your palladium under control. And, by the way, I'm not sure if it's good to have pure palladium.

Tom Grimshaw: I heard the same thing that it takes impurities to make these system work.

In the early days, I think they were thinking that lithium from a lithium hydroxide was important.

I think we kind of narrowed down what you would look for, what you would use, pure deuterium with lithium hydroxide. The materials we talked about. The signatures we talked about. And then the idea of a dynamic situation to disturb it with a loading, at least 50% or more.

That kind of summarizes the way I understand it.

One last question and that has to do with the idea that Graham brought into SKINR. Tell a little about his idea if you would, in briefly, and then were experiments done to test?

Arik El-Boher:	First of all, when we moved to the university, when the safety committee heard low-energy nuclear reactions, they got cold feet and they said "Whoa you're going to generate radiations and it is dangerous." And so on and so forth. I went to the safety committee and presented the results and showed that even in 64, we had all the sensors for detecting gamma rays, neutron detectors and so on and we didn't detect anything.
	Why I'm telling you this? Of course they approved and we could built our labs. Eventually they were convinced that it is safe. But why I'm telling you that, Graham is a nuclear scientist, physicist, and he never saw nuclear signature and in any of the excess heat events they run in NRL, he then asked himself:[inaudible 00:23:13].
	If it's not nuclear, let's say that it's not nuclear, it's not fusion. Then what is it?
	He was thinking about Axions, that a system excited in a specific right frequency, will trigger a heat event. He claims that actually the triggering for excess heat comes from space, by axions, you know it's like the password sesame, open. At a given frequency, these surges of axioms are entering the cell and generating heat. Then it's not nuclear, so there is no nuclear signatures, it is excess because it comes from the universe. Abundant. Source of energy.
	But the only problem is that you have to find, detect and prove that axions exist.
Tom Grimshaw:	Did you do that? Look for them?
Arik El-Boher:	No. But others all over the world, groups of scientists who are looking to prove that axions exist. You see, you're talking about dark matter and dark matter arranged the equations in galaxies in the universe, but no one proved yet that there is dark matter. It's very nice to use dark matter as a tool to balance the equations, but its existence has to be proved. There are two groups, those who claim that there is dark matter, or in other words, mass that you don't see. Or groups that correct gravity to balance the. Otherwise the universe physics is not explainable.
	Axions, unfortunately were not discovered yet. All kinds of experiments are being conducted to detect axions, all kind of scientists all over the world are still looking for axions so far unsuccessfully. If axioms are existing/observed, then there will be merit in the theory of Graham.
Tom Grimshaw:	Observed.
Arik El-Boher:	If observed, then it is possible to show Anomaly Heat Effect (AHE) because there is Graham's theory which shows how those axions in a specific frequency [inaudible 00:27:28] can generate heat in a space specific confinement. That's all I can say. He knows that. He have submitted a patent about this theory.
	I don't know what the status of this patent is? Is it maintained still as pending patent? Even, I'm not sure whether it was approved but even if it is approved you have to maintain it, to pay annual fees to keep the patent alive so I don't know what is the situation or the status of this patent. The university of Missouri covered the patent submission fees for registration
Tom Grimshaw:	It seems to me to be a hypothesis to explain a phenomenon which we haven't been able to explain that is based on another hypothesis that hasn't been proven so it's like a second order hypothesis.

Arik El-Boher:	It's the same as in fusion, in the beginning they talked about two body reaction, and then they talked about four and then multi-body reaction. Takashi and so on. But who said that it exists? Yes there were all kinds of researchers who found with CR 39 tracks of neutrons and charged particles but Andrei Lipson [inaudible 00:29:33] was very critical on the work of the research group in the navy in Naval research in San Diego. There isn't a proof of nuclear signature.
	Not to speak about the fact that if it's fusion, it's very hard to believe that it can happen, right? According to the known theories, one has to develop a new theory which will explain such a reaction and there are so many theories which are conflicting each other.
Tom Grimshaw:	Which is often the case in a very young or immature science.
	Okay, I think we should terminate here, end this. We're back up to 30 minutes again, for one thing. I just wanna thank you Arik for taking these many hours today to sit here in the gently falling snow fall.
Arik El-Boher:	I apologize that I cannot offer you something to eat.
Tom Grimshaw:	We're good.
Arik El-Boher:	We had tea, but if you want I can make you another tea.
Tom Grimshaw:	And more tea.
	It's Tom Grimshaw with Arik El-Boher. I've lost track of which session we're on but I do know it's still January the 12th and we're working here, Arik El-Boher and I are documenting his recollections and observations about LENR at the energetics technologies and SKINR so thank you again Arik.
Arik El-Boher:	Thank you.

Appendix D. Documents from Arik El-Boher

As noted in the Stage 1 report (Section 4), Dr. El-Boher contributed nearly 80 reports, presentations and other documents to the SLRDP. Table 4-4 provides a list of the documents in date order. They have been placed in the Project Dropbox folder.

The documents are listed in this Appendix D as they were originally identified – by file type – when they were incorporated in the project[1,2,3]. Because of the very large cumulative number of pages of the files, the documents are not yet printed for the Stage 1 report. D1, D2, and D3 show the lists of PDF, Word, and presentation files, respectively.

[1] "SKINR Documentation Project: Microsoft Word Files from Arik El-Boher". Memo to Dennis Pease and Arik El-Boher from Tom Grimshaw, December 18, 2018.

[2] "SKINR Documentation Project: PDF Files from Arik El-Boher". Memo to Dennis Pease and Arik El-Boher from Tom Grimshaw, December 20, 2018.

[3] "SKINR Documentation Project: Presentation Files from Arik El-Boher". Memo to Dennis Pease and Arik El-Boher from Tom Grimshaw, January 2, 2019.

D1. PDF Files Provided by Arik El-Boher

Year	Title	File Name
2003	Intensification of Low Energy Nuclear Reactions Using Superwave Excitation	Intensification of LENR using SW Excitation ICCF 10.pdf
2004	Excess Heat in Electrolysis Experiments at Energetics Technologies	Dardiklexcessheat.pdf
2004	Excess Heat in Electrolysis Experiments at Energetics Technologies	ICCF 11 Presentation.pdf
2007	New Physical Effects in Metal Deuterides	DARPA P16816 Finals.pdf
2008	Ultrasonically-Excited Electrolysis Experiments at Energetics Technologies	ICCF 14-Paper.pdf
2008	Ultrasonically-Excited Electrolysis Experiments at Energetics Technologies	ICCF14-Proceedings-Part-A,Energetics, P 106.pdf
2011	Developing Commercial Energy Sources Based on Deuterium-Palladium Systems (Concept Paper for Early Stage Transformational Project)	Concept paper_Energetics_Revised 8Aug11.pdf
2013	Progress toward Understanding AHE	Progress Toward Understanding Anomalous Heat-AEB MIT.pdf
2015	Effect of Cathode Pre-treatment and Chemical Additives on H/D Absorption into Palladium Via Electrochemical Permeation	Proceedings,BiberianJPjcondensed rICCF 19, 2015.pdf
2017	G Hubler, 8-14-2017, Comments on the Calibration Run on US4	Report on US4 caibrationGKH - Copy.pdf
2017	Test Results, US4 and Closed Cell, July 27/2017	Test results July 28 presentation.pdf

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

The University of Texas at Austin
Energy Institute

D2. Microsoft Word Documents Provided by Arik El-Boher

Year	Title	File Name
2008	Electrolytic Closed Cell, Wiring Diagram	Flow cell schemes 2008.doc
2008	Ultrasonically-Excited Electrolysis Experiments at Energetics Technologies	ET paper ICCF14_V1.doc
2011	Mastering Energy Generation Using Low-Energy Nuclear Reactions	Mastering Energy Generation Using Low-Energy Nuclear Reactions July 182011.doc
2013	SKINR Pd/SWCNT Gangopadhyay Cathode, November 18-20, 2013	Doc11.docx
2014	Production of Nanoporous Palladium from a Deuterium Loaded Wire Driven by a Low Energy, Fast Pulser	power modulator pulse system Gahl final_8_10_14_V5.doc
2015	Final Report on Calorimetry-Based Excess Heat Trials Using Celani Treated NiCuMn (Constantan) Wires	Final report on calorimetry Final July 23.docx
2015	Final Report on Calorimetry-Based Excess Heat Trials Using Celani Treated NiCuMn (Constantan) Wires	Final report on Celani Replication July 27-2015.docx
2015	Search for Low-Energy X-ray and Particle Emissions from an Electro Chemical Cell	Low Energy X rays ICCF19 V2 0_DCP (002).docx
2015	Search for Low-Energy X-ray and Particle Emissions from an Electro Chemical Cell	Low Energy X rays ICCF19 V2 0_DCP (003).docx
2016	Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with LIAlH4 and Free Li under High Temperature Hydrogen Gas	Final report on SKINR replication experimental program to seek excess heat in Ni+LiAl H4+Li mixture- Poster 1.docx
2016	Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with LIAlH4 and Free Li under High Temperature Hydrogen Gas	Final report on SKINR replication experimental program to seek excess heat in Ni+LiAl H4+Li mixture- Poster 2.docx
2016	SKINR HTGL Experimental Procedure Edit As Adapted from the MFMP (Martin Fleischman Memorial Project) Glowstick 5.2 Experiment, v3.1, Last Revised on 06 April 2016	HTGL Procedure v3.1.docx
2016	SKINR HTGL Summary Report, Last Updated: 27 May 2016	HTGL Summary Report.docx
2016	Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with LIAlH4 and Free Li under High Temperature Hydrogen Gas	ICCF 20 Arik Paper-Dec. 20,2016.docx
2017	Update Report on US-4 and Closed Cell Calibration	US-4 and Closed Cell Update- August 10, 2017.docx
None	Loading of Palladium Foil in 0.1 M LiOD	Loading1.doc

D3. PowerPoint Files Provided by Arik El-Boher

2003	2003 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Dardik et al., August.	Astl-Enea.ppt
2003	2003 (No Title). No date.	ET-1 Presentation.ppt
2003	2003 Energetics Technologies Ltd., ET-0 Cell Design. No date.	ET0 Presentation2.ppt
2003	2003 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Dardik, El-Boher, Lesin. No date.	Glow Discharge.ppt
2003	ICCF-10 Highlights. Ehud?, August.	HIGHLIGHTS.ICCF10-Ehud.ppt
2003	2003 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Dardik, et al., August.	Irv's two favorite graphics.ppt
2003	2003 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Dardik, et al., August.	Presentation animated.ppt
2003	2003 Energetics Technologies Ltd., Superwave Superwaves Studies. Full screen (Will not print). No date.	Presentatlon1.pps
2003	2003 Low Energy Nuclear Reaction Research at Energetics Technologies Ltd. Branover, et al., August.	Presentation2.ppt
2003	2003 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Branover, et al., August.	Tanya.Aug03.paper.ppt
2003	2003 Low Energy Nuclear Reaction Research at Energetics Technologies Ltd. Branover, et al., August.	Tanya.Aug03.Poster ppt
2003	2003 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Branover, et al., August.	Tanya.Aug03.Poster2.ppt
2004	2004 Experiment #64A: Excess Heat. No date.	(2015) ET # 64 a & b.pptx
2004	2004 Intensification of Low Energy Nuclear Reactions through Superwave Excitation. Dardik, et al., March.	Asti – El-Boher ppt
2004	2004 Excess Heat in Electrolysis Experiments at Energetics Technologies. Dardik, et al., November.	ENERGETIC· ICCF11.ppt
2004	2004 Energetics Technologies Ltd., Excess Heat Production in Electrolytic Cell ETE-4-56, March-April 2004, Omer, Israel.	Excess Heat1.ppt
2004	2004 Excess Heat in Electrolysis Experiments at Energetics Technologies. Dardik, et al., November.	FRASCATI 2004.ppt
2004	2004 Energetics Technologies Structure. No date.	USA visit March2004 1.ppt
2005	2005 Deuterium in Palladium, Structural Transformations of Pd, Energetics Technologies Limited, 6th International Workshop on Anomalies in Hydrogen/Deuterium Loaded Metals, 13-15 May, Sienna.	ENERGETICS-2 SIENA 2005.ppt
2005	2005 Excess Heat in Electrolysis Experiments at Energetics Technologies. Dardik, et al., May.	Sienna MayO5.ppt
2006	2006 Inhomogeneities of Pd Foils and Their Influence on the Structure of the Metal. No date.	Presentation-outline-ltaly-Sept-06.ppt
2006	2006 Progress in Electrolysis Experiments Technologies. Dardik, et al., April.	Rome seminar2.ppt
2006	2006 Low Energy Nuclear Reaction Research at Energetics Technologies Ltd. No date.	Rome September2006.ppt
2007	2007 Energetics Technologies Cold Fusion Research and Development. Greenspan and Lesin, June.	ET R&D_June07-Short-Short-Al.ppt
2007	2007 Absorption of the Deuterium in Palladium, Structural Transformations in the Metal, Energetics Technologies Ltd, Omer, Israel. No date.	Pd-transformations.ppt

2007	2007 ET Systems and Results. No date.	System and results-Final.ppt
2008	2008 (No Title), Calorimeter Assembly… No date.	Disassembly.ppt
2008	2008 Measurements Accuracy, Energetics Technologies Ltd. October.	Duncan Visit Oct. 2008-Accuracy.ppt
2008	2008 Facilities, Energetics Technologies Ltd. October.	Duncan Visit Oct. 2008-Faciities.ppt
2008	2008 Targets Preparation, Energetics Technologies Ltd. October.	Duncan Visit Oct. 2008-targets.ppt
2008	2008 Energetics: Data Acquisition System & Data Processing. November	Energetics Data_Acq. System DARPA Nov.08.ppt
2008	2008 (No Title), All Parts of "Sandwich" Itself… No date.	Sandwich.ppt
2008	2008 Energetics Technologies Ltd. Research and Development Activity. September.	Shaul - Introduction.ppt
2009	2008 Energetics Technologies Ltd., Overview of Experiment and Results. No date.	ETR&D Aug 2009_EG.ppt
2009	2009 Energetics Technologies Ltd., Research and Development Activity. June.	ETR&D June 2009s1-Fi.ppt
2009	2009 On the Accuracy of Energetics Technologies Excess Heat Determination. Dardik, et al., October	ICCF 15_accuracy 22.09.09 final.ppt
2009	2009 Modification of Pd Service – – Some Peculiarities of Pd Behavior during Electrolysis, the Recent Results. No date.	Mark March-09.ppt
2009	2009 Thermal Effects in Deuterium Loaded Pd. No date.	Thermal Effects in D2 Loaded Pd Wires - last ver..ppt
2010	Wires Subjected to SuperWave Modulated Electrical Current. Lesin and El-Boher, September.	A Seminar-September 2010 - MIZU.ppt
2010	2010 Energetics Technologies Experience in Generating Heat from Palladium-Deuterium Systems. Lesin and El-Boher, September.	MIZU Seminar-September 2010 - V1.ppt
2010	2010 SKINR: Data Acquisition System & Data Processing. No date.	SKINR-Data_Acquisition_System_.ppt
2010	2010 ET Systems and Results. No date.	System and results Missouri May 2010.ppt
2011	2011 Energetics Technologies USA. October.	ET_Oct_6,_2011-V1.ppt
2011	2011 Experiment #1007, 100 Days. No date.	Exprim #1007 for presentation 03-11-2011-short.pptm
2012	2012 Data Acquisition Systems February 2012.	DATA ACQUISITION SYSTEMS 2012.pptx
2012	2012 Excess Energy; Experiment #64a. No date.	ICCF11- Selected.pptx
2012	2012 Anomalous Results in Fleischmann-Pons Type Electrochemical Experiments, (Not SKINR?). Dominguez, et al., August.	ICCF17_FPE presentation final no backups.ppt
2012	2012: Analysis of Materials. No date.	lrregularity-Apr-22-2012.pptx
2012	2012 Open Cell Electrolytic Loading Facilities. No date.	Lab Photos.pptx
2012	2012 Deuterium (Hydrogen) in Palladium, Structural Transformations in the Middle, Tsirlin, April 2, 2012	SKINR-Apr-22-2012.ppt
2012	2012 SKINR/ET Systems and Results. No date.	SKINR-ET Exp Results Missouri 2012- Final.pp!
2012	2012 SKINR/ET Systems and Results. No date.	SKINR-ET Exp. Results Missouri 2012- Final (2).ppt
2012	Summary of ET-SKINR Electrolysis Results 2002-2012. El-Boher, April.	Summery of ET-SKINR electrolysis results -2012.pptx
2013	2013 (No Title), Photos of Celani Cell. No date.	Celani04082013.pptx
2013	2013 Celani's Replication Program. No date.	CelaniWireResults07152013.pptx

2013	2013 Celani's Replication Program. No date	CelaniWireResults10072013.pptx
2013	Pd/Pd'/SWCNT/Pd'/Pd, XP 1062, Open Cell #1, Electrolyte: 0.1M LiOD. November.	EXP 1062 SWCNT (2).pptx
2013	2013 Excess of Power during Electrochemical Loading: Materials, Electro Chemical Conditions and Techniques, July 2013. Violante, et al., July	ICCF18 V.pptx
2013	2013 (No Title), Energetics Technologies, Loading of Foil 50 Microns. Undated.	Loading with different waves.ppt
2013	2013 SKINR Facilities, April.	SKINR Facilities (2).ppt
2013	2013 (No Title), November 18 – November 19. November.	The first and second burst.pptx
2014	2014 "AHE" in Electro-Chemical Experiments with PD Nano Particles Suspensions. Azizi, et al., October 9-12, 2014.	"AHE" in Electro-chemical Experiments with Pd Nano particles suspensions October 2014 (2).pptx
2014	2014 "AHE" in Electro-Chemical Experiments with PD Nano Particles Suspensions. Azizi, et al., October 9-12, 2014.	"AHE"in Electro-chemical Experiments with Pd Nano particles suspensions October 2014.pptx
2014	2014 "AHE" in Electro-Chemical Experiments with PD Nano Particles Suspensions. Azizi, et al., October 9-12, 2014.	"AHE" in Electro-chemical Experiments with Pd Nano particles suspensions Erice October 2014.pptx
2014	2014 SKINR Facilities, October 2014.	Facilities.ppt
2014	2014 Fabrication and Morphological Study of Pd-SWCNT-Pd Electrodes. Bok, February 13, 2014.	Pd SWCNT Presentation Feb 13-2014.ppt
2014	2014 Fabrication and Morphological Study of Pd-SWCNT-Pd Electrodes, February 28, 2014.	Pd SWCNT Presentation Feb 28-2014 for Arik (1).ppt
2014	2014 Progress toward Understanding AHE. Azizi, et al., October 9-12, 2014.	Progress Toward Understanding Anomalous Heat-AEB Erice October 2014 (2).pptx
2014	2014 Progress toward Understanding AHE. Azizi, et al., October 9-12, 2014.	Progress Toward Understanding Anomalous Heat-AEB Erice October 2014.pptx
2014	2014 Replication of Celani's CuNi Treated Wires. El-Boher, Hubler, Isaacson. October 9-12, 2014.	Replication of Celani's CuNi Treated Wires Erice October 2014.pptx
2014	2014 Fabrication and Morphological Study of Pd-SWCNT-Pd Electrodes. El-Boher, et al., February 28, 2014.	Final report on calorimetry based excess heat trials using Celani treat.ppt
2015	2014 Fabrication and Morphological Study of Pd-SWCNT-Pd Electrodes. El-Boher, et al., February 28, 2014.	Pd SWCNT Presentation Feb 28-2014 for Arik (2).ppt
2016	2016 (No Title) Photos of Micro Craters. No date.	Craters.pptx
2016	2016 Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with LiAlH4 and Free Li under High Temperature Hydrogen Gas. El-Boher, et al., October.	HTGL Poster ICCF20 Arik Final1.pptx
2016	2016 Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with LiAlH4 and Free Li under High Temperature Hydrogen Gas. El-Boher, et al., October 2-7, 2016	HTGL Sendai Japan October 2-7, 2016.pptx
2016	2016 Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with LiAlH4 and Free Li under High Temperature Hydrogen Gas. October.	Poster ICCF20 Arik- Final.pptx
2016	2016 Final Report on SKINR Replication Experimental Program to Seek Excess Heat Using Ni Powders Mixed with	Presentation ICCF20 Arik6.pptx

	LiAlH4 and Free Li under High Temperature Hydrogen Gas. October	
2017	2017 (No Title) Large Table. March-April.	Dean Loboa - PdNp results Updated May 9.pptx
2017	2017 (No Title) Large Table. March-April.	PdNp results Updated May 9.pptx
2017	2017 SKINR System of Electrolytic Cells with US Excitation and Mass Flow Calorimetry. No date.	SKINR - CALORIMETERS (1).pptx
2017	2017 Electrical Electrolysis Experiments at Energetic/SKINR. Dardik, et al. No date.	SKINR - presentation (1).pptx
2017	2017 TE2 PdNP-HD. April 2017.	TE2 PdNP-HD April4- April 21 (4).pptx
2017	2017 Test Results US for and Closed Cell. July 27, 2017.	Test results July 28 presentation.pptx
2017	2017 Update Report on US-4 and Closed Cell Calibration. August 2, 2017.	Update Report1 Aug 2_2017.pptx
2017	2017 Update Report on US-4 and Closed Cell Calibration. August 2, 2017.	Update Report1 Aug 11_2017 Final.pptx
2017	Hubler, Progress toward Understanding Anomalous Heat. No date.	Hubler AH DTRA3 (2).pptx
No Date	(No Title). No date.	Assembly.ppt
No Date	Progress Toward Understanding Anomalous Heat. No date.	Progress Toward Understanding Anomalous Heat.pptx

Appendix E. Annual Reports

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Attachment A.

Year 1 Annual Report, 2012

SUMMARY

SKINR has initiated its research activity very smoothly in the Missouri Innovation Center Labs (MIC), after Energetics Technologies USA LLC ended its activity in April 1, 2012.

During 2012, SKINR conducted experimental research in the open and closed electro-chemical cells with few excess heat events as well as with the gas loading systems. SKINR also initiated a replication research program with its high accuracy calorimetry, based on Dr. Celani positive excess heat results with high temperature Ni-Cu wires gas loaded by hydrogen.

In parallel SKINR designed and prepared specifications for the new labs in Engineering Building West (EBW) and for the lab in Physics. SKINR supervised the erection of the infrastructure in EBW and in Physics.
In November 2012 SKINR stopped its research activity, disassembled the experimental facilities and packed them for moving into the new lab spaces in EBW and Physics.
By the end of 2012 as planned, SKINR handed the incubator lab spaces back empty and clean, SKINR is still in the process of re-assembling the experimental facilities in EBW and in Physics (see attached pictures). All SKINR's facilities will be up and running not later than April 2013.

SKINR and seven scientific groups from the University of Missouri collaborating with SKINR, have outlined a five years program to try to understand the mechanism responsible for the Anomaly Heat effect (AHE) also known as LENR. Understanding of the mechanism will allow having higher levels of excess heat, with better reproducibility rate and for longer times.

Highlights of SKINR achievements in first year

SKINR has initiated its research activity in April 1, 2012. The research program continued smoothly in the Missouri Innovation Center Labs (MIC), after Energetics Technologies USA LLC stopped its activity on March 31, 2012.
During 2012, SKINR conducted experimental research in the open and closed electro-chemical cells with few excess heat events as well as with the gas loading systems. SKINR also initiated a replication research program with its high accuracy calorimetry, based on Dr. Celani positive excess heat results with high temperature Ni-Cu wires gas loaded by hydrogen.
In parallel SKINR designed and prepared specifications for the new labs in Engineering Building West (EBW) and for the lab in Physics. SKINR supervised the erection of the infrastructure in EBW and in Physics.
In November 2012 SKINR stopped its research activity, disassembled the experimental facilities, packed them for moving into the new lab spaces in EBW and Physics.
By the end of 2012 as planned, SKINR handed the incubator lab spaces back empty and clean, except for the gas loading replication experiment, which continued its operation till the end of February 2013.

SKINR is still in the process of re-assembling the experimental facilities in EBW and in Physics (see attached pictures). All SKINR's facilities will be up and running not later than April 2013.

SKINR and seven scientific groups from the University of Missouri collaborating with SKINR, have outlined a five years program to try to understand the mechanism responsible for the Anomaly Heat effect (AHE) also known as LENR. Understanding of the mechanism will allow having higher levels of excess heat, with better reproducibility rate and for longer times.
The five years program started on January 2012. SKINR labs are focused on Deuterium/Hydrogen loading of metallic lattices in three main directions: Electro Chemical, Gas Loading and Ions Bombardment/Glow Discharge.

The seven scientific groups collaborating with SKINR are:

1. High Intensity Ions Bombardment- John Gahl's team.
2. Low intensity Ions Bombardment and High Pressure Shock ways on Gas Loaded targets- Scott Kovaleski's team.
3. Development of Nano Structures on Metallic lattices- Shubhra Gangopadhyay's team.
4.Charged Nano Particles suspension- Kattesh Katti's team.
5. Neutron Scattering in MURR of loaded targets- Helmut Kaiser's team.
6. High Pressure Gas Loading- Peter Pfeifer's team.
7. Gas Loading Thermal Shock and Neutron Diamond detectors- Mark Prelas's team.

SKINR labs are in two sites:

Physics, room 301 Lab contains :

Gas Loading systems,
Glow Discharge systems,
Digital Optical Microscope operated by Mark Tsirlin,
and RF Plasma Coating system.

Mark Tsirlin, Dennis Pease and Bill Isaacson having offices in Physics room 301, they may conduct the tours in SKINR Physics Labs.

Engineering Building West (EBW), rooms 135, 137 and 139:

Room 135 contains:

Foil's preparation lab which contain, roll milll. vacuum annealing furnace, heat treatment furnaces , cell's assembly bench and Glow Discharge etching facility.

Room 137 contains:

Electro Chemical Closed cells with Mass Flow Calorimetry, Electro Chemical Open Cells excited by Ultra Sound with Mass Flow Calorimetry and Electro Chemical Semi Closed Cells with thermo Electric Calorimetry.

Room 139 contains:

Electro Chemical Open Cells with Isoperibolic Calorimetry.

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Attachment B.

Year 2 Annual Report, 2013

Highlights of SKINR achievements in the second year

Prepared by:

Graham K. Hubler, Director

and

Arik El-Boher, Research Group Leader

Sidney Kimmel Institute for Nuclear Renaissance

November 10, 2013

EXECUTIVE SUMMARY

SKINR renewed experimental operations in May 2013 after a hiatus due to the moving of all laboratory equipment and offices onto the UM campus to spaces in Physics and Engineering. Most of the experimental cells and supporting equipment are restored to operation but with many innovative changes described below, aimed learning the mechanism of anomalous heat (AH).

A close collaboration begun last year with F. Celani from INFN, Italy has not produced any sign of anomalous heat in Ni-Cu wires. The nanoparticle suspension experiments have resulted in up to 50% excess heat with reasonable reproducibility. This result is being thoroughly vetted and a patent application has been submitted. Over 20 new Pd cathodes have been tested with no heat results to date, but we are just beginning a 500-cathode effort with our collaborators. Dr, Hubler is actively pursuing supplemental funding for SKINR in order to expand and sustain the Institute.

In addition to the six scientific groups from the University of Missouri collaborating with SKINR, we initiated collaborations with 7 institutions in the US and Europe. The most recent is Aerospace Corp., El Segundo, CA, a major developer of satellites for the military, NASA and commercial applications. We share information, results and samples. It is our belief that the collaborations will accelerate our knowledge about how to gain reproducibility in experiencing AH. Two papers on Deuterium bombardment of Pd and one theory paper are in preparation, and two papers were submitted to the proceedings of ICCF 18.

The University of Missouri hosted the ICCF18 conference in July 2013. SKINR supported the conference by providing some travel support for invited speakers, giving several invited and contributed talks, and conducting tours of SKINR facilities. The conference was the most successful ever due to its sponsorship at a major US university and its association with SKINR.

In June 2013, Dr. Duncan and Dr. Hubler were invited to address the European Parliament in Brussels on the subject of AH, and Dr. Hubler gave a seminar that was well received at the University of Rome-La Sapienza. In August 2013, Dr. Duncan and Dr. Hubler were invited to the World Federation of Scientists International Seminar Series in Erice, Sicily, where they met with collaborators and interested scientists from the Federation. Both trips were totally funded by the Europeans and did not affect the SKINR budget. Dr. Duncan also delivered a seminar at the Naval Research Laboratory (NRL) in March 2013 on SKINR and AH.

In August 2013, one of the original members or Energetics, Dr. Mark Tsirlin, retired from SKINR. He was replaced by Dr. JingHao He in October, a former employee of NRL under Dr. Hubler where he worked on the AH project.

SKINR has quickly gained recognition as the preeminent laboratory in the field of AH and much is expected of us. We accept this challenge and have a research plan in place to understand the mechanism that will allow having higher levels of excess heat, with better reproducibility rate and for longer times.

Highlights of SKINR achievements in the second year

The University of Missouri hosted the ICCF18 conference in July 2013. SKINR supported the conference by providing some travel support for invited speakers, giving several invited and contributed talks, and conducting tours of SKINR facilities. There were many comments from the visitors extolling the quality and professionalism of the SKINR staff and facilities. The conference was attended by 250 participants and was the most successful ever due to its sponsorship at a major US university and its association with SKINR. National Instruments (NI) is the major supplier of experimental diagnostic and computer control equipment in the world. Their CEO gave an invited talk and conducted a week long course on Labview (experiment control software) after the conference and charged 1/3 the normal fee. Five members of SKINR took the course to increase their skills with LabView. NI is supporting various groups around the world with cut-rate prices on their equipment and technical support. Dr. El-Boher was invited to and attended NI week later in July where he described the SKINR mandate and activities to the conferees.

From May to June, recalibration of 20 different cells and calorimeters were accomplished. The Celani H loading of Ni-Cu wire progressed nearly uninterrupted. While in Italy in June, Dr. Hubler met with Dr. Celani in his laboratory to gain more insight, and Dr. Celani spent a day at SKINR prior to the ICCF18 conference but in spite of this close collaboration, AH has not been found. We are now skeptical of Celani's experimental results. This will continue for about 2 more months and will cease of no AH is found.

Also, during the hiatus the nanoparticle suspension experiment was able to continue. These particles made by Prof. Kattesh Katti are adapted from his medical radioactive tag program targeting of cancer tumors where he used Au nanoparticles. He substituted Pd for Au and SKINR deposits them in situ on a Pd cathode in a calorimeter. This method of cathode preparation, unique to SKINR, has yielded our first AH results.

It has been seen 4 times in several different cells. The final disposition of this result will be after we run the experiment in closed cells a number of times as a rigorous check on the preliminary results. A patent has been submitted for the nanoparticle cathode preparation method.

Our 9 open cells (the original Energetics workhorse cells) are running and collecting data on various cathodes. Two have been converted to a "hybrid" cell by moving the recombiner from outside to inside the cell. Dr. Azizi's idea worked out very well as the cell calibrates extraordinarily well. More of the cells will be converted to the hybrid design. Running now are cathodes made by SKINR, two cathodes made by ENEA, and several made by graduate students of Dr. Gangopadhyay at MU and funded by SKINR. SKINR obtained 6 NRL-designed cells from ReResearch Inc. for a nominal fee. These cells are all plastic, closed cells with a smaller electrolyte volume. SKINR is promoting the idea that these cells will spread around the world for use in these studies so that all researchers will have a common platform with which to compare data.

Mechanistic Experiments - Low energy x-ray/RF diagnostics

It is SKINR's belief that energy in some form must be emitted from active cathodes that are producing heat. It is also true that low energy or particle emission from active cathodes has not been examined rigorously. Therefore, the two on-going experiments described below address this hole in the data.

One of our three-ultrasound cells is now running and the second is in the calibration stage. These cells produced the highest reproducibility of all the experiments at Energetics so SKINR is implementing x-ray detection and RF diagnostics on these cells by installing thin membranes between the electrolyte and the detectors.

A new cell uses a 1 μm thick Si_3N_4 membrane (donated by NRL) on which Pd is vapor deposited to a thickness of 100 nm. We are performing electrolysis on this cell and x-rays as low an energy as 1 keV make it out of the cell to our detector. Also, charged particles above ~30 keV will emerge from the cell and also excite the 19 keV k x-ray of Pd that is easily detected.

These two experiments, that increase the sensitivity by 11 orders-of-magnitude over calorimetry, will be a stringent test to theories that predict electromagnetic or particle emission. Also, if and when we see emission it will give us unprecedented clues as to the origin of the AH. This experiment was run for two weeks before the detector failed in late October. The repaired detector has arrived and the experiment will commence soon.

Three new calorimeters have been brought on-line. Two are from A COMPANY and one from NRL. All were donated to SKINR. They operate on thermoelectric modules and are closed cells. The two from A COMPANY will be used for normal cathode studies; the one from NRL is compact and will be used to study the effect of external polarizing magnetic fields on cathode loading and heat production.

For new basic studies of hydrogen loading, we are initiating a permeation dual cell arrangement. This allows the determination of the effects of electrolyte additions, surface contaminants and voltage and current changes on the catalytic properties of the surface and loading status of the cathode.

A new potentiostat has been ordered to enable several experiments and to conduct electrochemical impedance spectroscopy at higher frequencies. Figure 1 is from our collaboration with ENEA and shows that the cathode is in a resonance condition when it produces heat. The Nyquist plot displays a resonance condition not known in electrochemistry. Figure 2 displays the same information when the cathode is not producing excess heat and there is no resonance condition. This is very strong evidence that the cathode is in a resonance condition, is new information, and we believe an important new clue in learning the mechanism of AH.

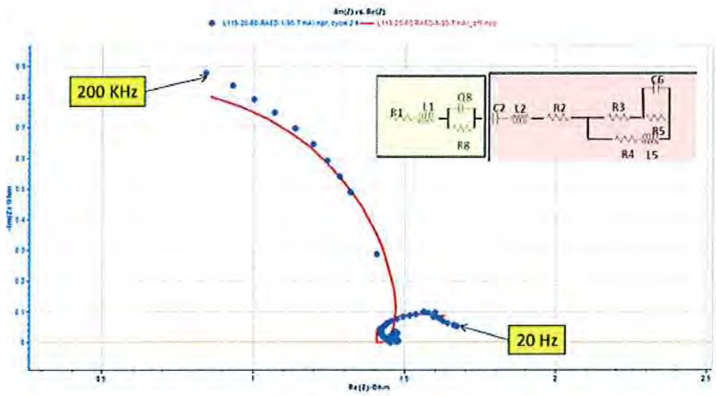

Figure 1

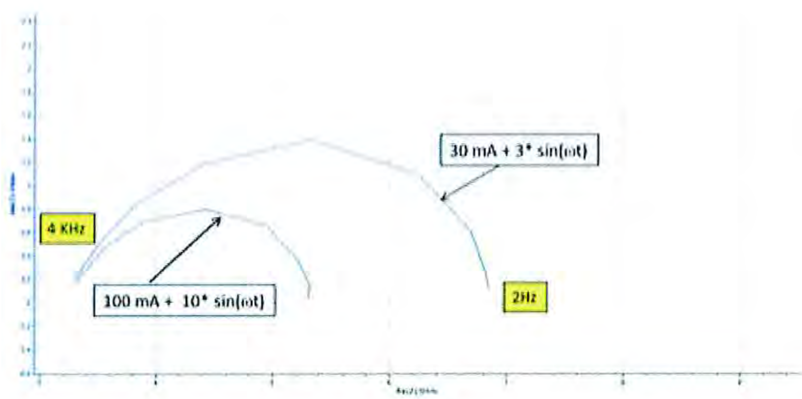

Figure 2

Another new initiative is the reproduction and extension of the "exploding wire" experiments conducted by Mike McKubre and SRI. His preliminary results showed that by running a current pulse through Pd when loaded with deuterium AH was produced. SKINR will improve the calorimetry and introduce nuclear radiation detectors. SRI loaned SKINR the hardware to perform the experiments and has visited SKINR to help in the experiments and Dr. Azizi visited SRI in November to learn the procedure for H loading of the wires. In October our collaborators from ENEA, SRI and Coolescence visited SKINR for a week where planning and experimental procedures were worked out.

Collaborations within the University of Missouri

Six scientific groups are collaborating with SKINR. Dr. Duncan set up this arrangement as SKINR was being founded. Work by Professor Kattesh Kattie (Radiology Department) was already discussed. Work by Professors Shubhra Gangopadhyay, John Gahl, Peter Norgard, Mark Prelas and Helmut Kaiser are described below.

Professor Shubhra Gangopadyay

Professor Gangopadhyay has a powerful research group in plasmonics with many graduated students. The state-of-the-art capabilities of her institute dovetail nicely with needs of SKINR for fabrication of cathodes. Cathodes structures fabricated include numerous Pd/Pdfilm/CNT/Pdfilm (CNT = carbon nanotubes) cathode structures, Pt thin films on thin Si_3N_4 membranes, and artificially structured cathodes using template and embossing. This work supports two students and has recently resulted in an excess heat event. It is being vetted and will be reported at a later date.

Professor Mark Prelas

Our work this year has produced encouraging results in two different experiments and also introduced additional analytical tools to benefit all of SKINR. In the thermal shock experiment we have: observed the production of a large number of neutrons without requiring high-energy plasmas or accelerators; updated our analytical systems to provide real-time data analysis and processing without requiring human intervention; presented results at the 18th International Conference of Cold Fusion; and submitted a proceedings paper for ICCF18 describing our successes. The results supported prior thermal shock work that was reported at ICCF-17. The proceedings paper for ICCF 17 describing the thermal shock method and unpublished results was accepted and will soon be published. A US patent application titled Method and Apparatus for Generating Neutrons from Metals Under Thermal Shock (Docket No. 44444) was filed on August 5, 2013.

Our second experiment (electrolysis of Pd deposited on a diamond radiation detector) has also been successful. The initial work was reported at ICCF-17 that showed that low energy particles were produced with a peak at 312.5 keV, 658.5 keV and 881.7

keV. The energies do not match up with ions created in DD fusion. We then looked into possible beta producing reactions that could generate energies in this range. The stable isotopes of Pd are Pd-102 (abundance 1.02%), Pd-104 (abundance 11.14%), Pd-105 (abundance 22.33%), Pd-106 (abundance 27.33%), Pd-108 (abundance 26.46%), Pd-110 (abundance 11.72%). If neutrons were produced, then a neutron capture reaction could occur which produces beta spectra with average energies near the observed peaks: The beta spectrum is complex so the peaks generally do not occur at the average beta energy.

n+Pd-106→Pd-107 →Ag-107+ beta + 0.034 MeV (average beta energy 0.11 MeV)
http://www.nndc.bnl.gov/chart/decaysearchdirect.jsp?nuc=107PD&unc=nds

n+Pd-108→Pd-109 →Ag-109 (stable)+ beta + 1.115 MeV (average beta energy 0.372 MeV)
http://www.nndc.bnl.gov/chart/decaysearchdirect.jsp?nuc=109PD&unc=nds

n+Pd-110→Pd-111→Ag-111 + beta + 2.22 MeV (average beta energy 0.74 MeV) →Cd-111 (stable)+ beta + 1.037 MeV (average beta energy 0.346 MeV)

In 2013 we focused on building better and more reliable diamond sensors, reducing noise and experimenting with diamond sensors and beta sources. We have demonstrated the ability to reliably produce a robust diamond-based sensor for radiation detection within chemically active environments using metal layers of Ti and Pd. It was shown that the improved diamond sensor does responds to standard beta check sources. We also tried to duplicate the 2012 experiments and appear to have measured a new low-energy process of charged-particle production that arises from deuterated titanium metals with peak energy of 650 keV. Both of these results were presented at ICCF18 and have been submitted in a proceedings paper.

Professor John Gahl and Dr. Peter Norgard

During the bulk of 2013 the group was involved in two major efforts related to the SKINR research goals, namely; (1) investigating energetic reactions involving accelerated deuterons with palladium and other metals of interest, and (2) developing hardware for the in situ neutron diffraction study of deuterated palladium.

Assistance was provided to Helmut Kaiser in the development of an electron-Cyclotron resonance hydrogen plasma source (ECR-H) with an instrumented plasma chamber. The ECR-H source was modeled and the original drawings were produced By Andrew Gunn under the supervision of Helmut Kaiser. Peter Norgard assisted in the design of the chamber including the ECR reaction chamber, high-voltage interconnects, and a high power radio frequency (RF) driving source.

Investigations of energetic deuteron reactions involving metal targets were conducted with assistance from employees at the MU Research Reactor. Particularly helpful assistance came from Alex Saale of the cyclotron facility. These investigations were aimed at developing a further understanding of the reaction process in the target metals, particularly at energies below the Coulomb threshold where most low energy nuclear reactions (LENR) are expected to occur. We developed the analytical techniques required to unambiguously identify distinct nuclear decay pathways relevant to the LENR regime.

Peter Norgard presented original research findings at the ICCF18 and John Gahl participated in a panel. The presentation was entitled "Cross Section Measurement of Deuteron-Induced Reactions," and outlined initial findings from the deuteron-reaction research.

A journal paper was prepared entitled "Deuteron Activation of 110Pd Leading to the Production of 111Ag," The paper provides a detailed description of the data analysis techniques developed for the deuteron-reaction research as well as an experimentally derived branching ratio and a relative cross section analysis. So called (d,p) reactions were seen to dominate over (d,n) reactions, contrary to published computed cross sections, and potentially significant to LENR understanding. The paper was prepared for a December submission to Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms. A follow on paper fully describing the cross section is in preparation.

Recent work has involved the development of a small, compact pulsed power source that will be used to drive deuterium-loaded wires. The source will deliver modest amounts of energy (<1J) very quickly (<100ns) resulting in very high power (>1Mw). Various diagnostics are being developed, including liquid nitrogen calorimetry, neutron detectors, and gamma spectroscopy for detection and identification of radioisotopes. We have also made contributions to the SKINR group as a whole this year. We have prepared a residual gas analyzer (RGA) that will be used to determine the presence of transmutation products within samples submitted by members of the group. We have also coordinated with members to set up radiation detection systems in excess heat experiments with the goal of identifying possible particles and mechanisms that cause the excess heat effect.

Professor Helmut Kaiser

Neutron scattering has been a powerful tool in the investigation of hydrogen in metals for over 30 years. Because H/D play a crucial role in the Anomalous Heat Effect, we are preparing the following three *in-situ* neutron diffraction experiments, using the Powder Instrument at MURR:

1. H/D loading of palladium and other metals using an electrochemical cell and *in-situ* neutron diffraction. The novelty of this study is to take diffraction data, while the electrochemical cell is in operation. Neutron diffraction will provide answers about the H/D absorption (structural information) during the cathodic reaction in the electrolysis process as a function of applied current. The sample environment is basically ready to go. By the end of this month (Dec. 2013), we will carry out neutron diffraction measurements for characterizing the individual components without applied current. The project application/beam experiment proposal will be submitted for approval by Health Physics and the MURR Safety Committee in the middle of this month. After approval, the experiment can be started – the goal is by the beginning of February 2014.
2. H/D gas loading of Pd (Ni, Ti, ...) up to 200 bar. Neutron diffraction measurements again will provide insight in the structural changes due to H/D absorption as a function of applied pressure for comparison with the results of the electrochemical cell

measurements. The pressure cell has been built and is basically ready to go. This project application/beam experiment proposal needs a little bit more work; it should be possible to be submitted by the end of December. After approval, the experiment can be started but needs to be coordinated with the electrochemical cell experiment.

3. H/D plasma loading of Pd (Ni, Ti, ...) with an ECR (Electron Cyclotron Resonance) glow discharge cell and *in-situ* neutron diffraction. In this experiment, the target (Pd, Ni, Ti, ...) will be bombarded with positively-charged H/D ions as a function of H/D pressure in the ECR cell and as a function of negative potential applied to the target, while neutron diffraction data will be collected *in-situ*. These experiments will be the first time that H/D absorption (structural information) will be studied using an ECR glow discharge cell. The cell design and the layout of the gas handling system have been completed. Various components of the ECR electronics (HV power supply, waveguide, sensors, tuner, magnetron, ...) have been purchased. The next step will be purchasing of the other components (for the ECR cell and the gas handling system) and fabrication of the ECR cell. The project application/beam experiment proposal is in a first-draft stage. The plan is to submit this document to Health Physics and the MURR Safety Committee in January of 2014.

International Ad-Hoc Collaborations.

SKINR has forged collaborations with 7 research entities in the last 12 months. The purpose is to share materials and results in order to speed up the expansion of the knowledge base in the field. We will soon exchange NDA's, but otherwise keep a very open very active exchange of ideas and data. Figure 3 shows the parties involved. Primarily we exchange Pd cathodes and share the results of running them in calorimeters and we analyze each other's materials. We also are using similar cells and calorimeters designed by NRL in order to compare data more precisely. Some equipment has change hands. For example, NRL has loaned SKINR detectors and calorimeters, A COMPANY has given 2 calorimeters to SKINR, and ReResearch manufactured 6 cells for SKINR at a nominal fee. SKINR In turn sent cathodes to most of the collaborators and shared loading protocols. National Instruments (NI) is a major US corporation that supports research in AH. NI supports SKINR by offering a 70%

discount on their process control hardware and control software. SKINR has an excellent relationship with the CEO and VP for research and development.

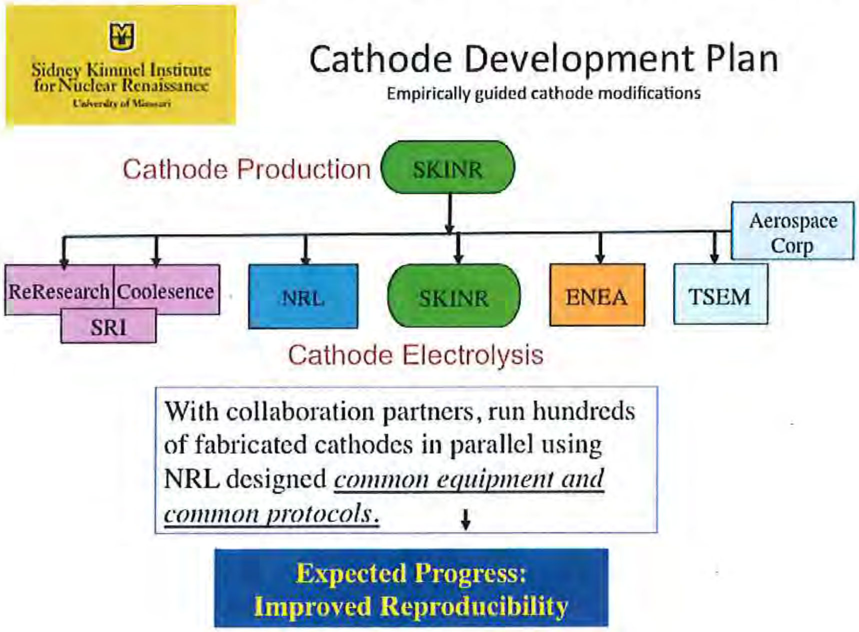

Figure 3

ReResearch and Coolesense are small 5 person companies with excellent scientific talent, NRL is the lead scientific laboratory in DoD, SRI is a nonprofit laboratory associated with Stanford University, ENEA is the Italian equivalent of the US Department of Energy, and Aerospace is a large FFRDC (Federally Funded Research and Development Corp.) that builds satellites for the US government and industry. All of these collaborators have been vetted for their exceptional abilities and scientific acumen and are worthy partners for SKINR. SKINR staff has visited each collaborator at least once in the last year and all of the collaborators have visited SKINR at least once in the last year. These exchanges are very useful for planning experiments w and performing joint data analyses.

SKINR is developing a new theory of the AHE that is home grown. It suggests an experiment that we will pursue this year, if possible. The theory is too controversial to explain in this report, but we are happy to discuss it by more secure means. It is no more right or wrong than the many theories that are postulated but it is entirely different and exciting to contemplate, and it does not invent new physics or violate known physical laws.

What have we learned?

Even though we were 90% shut down from late December 2102 to early August 2013 due to the relocation of the laboratories, much progress has been made. We:

• Have found no heat in the Celani Ni-H wire experiment

• Have promising anomalous heat with the Pd nanoparticle suspension, self-organizing cathodes

• Learned that the cathode is most probably in a resonance condition during excess heat events (from ENEA)

• Added 4 new members to the informal research consortium

• Explored new protocols for improvement of H loading both in speed and atomic fraction

• Initiated two new experiments focused on determination of the mechanism of the AHE

• Hired a new very talented employee (Dr. JingHao He) and experienced the retirement of one employee (Dr. Mark Tsirlin)

• Participated in and supported the ICCF18 conference at the University of Missouri where SKINR was featured and where the superb personnel and facilities of SKINR was demonstrated to the gathering of scientist from around the world

• Established SKINR as the preeminent laboratory in the world that is pursuing the Anomalous Heat Effect. Our reputation was enhanced by SKINR conference participation and laboratory tours

We have high hopes that our fundamental experiments will reveal new and important information on the mechanism of AH in 2014.

Enclosures

Encl. 1 SKINR Summary Slides

Encl. 2 ICCF18 paper

Encl. 3 Paper by John Gaul et al.

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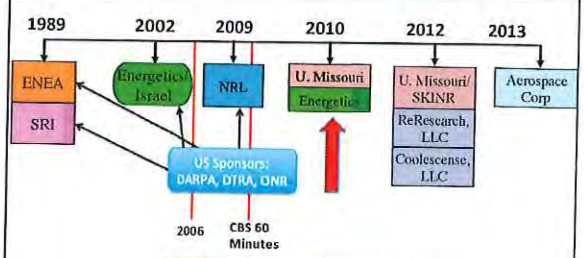
Year 2, Enclosure 1

Sidney Kimmel Institute for Nuclear Renaissance (SKINR) Overview

Graham K. Hubler, Ph.D.
Director, Sidney Kimmel Institute for Nuclear Renaissance (SKINR)
Department of Physics and Astronomy
University of Missouri
Columbia, Missouri, 65211 USA
hublerg@missouri.edu
571 641-1471

SKINR Directive: To find the origin of the Anomalous Heat Effect (AHE) with a sound materials science approach and with no preconceptions as to the origin of the phenomenon. To publish findings in the open literature and to openly collaborate world wide with researchers in the field and in cross disciplines.

International Collaboration and Time-Line of Partner Involvement



Expected Progress:
- Improve Reproducibility
- Reveal Mechanism

SKINR Staff

Administratively located in the UM Department of Physics and Astronomy

Orchideh Azizi
Arik El-Boher (Research Group Leader)
JingHao He (new hire)
Graham Hubler (Director)
William Isaacson
Dennis Pease

SKINR has Laboratory space in the Department of Physics and in the Department of Electrical Engineering – Dr. Shubra Ganghopadhyay was instrumental in donating space to SKINR

R. Duncan; UM Vice Chancellor for Research

Involvement of UM Professors in SKINR-related Activities

J. Gahl, Electrical Engineering
-Pd(d,p); Ni(p,p) on cyclotron, exploding wires
S. Gangopadhyay; Electrical Engineering
-CNT; nanoporous; artificially structured cathodes; Pd deposition on membranes
H. Kaiser: Dept. of Physics & Astronomy/MURR
-neutron scattering on PdD. PdH
K. Kattie; Dept. of Radiology
-In situ nanoparticle deposition on cathodes
S. Kovaleski, Electrical Engineering
-Piezoelectric ion sources, low energy ion bombardment
M. Prelas, Nuclear Engineering
-Neutrons form thermally shocked TiDx, diamond particle detectors
P. Pfeiffer; Dept. of Physics & Astronomy
-Fundamental Hydrogen charging of metals studies

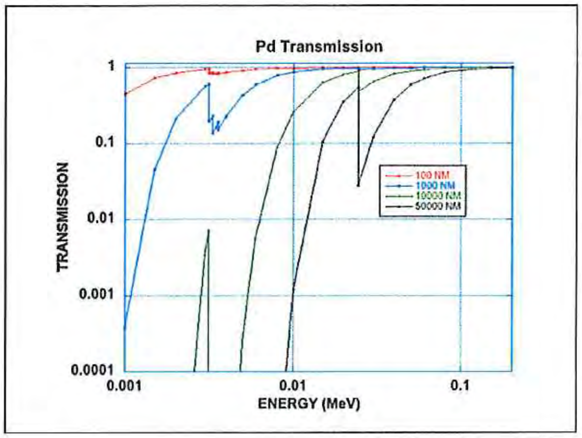
Graduate Students and Post-Docs

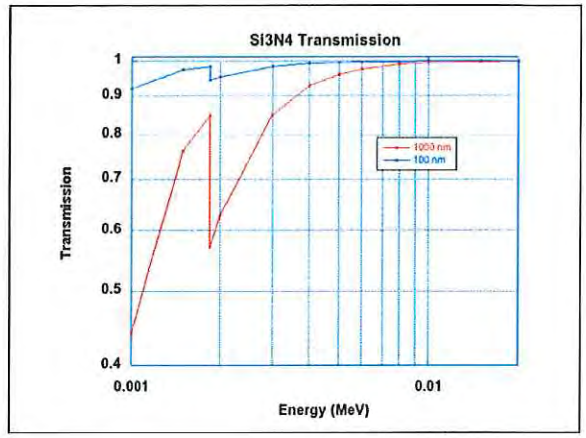
Charles Weaver – M. Prelas – Nuclear Engineering
Peter Norgard – J. Gahl and S. Kovaleski – Electrical Engineering
Dr. Cherian Mathai – S. Gangopadhyay - Electrical Engineering
Somik. Mukherjee - S. Gangopadhyay - Electrical Engineering
Gupta Sagar – K. Katti - Radiology
Andrew Gunn – H. Kaiser – Physics & Astronomy

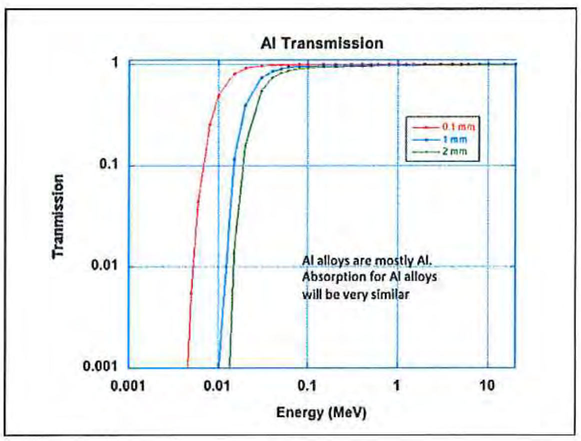
Most Energetic Anomalous Heat Events by the University of Missouri (SKINR)

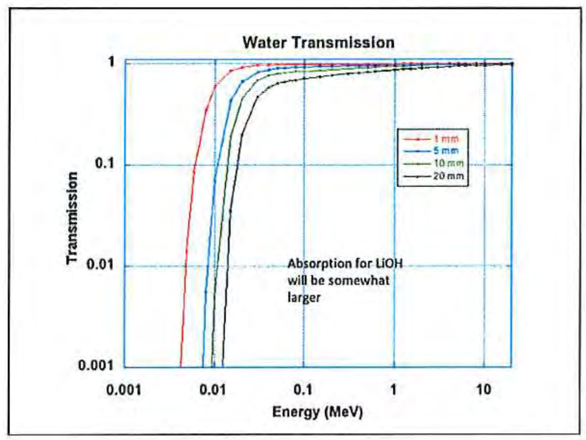
	ENEA fabricated cathodes				40% reproducibility			
Experiment	**56**	**64a**	**64b**	**GD-14 1**	**US1-1 5**	**US3-0 5**	**US3-06**	**US3-21**
EE, MJ	3.1	1.1	> 3.5	2.4	0.19	1.1	1.32	0.026
EP, W	3	19	> 11	14	0.25	0.8	0.9	0.13
Max COP, %	80	2500	> 1500	75	600	3000	525	650
Duration of EH, h	300	17	80	90	280	960	445	55

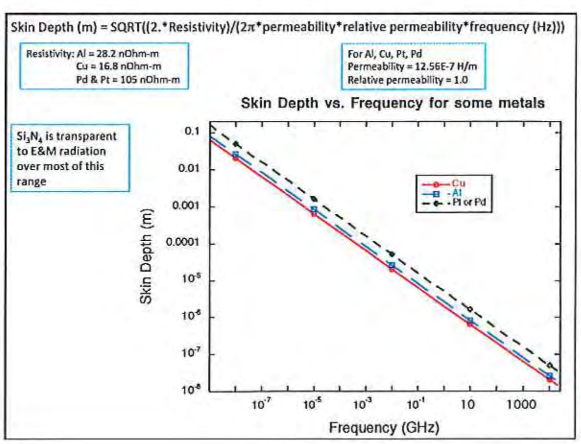
The Naval Research Laboratory – 5 events from 2-10X excess (2011-2102)
Stanford Research International – dozens of events 2-10x excess (1990 to present)
ENEA, Frascati Laboratory, Italy – dozens of events 2-5x excess (1990 to present)

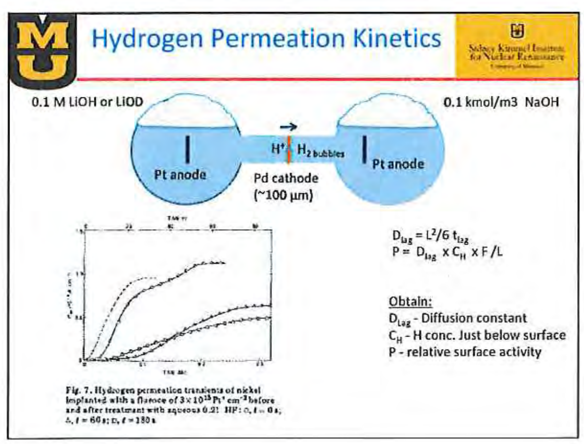

Pd Transmission
TRANSMISSION
ENERGY (MeV)
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
100 NM
1000 NM
10000 NM
50000 NM


Si3N4 Transmission
Transmission
Energy (MeV)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.001
0.01
1000 nm
100 nm


Al Transmission
Tranmission
Energy (MeV)
1
0.1
0.01
0.001
0.001
0.01
0.1
1
10
0.1 mm
1 mm
2 mm
Al alloys are mostly Al.
Absorption for Al alloys
will be very similar


Water Transmission
Transmission
Energy (MeV)
1
0.1
0.01
0.001
0.001
0.01
0.1
1
10
1 mm
5 mm
10 mm
20 mm
Absorption for LiOH
will be somewhat
larger


Skin Depth (m) = SQRT((2.*Resistivity)/(2π*permeability*relative permeability*frequency (Hz)))
Resistivity: Al = 28.2 nOhm-m
Cu = 16.8 nOhm-m
Pd & Pt = 105 nOhm-m
For Al, Cu, Pt, Pd
Permeability = 12.56E-7 H/m
Relative permeability = 1.0
Skin Depth vs. Frequency for some metals
Si3N4 is transparent
to E&M radiation
over most of this
range
Skin Depth (m)
Frequency (GHz)
0.1
0.01
0.001
0.0001
10-5
10-6
10-7
10-8
10-7
10-5
10-3
10-1
10
1000
Cu
Al
Pt or Pd


Hydrogen Permeation Kinetics
0.1 M LiOH or LiOD
0.1 kmol/m3 NaOH
Pt anode
H+
H2 bubbles
Pt anode
Pd cathode
(~100 μm)
D_lag = L²/6 t_lag
P = D_lag x C_H x F /L
Obtain:
D_Lag - Diffusion constant
C_H - H conc. Just below surface
P - relative surface activity
Fig. 7. Hydrogen permeation transients of nickel implanted with a fluence of 3×10^15 Pt+ cm^-2 before and after treatment with aqueous 0.2% HF: ○, t = 0 s; △, t = 60 s; □, t = 180 s

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Year 2, Enclosure 2

Excess of Power During Electrochemical Loading: Materials, Electrochemical Conditions and Techniques

Violante[1], *E. Castagna*[1], *S. Lecci*[1], *F. Sarto*[1], *M. Sansovini*[1], *T. D. Makris*[1], *A. Torre*[1], *D. Knies*[2], *D. Kidwell*[2], *K. Grabowski*[2], *D. Dominguez*[2], *G. Hubler*[3], *R. Duncan*[3], *A. El Boher*[3], *O. Azizi*[3], *M. McKubre*[4], *A. La Gatta*[5]

(1) ENEA, Unità Tecnica Fusione, C. R. Frascati, Frascati, ITALY
(2) Naval Research Laboratory (NRL) Washington DC, USA
(3) SKINR, University of Missouri, Columbia (MO), USA
(4) SRI International Menlo Park (CA) USA
(5) Consorzio Veneto Ricerca-TSEM Padova, ITALY

Abstract

The critical role of the electrode material characteristics in increasing the probability for observation of excess of power during electrochemical loading of palladium cathodes with deuterium is investigated, and, excesses of power production obtained by using palladium material with these identified characteristics are reported. Characterizations have been performed by using SEM and AFM microscopy as well as electrochemical analysis and XPS. The emerging scenario suggested by these results is that the poor control in achieving the identified material status is reflected in the reproducibility of the excess heat phenomenon.

Introduction

A significant body of research has been carried out to have a controlled mass transfer of deuterium into palladium cathodes in order to reproducibly exceed the loading threshold [1,2] required to observe excess power production during electrochemical loading [3-6].

The experimental data showed that loading up to about D/Pd = 0.9 (atomic fraction) is a fundamental necessary condition; additional conditions required to observe the onset of the effect [7-9] are enhanced mass transfer, crystal orientation, and specific surface morphology.

Different lots of palladium, most of them from the same producer, gave completely different behavior above the loading threshold D/Pd=0.9. Three different behaviors have been identified:

1) Large excess of power (> 100% of the input power).
2) Low excess of power (< 20% of the input power).
3) No excess of power.

The excess heat effect was observed by using also $Pd_{90}Rh_{10}$ cathodes. Some specific features were identified for the active electrodes with both materials. The active palladium electrodes had mostly (100) orientation of the polycrystals, enhanced hydrogen (deuterium) diffusivity, average grain size around 100 microns and a well-defined surface morphology identified by means of the power spectral density function (PSD).

Active $Pd_{90}Rh_{10}$ cathodes have a high diffusivity and a surface morphology, in terms of PSD, very similar to the one belonging to the active Pd samples. The differences are a mixed orientation of the crystals and a lower grain size, typically some ten's of microns. Doping with contaminants has been performed for both Pd and $Pd_{90}Rh_{10}$ cathodes i order to achieve the material characteristics belonging to samples producing excess of power.

Materials

The most significant evidence related to the cathode behavior in terms of excess of power production is the different spectrum of contaminants. It is well known from physical metallurgy that contaminants may have several effects on the metal characteristics:

- Contaminants may act on: grain size, crystal orientation and grain boundaries.
- It is well known from the literature [10] that contaminants modify the effect of chemical etching on surface morphology.

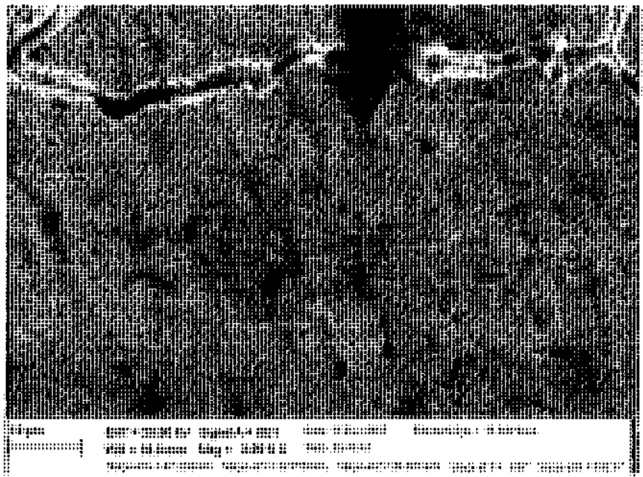

Fig. 1a. SEM of the surface of #64 electrode giving up to 3500 %.

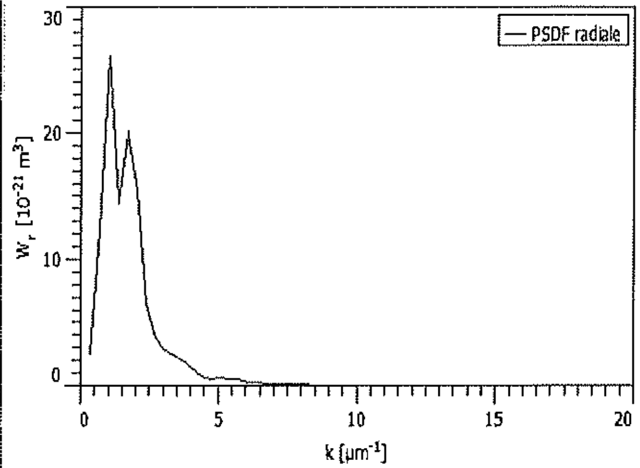

Fig. 1b PSD #64 cathode surface.

A Scanning electron micrograph (SEM) of the surface of #64 cathode that produced up to 3500% excess power reveals what we call a labyrinth morphology as shown in Fig. 1a. This sample displayed the PSD shown in Fig. 1b and we have determined that the PSD and excess power are correlated – they are proportional so the higher the PSD peaks the greater the power excess. By contrast, non-active samples have a very low PSD signal as shown in Figs. 2a,b.

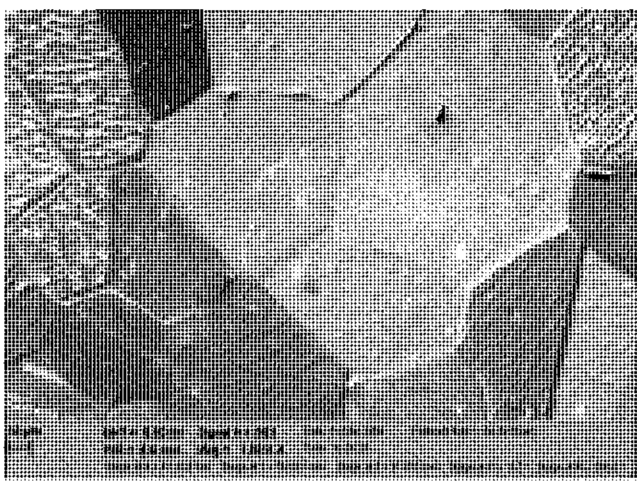

Fig. 2a. SEM of a non-active electrode surface

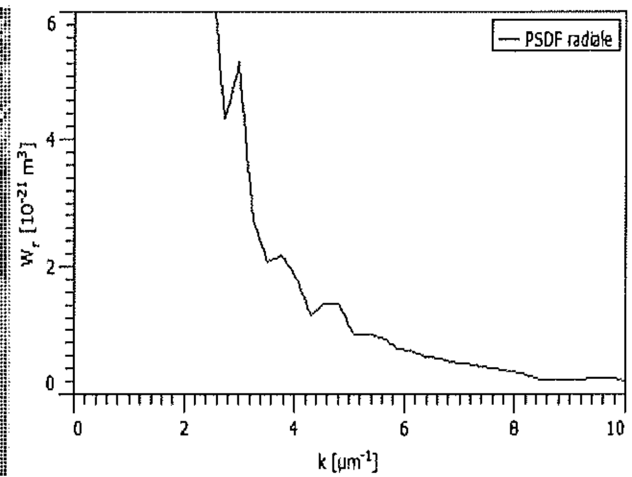

Fig. 2b. PSD of non-active electrode surface.

Fabrication of a Pd cathode characterized by crystals mainly (100) oriented, average grain size around 100 microns and with a surface morphology reproducing a PSD with more than two peaks with decreasing amplitude from the left to the right as in Fig. 1b is not easily achieved. It was understood that materials having a larger concentration of Pt as contaminant gave more often a labyrinth structure as the one shown in Fig. 1a after the chemical etching with aqua Regia. For such a reason, two palladium cathodes obtained by using a starting Pd able to give (100) orientation and proper grain size but unable to give the labyrinth structure after etching, were sputtered with a few nanometers of Pt and annealed at 850 °C. After the thermal treatment the two samples were etched which produced the required surface morphology as shown in Fig 3.

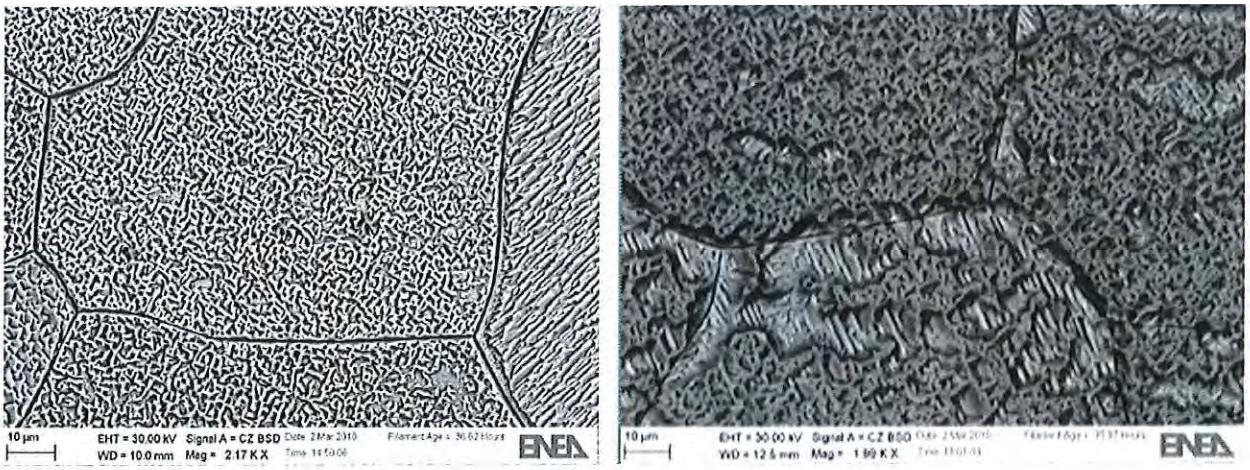

Fig. 3. SEM of the surfaces of two Pd samples, doped by adding Pt on the surface and etched with Aqua Regia 50%.

The PSD for both the samples were substantially modified compared to the one etched without the deposited Pt (Fig. 2b) as seen in Fig. 4.

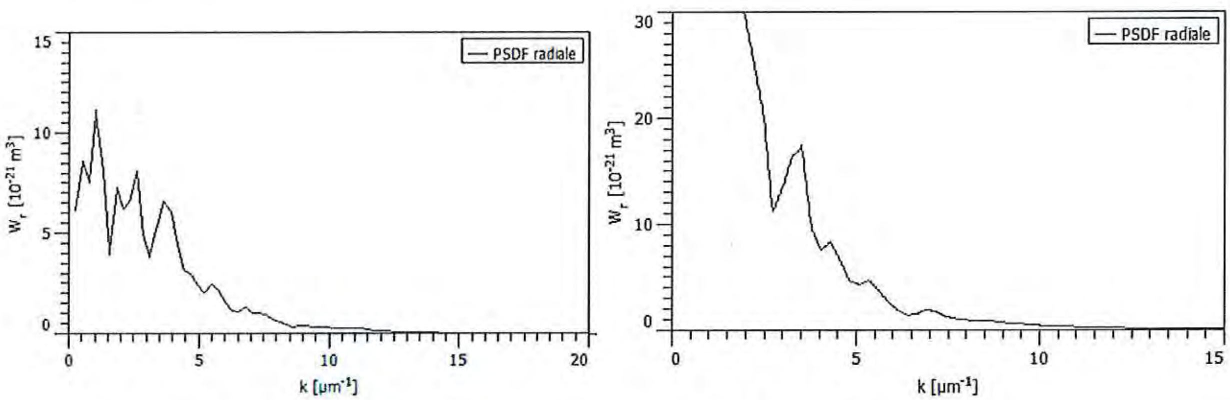

Fig 4. PSD for two Pd samples after Pt deposition, annealing and etching in aqua regia.

These two samples were electrolytically loaded with deuterium in 0.1M LiOD in two different mass flow calorimeters and both gave excess of power up to 25% of the input power. The results are shown in Fig. 5 where power in and power out in mW are plotted versus time in seconds.

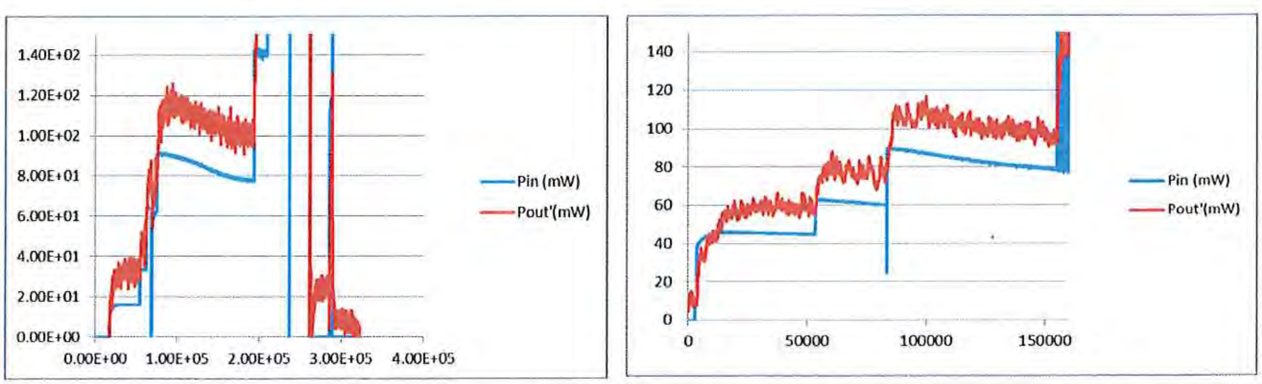

Fig. 5. Data showing excess power up to 25 % produced by each of the Pd cathodes doped on the surface with Pt before annealing and etching.

A similar study was carried out on $Pd_{90}Rh_{10}$ cathodes prepared by applying the protocol developed at NRL [11]. Palladium and Rhodium have been melted at 90/10 atomic ratios in an alumina crucible by using a hydrogen-oxygen torch. The melted material was annealed at 900 °C and then cold rolled to a thickness of 50 μm. After rolling the sample was annealed again at 850°C and then etched with Aqua Regia. Fig.6 shows the surface of sample L119(20-60) after the chemical etching.

Fig. 6. Surface of the L119(20-60) $Pd_{90}Rh_{10}$ sample.

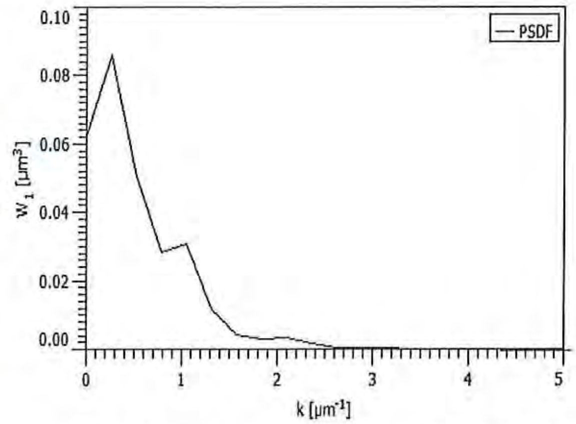

Fig. 7. Power spectral density of L119(20-60).

A second sample (L119(100-140) was prepared from the produced $Pd_{90}Rh_{10}$ alloy. Both the samples have been analyzed by EDX and we observed some content of Si (Silicon oxide) on the surface of L119(20-60). Fig. 7 shows the PSD of the surface of L119(20-60); again we may observe the typical structure of the peaks with decreasing amplitude from left to right. It should be noted that the peak positions are very close to the position of peaks in Fig. 1b. Figure 8 shows the energy dispersive x-ray spectrum (EDX) for sample L119(20-60) where Si is clearly evident.

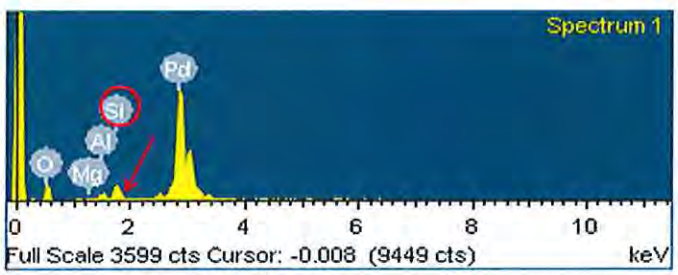

Fig.8. EDX of sample L119(20-60). Si is the most abundant contaminant on the surface.

A calorimetric study on sample L119(20-60) was performed by using the differential calorimeter developed at NRL [12] and the time history of power in and power out is shown in Fig. 9a.

We may observe in Fig. 9a that the power excess spontaneosly develops after ~290000 sec elapsed time and was stable for about 12 hr. We assumed the effect to be a bias shift of the calorimetric system which was checked by inverting the current to deload the cathode and after deloading an input power level was applied close to the one existing before changing the polarity. After the thermal transient (with some adjusting of the input power at the required level) a perfect balance of power in equals power out was observed (the output curve was overlapping the input curve (see Fig. 9a). This confirmed that the signal was a real effect. The polarity was then reversed again and PdRh was reloaded at a higher current value. As soon as the cathode was reloaded (~355000 sec elapsed time) the system gave again an excess that was larger than the previous one.

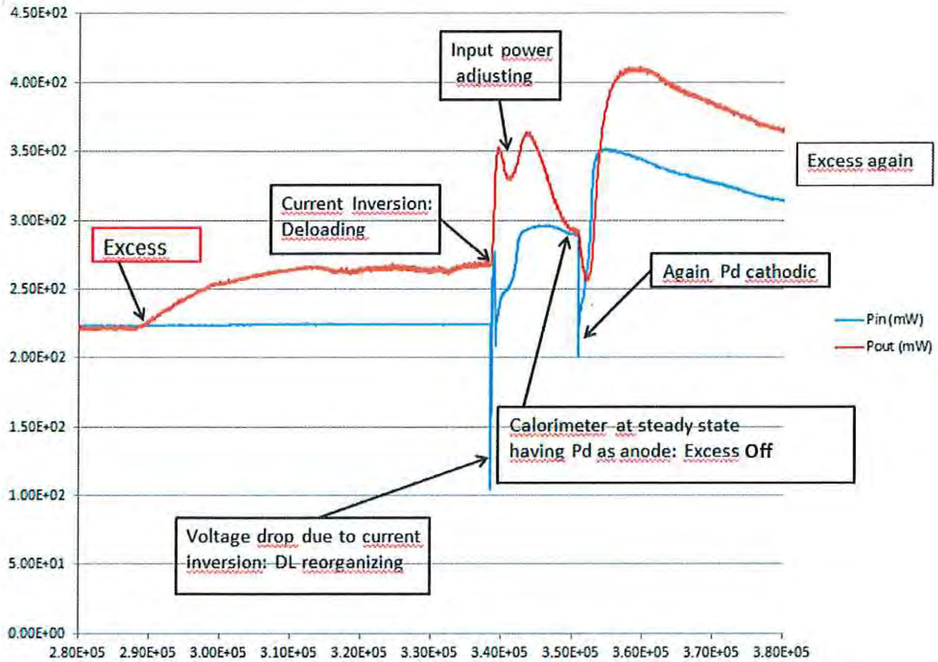

Fig. 9a. Excess power occurs (~290000-355000 s) and is switched off by current inversion. Restoring the original cathodic polarization restarts the power excess.

Figure 9b shows the same calorimetric run after 530000 s.

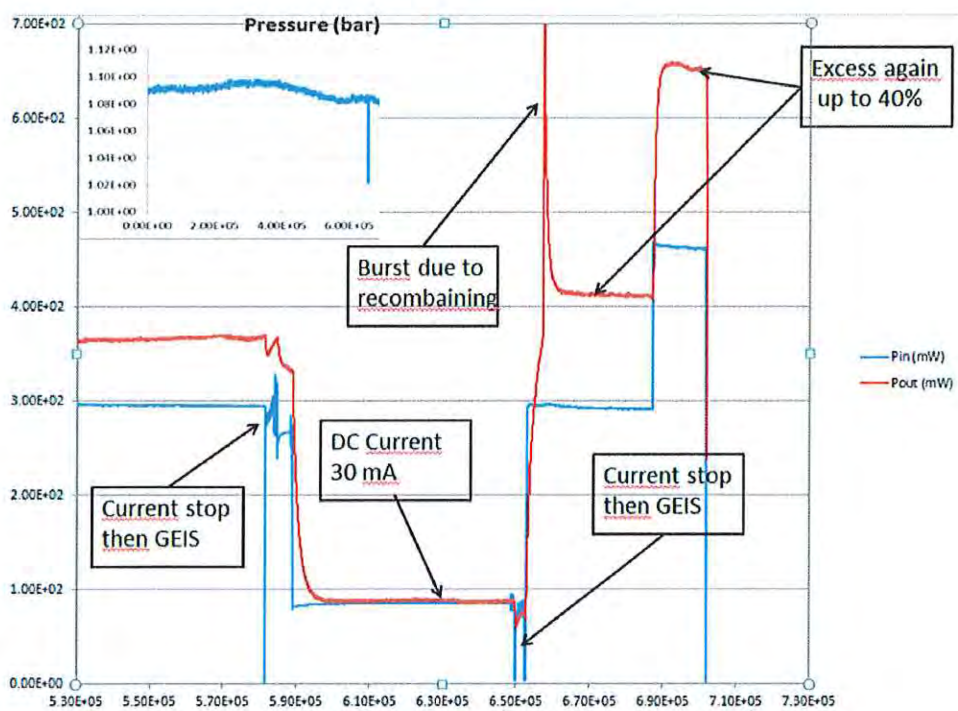

Fig. 9b. Excess power for the same run as in Fig. 9a at longer time.

After ~580000 s it was decided to perform a Galvanostatic Electrochemical Impedance Spectroscopy (GEIS) using the Biologic VP 200 Galvanostat-Potentiostat electrochemical spectrometer that was controlling the experiment. This operation was performed in order to extract, in situ, new information concerning the status of the electrochemical interface in terms of an equivalent circuit.

Five impedance spectra were acquired during the excess but Nyquist plots during the excess gave scattered points, revealing a significant disturbance during the effect; however, one plot was clearly readable after removing the noise. The EIS was carried out within the frequency range 200-KHz-20 Hz and the Nyquist plot is shown in Fig. 10 with frequency decreasing from left to right in the plot. The equivalent circuit during the excess is also shown in the insert in Fig. 10. The Nyquist plot clearly has resonating component inside. The applied DC current during the measurement was 90 mA with 7 mA sine probe amplitude.

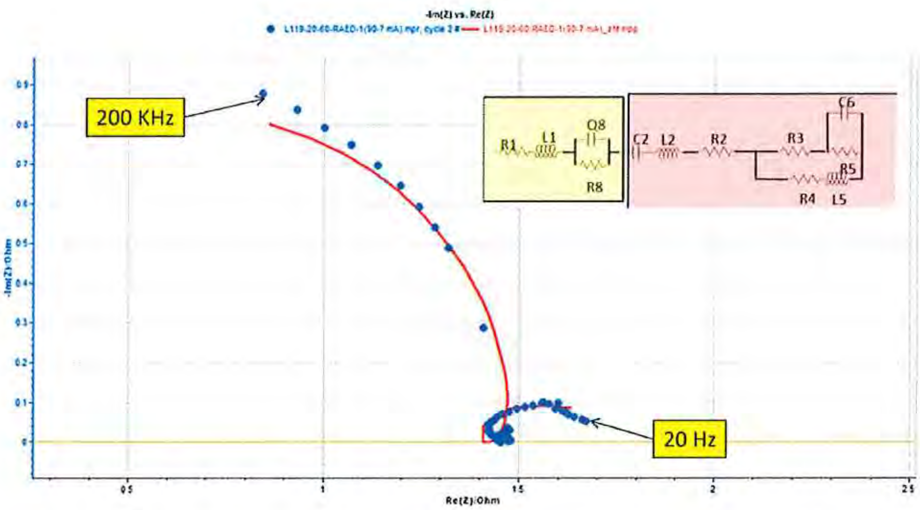

Fig. 10. In situ Electrochemical impedance Spectroscopy on Sample L119(20-60). Excess-on.

Then the current was reduced to 30 mA DC and a sufficient time was allowed to elapse (some hours) to complete the thermal transient of the calorimetric equipment (roughly within the time interval 590000-650000s). The excess power disappeared as can be seen from Fig. 9b and a new impedance analysis was performed and 25 Nyquist plots were acquired within the frequency range 400 KHz-10 Hz. Most of the plots unstable yielding very scattered points as during the excess. In some cases it was possible to extract a signal from the noise. Two of them are shown in Figs. 11a and 11b.

In Fig. 11a the proper fitting of the impedance spectrum was achieved by inserting a typical RLC within the circuit with a resonant frequency of 166 Hz.

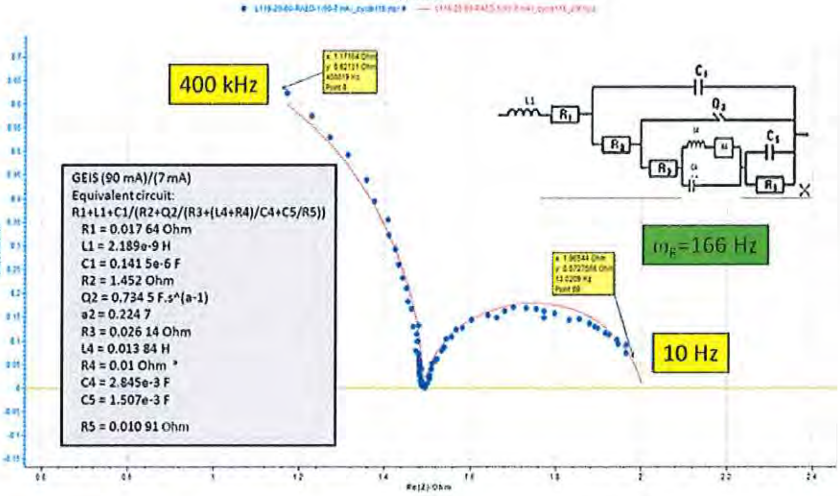

Fig. 11a. In situ Electrochemical impedance Spectroscopy on Sample L119(20-60). Excess-off.

Figure 11b shows another GEIS plot carried out after switching off the excess and we may see that an equivalent circuit quite similar to the one obtained during the power excess by reducing the current to 30 mA

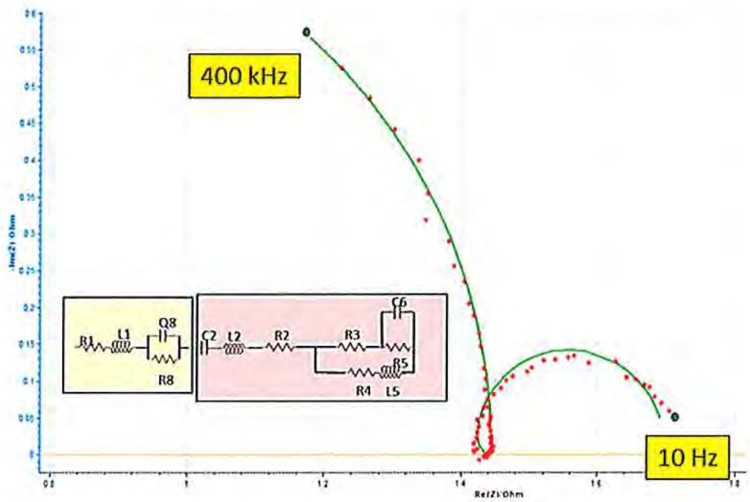

Fig. 11b. In situ Electrochemical Impedance Spectroscopy on Sample L119(20-60). Excess-off

In this case the equivalent circuit includes LCR components having a resonating frequency of about 200 KHz.
After that the current was set to zero for a few seconds and the GEIS was performed again by maintaining the DC current at 30 mA and by applying 3 mA sine wave. The Nyquist plot is shown in Fig. 12. It is clear that RLC component disappeared as soon as input power was set to null.
The surprising result, even if preliminary, is that the excess power is characterized by a specific electrochemical structure of the interface (equivalent circuit) that remains also after switching off the effect by reducing the current, but such a structure is destroyed if the system is more strongly perturbed by reducing the current to zero.
The inductive behavior in Fig. 12 (negative imaginary component) at high frequencies is due to the wiring and connection of the cell and perfectly reproduces the tests performed with dummy circuits. The increasing of the electrolyte impedance is due to the cooling since the power load on the cell is reduced.

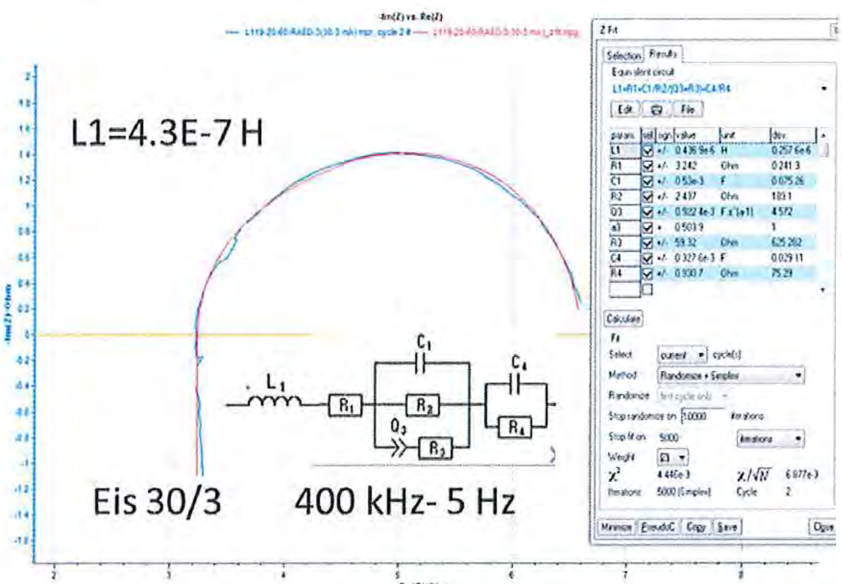

Fig.12 GEIS, 30mA/3mA 400 kHz – 5Hz: Excess-Off.

Even if the results have to be considered as preliminary and need to be replicated, it is clear that the electrochemical interface substantially changes during the production of excess and that the presence of LRC components are suggestive of a resonant mechanism at the interface.
Fig. 13, as reference, shows a GEIS at two different current level performed on an inactive Pd cathode.

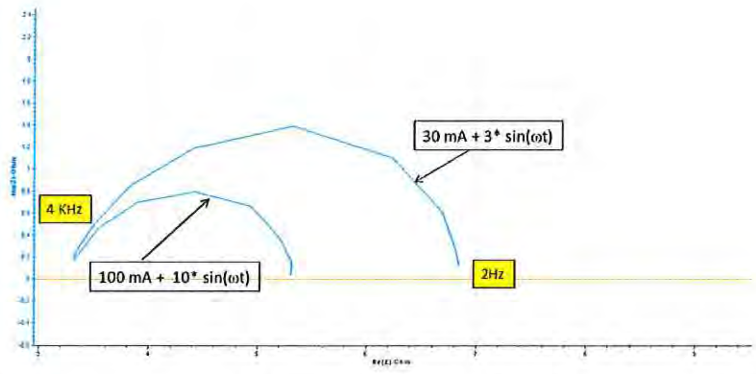

Fig. 13 GEIS performed on inactive Pd electrode at two different current levels

As soon as the GEIS was completed, the cell current was increased again at 90 mA and the excess power restarted at a somewhat higher level as can be seen in Fig. 9b. There is a big power spike after increasing the current due to D2 and O2 gas recombination as the catalyst restarted as is confirmed by the negative pressure spike in the cell pressure plot (top left Fig. 9b). Further increasing the current produced greater excess power up to approximately 40% of the input. A small oscillation of both current and potential was observed during the excess.

The cell was switched off during the excess in order to physically investigate the status of the sample surface during an excess power event. Fig. 14a shows an SEM image of the electrode surface as was during the excess. Fig. 14b shows the PSD. The most significant peaks are always in the region of k up to about 5 μm^{-1}. EDX revealed that during the excess, Fe, Cu and Pt were on the electrode surface.

Fig. 14a. SEM image of the electrode surface as it was during the production of excess power.

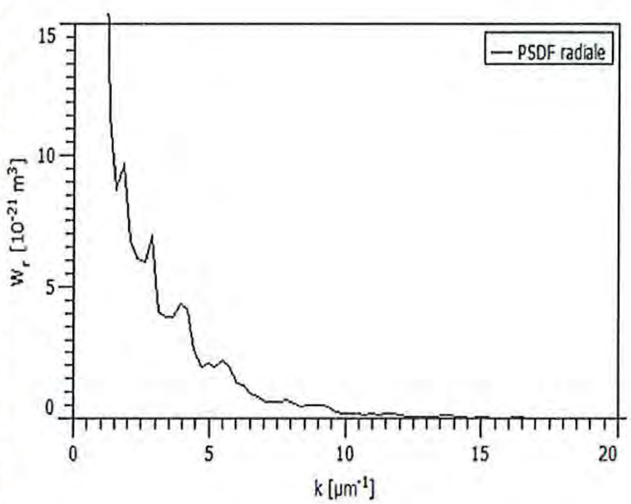

Fig. 14b. PSD of the surface shown in fig 14a.

Two additional samples from the sample PdRh lot were investigated and were found to be totally inactive regarding the appearance of excess power.
No evidence of specific surface contaminants was observed on these two samples. Since Si was absent on the surface of the inactive samples, a new lot of PdRh was prepared by adding intentionally Si as a contaminant. One sample was investigated in the differential calorimeter mentioned above.

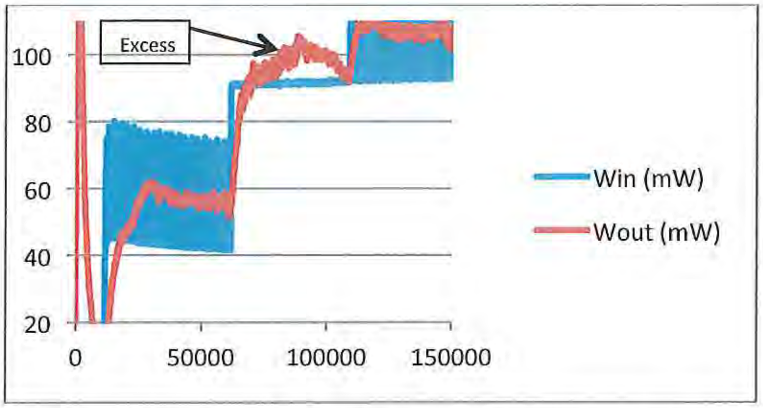

Fig.15. L133 (40-80), $Pd_{90}Rh_{10}$ Si doped, up to16% excess of power.

Fig. 15 shows the occurrence of an excess of power up to 16% with sample L133 (40-80) Si doped. The XPS analysis reveals that Si is in oxide form. The burst survived for 10 hr. The large band of the input power before and after the event is due to a superwave current modulation [13]. While we do not have a statistical basis for a conclusion, we may consider that such a result suggests that the presence of specific contaminants on the surface of the electrodes are important to observe excess power.

Conclusions

This paper describes experiments that reveal new information regarding the status of deuterium loaded Pd cathodes during production of excess power in electrolytic cells (0.1M LiOD, Pt anode, PdRh alloy cathode).
First, electrochemical impedance spectroscopy (EIS) during excess power production reveals the presence of resonances at the surface/electrolyte boundary that requires an LRC component in the circuit diagram to reproduce the Nyquist plot.
Second, the LRC component of the Nyquist circuit diagram is still present when the input power is reduced and no excess power is present.
Third, the voltage and current during excess power events and after excess power events at reduced input power are unstable causing the EIS to be indecipherable at most times.
Forth, as shown previously (reference) there is a strong correlation between the position and strength of peaks in the power spectral density (PSD) of those cathodes that produce excess power.
Fifth, though not conclusive, this work suggests that the presence of specific contaminants (Si, perhaps others) on the cathode surface are important for observation of the excess power.
Sixth, this work points to the importance of materials science to achieve the surface morphology, alloy composition, contaminant control and grain orientation [7-8] necessary for the observation of excess power in these material systems.

References

[1] K. Kunimatsu, N. Hasegawa, A. Kubota, N. Imai, M. Ishikawa, H. Akita and Y. Tsuchida, Deuterium Loading Ratio and Excess Heat Generation during Electrolysis of Heavy Water by a Palladium Cathode in a Closed Cell Using a Partially Immersed Fuel Cell Anode., Proc. Third Int. Conf on Cold Fusion, Nagoya (Japan) October 20-25, 1992 (p.31).
[2] M. C. H. McKubre, S. Crouch-Baker, A. M. Riley, S. I. Smedly, F. L. Tanzella, Excess Power Observation in Electrochemical Stusies of the D/Pd System; the Influence of Loading, Proc. Third Int. Conf on Cold Fusion, Nagoya (Japan) October 20-25, 1992 (p.5).

[3] A. Adrover, V. Violante et Al. Stress induced diffusion of hydrogen in metallic membranes, Cylindrical vs. planar formulations I, J. Of Alloys and Compounds I(2003).
[4] A. Adrover, V. Violante et Al. Stress induced diffusion of hydrogen in metallic membranes, Cylindrical vs. planar formulations II, J. Of Alloys and Compounds I(2003).
[5] A. Adrover V. Violante et Al. Effects of self-stress on hydrogen diffusion in Pd membranes in the coexistence of α and β phases. J. of Alloys and Compounds II (2003).
[6] V. Violante et Al., Consequences of Lattice Expansive Strain Gradients on Hydrogen Loading in Palladium. Phys. Rev. B, Vol. 56, N. 5 (1997) 2417-2420.
[7] V. Violante et Al., Material Science on Pd-D System to Study the Occurrence of Excess of Power, Proc. ICCF-14 Washington DC 10-15/8/2008, Vol 2, Pg (429-436).
[8] V. Violante et Al., Evolution and progressin material science for studying the Fleishmann and Pons effect (FPE), Proc. ICCF-15 Oct 5-9 2009 Rome Italy, Pg 1.
[9] V. Violante et Al. The study of the Fleishmann and Pons effect through the materials science development. Proceedings of the XVI International Conference on Condensed Matter Nuclear Science. Chennai, India, Feb 6-11 2011, pg 313.
[10] M.A. Gosàlvez and R.M. Nieminen, New J. Phys. (2003) **5**, 100
[11] D.D. Dominguez et Al., Are Oxides Interfaces Necessary in Flaischmann and Pons Type Experiments?, Proceedings of the XVI International Conference on Condensed Matter Nuclear Science. Chennai, India, Feb 6-11 2011, pg. 53.
[12] D. Knies et Al, Differential Thermal Analysis Calorimeter at the Naval Research Laboratory, Proc. ICCF-15 Oct 5-9 2009 Rome Italy, pg 11.
[13] I. Dardik , et Al. , Intensification of Low Energy Nuclear Reactions Using SuperWave Excitation, 10th International Conference on Cold Fusion, Cambridge (MA) USA 24-29/08/ 2003, pg. 61.

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Deuteron Activation of ^{110}Pd Leading to the Production of ^{111}Ag

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This work describes the analysis techniques used on palladium foils irradiated by a deuterium ion beam and then rapidly counted to capture greater experimental detail. Radioactive decay chains may ordinarily be corrected using the Bateman equations; however this approach does not conveniently address complex decay schemes like those leading from ^{110}Pd to ^{111}Ag. The purpose of the this work was to verify the activation branching ratio of the ^{110}Pd(d,p) reaction channel and to perform a comparison of the activation branching ratio with computed libraries.

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I. INTRODUCTION

The study of the interaction of accelerated deuterons with high-Z targets is of particular interest due to the weak binding of the deuteron's neutron and proton. Various researchers have for decades (starting with amongst many others, Lawrence, Oppenheimer and Bethe in the 1930s) measured and calculated (d,p) and (d,n) cross sections for numerous elements[1–3]. These studies are of particular interest to researchers working in fields as varied as stellar nucleosynthesis and radio pharmacology.

Typically, cross sections are determined experimentally by using "stacked foil" techniques[4,5]. Accelerated by a cyclotron to high energy, the deuteron beam losses energy as it progresses through the stack. Gamma counting the various foils gives the production of resulting isotopes (and hence their production cross sections) as a function of beam energy. Typically targets are highly activated and consequently counting is often delayed making it difficult or impossible to measure short lived transitions.

The interaction of deuterons with palladium can produce useful or promising isotopes for radio pharmacology such as ^{109}Pd or ^{111}Ag[6,7]. Various and complex production pathways from ^{110}Pd to ^{111}Ag (described in detail later) coupled with a short half-life (23.4 min) for beta decay from produced ^{111}Pd to ^{111}Ag, makes previously published data, obtained after many hours of decay, unable to quantify these branching ratios. This work describes the analysis techniques used on palladium foils irradiated by a deuterium beam and then rapidly counted to capture greater experimental detail. These analysis techniques were then used to verify the activation and branching ratios of the ^{110}Pd(d,p) reaction channel. Additionally, we determined the relative activation ratios for the (d,p) and (d,n) reaction channels on ^{110}Pd.

II. COMPLEX DECAY

The irradiation of natural palladium with accelerated deuterons will produce numerous activation products. Of particular interest are the reaction channels ^{110}Pd$(d,n)^{111}$Pd and ^{110}Pd$(d,p)^{111}$Ag. In either case,

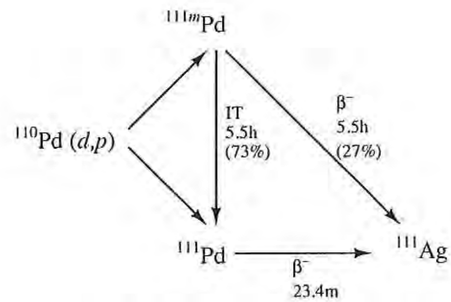

FIG. 1. Illustration of the activation and decay branches for ^{110}Pd undergoing the (d,p) activation channel.

both a metastable and ground state isomer are formed. The metastable palladium isotope ($\tau_{1/2} = 5.5\,\mathrm{hr}$) undergoes either an isomeric transition into the ground state or β^- decays directly into ^{111}Ag, as suggested by the decay scheme in Fig. 1.

The metastable silver isotope ($\tau_{1/2} = 1.08\,\mathrm{min}$) undergoes either an isomeric transition into the ground state or β^- decays directly into ^{111}Cd, as suggested by the decay scheme in Fig. 2. For the purposes of the experiment described, the half-life of the metastable isomer of silver was short enough with respect to the ground sta ($\tau_{1/2} = 7.47\,\mathrm{d}$) to be considered "prompt" and no cc rections for this decay were required. Additionally, t γ-rays produced by the metastable decay were outside the calibrated range for the detector system.

III. EXPERIMENTAL METHODS

Target irradiation was carried out using cyclotron-accelerated deuterons. The deuteron beam was taken from one of the auxiliary beam ports of a General Electric PETRACE cyclotron. The cyclotron produced an 8.4 MeV (±200 keV) 10 μA deuteron beam, which was passed through 60 μm of HAVAR. The beam energy incident on the target stack was 5.5 MeV ± 5 %, based on the cyclotron energy uncertainty and TRIM-2008 Monte Carlo simulations. The full-energy irradiation lasted ap-

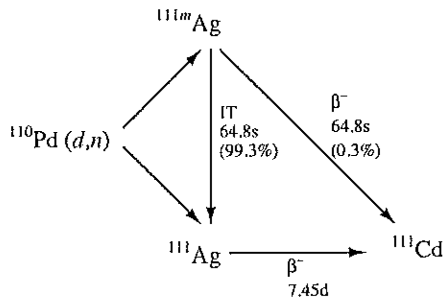

FIG. 2. Illustration of the activation and decay branches for ^{110}Pd undergoing the (d, n) activation channel.

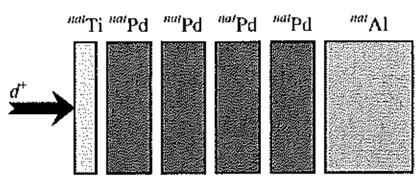

FIG. 3. Illustration of the target foil arrangement used in the experiment.

proximately 40 s, and the irradiation was bracketed by two 10-s beam-current ramping periods.

The experimental target was composed of titanium and palladium foils fabricated into discs and compressed together. The discs were each 1.905 cm in diameter. The titanium foil was obtained from Alfa Aesar, had a 99.8 % purity, and was 12.7 μm in nominal thickness. The palladium was also obtained from Alfa Aesar, had a 99.9 % purity, and was nominally 25 μm thick. The targets were arranged as illustrated in Fig. 3. The target stack was modeled in TRIM-2008 and the deuteron beam was shown to be completely stopped within the 4^{th} palladium foil. The target foils were backed by a thick aluminum plate that provided mechanical compression.

The target stack was removed from the accelerator approximately 30 min after the end of irradiation and taken to a high-purity germanium detector (HPGe) for counting. The detector efficiency was determined using a traceable, calibrated multi-gamma card source on the detector shelf that was used for the counting. The detector had a 2.3 keV-wide peak (full width, half maximum) at 1.332 kV[8]. The palladium foils were each counted with a 20 min live time, starting with the foil nearest the cyclotron output and working backwards in order. The count sequence was repeated twice more with a 5.5 hr interval between counts.

The γ-ray lines used for counting were identified after searching for interferences due to other ^{nat}Pd (d, x) decay products. The metastable isomer of ^{111}Pd undergoes an isomeric transition ($I_{IT} = 73\,\%$), producing a 172.2 keV γ-ray ($I_\gamma = 34\,\%$) with a 5.5 hr half-life. The ground-state isomer of ^{111}Pd undergoes β^- decay ($I_{\beta^-} = 100\,\%$) and produces a 580.0 keV γ-ray ($I_\gamma = 0.8\,\%$) with a 23.4 m half-life. The ground-state isomer of ^{111}Ag undergoes β^- decay ($I_{\beta^-} = 100\,\%$), producing a 342.1 keV γ-ray ($I_\gamma = 6.7\,\%$) with a 7.47 d half-life.

The stacked foil method described above is used in a larger effort to develop a complete evaluation of palladium cross section versus energy, especially at energies less than 5 MeV. This work involves the presentation of the mathematical development needed to conduct the complex decay corrections and hence to determine the activation branching ratio. Because short irradiation times were necessitated by the need for rapid counting (capturing greater experimental detail of short lived isotopes) this paper only utilizes data from the first palladium foil. That foil interacted with the beam at the highest energy of any palladium foil, and hence is the most activated in this short irradiation resulting in the clearest gamma lines.

IV. COMPLEX DECAY CORRECTIONS

Radioactive decay chains may ordinarily be corrected using the Bateman equations, however the approach of Bateman does not conveniently address complex decay schemes of the type illustrated in Figs. 1 or 2[9]. An approach was undertaken using eigenvalues and eigenvectors to algebraically determine solutions to the complex decay scheme[10]. The algebraic approach was used to determine generalized expressions that could ascribe the activity contributions to all daughter components of the decay scheme, given initial activities.

The expressions determined using the algebraic approach are given as equations (1) through (3), where subscript 1 refers to ^{111m}Pd, subscript 2 refers to ^{111}Pd, and subscript 3 refers to ^{111}Ag. In the equations, the λ_x term is the decay constant ($\lambda = \ln(2)/\tau$), and N_x^0 refers to the initial number of atoms of the x^{th} isotope. The palladium metastable state decay branch ratio is accounted for as $\lambda_1^2 = 0.73\lambda_1$ and $\lambda_1^3 = 0.27\lambda_1$.

$$N_1(t) = N_{1,0}e^{-\lambda_1 t} \tag{1}$$

$$\begin{aligned} N_2(t) = {} & N_{2,0}e^{-\lambda_2 t} + \\ & N_{1,0}\frac{\lambda_1^2}{\lambda_1 - \lambda_2}\left(e^{-\lambda_2 t} - e^{-\lambda_1 t}\right) \end{aligned} \tag{2}$$

$$\begin{aligned} N_3(t) = {} & N_{3,0}e^{-\lambda 3t} + \\ & N_{2,0}\frac{\lambda_2}{\lambda_2 - \lambda_3}\left(e^{-\lambda_3 t} - e^{-\lambda_2 t}\right) + \\ & N_{1,0}\frac{\lambda_1^2\lambda_2 - \lambda_1\lambda_1^3 + \lambda_1^3\lambda_2}{(\lambda_1 - \lambda_2)(\lambda_1 - \lambda_3))}e^{-\lambda_1 t} - \\ & N_{1,0}\frac{\lambda_1^2\lambda_2}{(\lambda_1 - \lambda_2)(\lambda_2 - \lambda_3)}e^{-\lambda_2 t} + \end{aligned}$$

TABLE I. Transmutations produced in the 1^{st} palladium target foil by irradiation with deuterons.

Product Isotope	Initial No. Atoms	Equivalent Activity [μCi]
^{111m}Pd	$7.51 \times 10^7 \pm 4.75\,\%$	0.103
^{111}Pd	$4.14 \times 10^8 \pm 1.95\,\%$	7.970
^{111}Ag	$4.11 \times 10^8 \pm 19.26\,\%$	0.017

$$N_{1,0}\frac{\lambda_1^2\lambda_2 + \lambda_1^3\lambda_2 - \lambda_1^3\lambda_3}{(\lambda_1 - \lambda_3)(\lambda_2 - \lambda_3)}e^{-\lambda_3 t} \tag{3}$$

The equations for the decay of the reaction products from the (d,p) and (d,n) reaction channels on ^{110}Pd clearly demonstrate the complexity of the decay scheme. In the case of ^{111}Pd, the growth of activity with time depends on the starting activity of ^{111}Pd and the activity of the metastable isomer, ^{111m}Pd. The case of ^{111}Ag is even more complicated, as all of the activity resulting from the (d,p) reaction channel eventually decays into the silver isotope, however, the timing of that process is critical.

It is clear from the decay expressions that the activity of ^{111m}Pd is independent of the other decay processes, therefore this isotope was first corrected to arrive at a starting value, $N_{1,0}$. The initial number of atoms of isotope x, N_x^0, is mathematically related to the initial activity, A_0 [dps], and the half life, τ [s], of the isotope using the integral in (4). The initial activity, A_0, was determined by converting the net peak area from the HPGe detector system into an equivalent initial activity using standard methods[11]. Corrections for irradiation time, count duration, and delay to count were applied, as well as efficiency correction factors.

$$N^0 = \int_0^\infty A_0 e^{-t/\tau}dt = \tau A_0 \tag{4}$$

The number of atoms contributed to ^{111}Pd by the isomeric transition of ^{111m}Pd was calculated using (2). The time value used in the equation corresponded to the delay from the start of the experiment to the time that the count was initiated. The initial activity of the ground-state isomer, $N_{2,0}$ in (2), was set to zero. The resulting value for N_2 was taken as the contribution of N_1 to the "activity" of N_2. The silver isotope was corrected in a similar fashion, except that equation (3) was used instead, and the corrected number of initial atoms of ^{111}Pd, the value of $N_{2,0}$ computed in the previous step, was also used. The transmutations produced by irradiation are summarized for the three isotopes in Table I.

Figure 4 illustrates the time evolution of the number of atoms for each of the three species considered relative to the initial number of atoms produced by irradiation, based on an evaluation of equations (1) through (3). The two isomers of palladium decay in time, whereas the isomer of silver is shown to increase to a maximum value of about 2.06 times the initial number of transmutations nearly 8.86 hr after irradiation, followed by an exponential decay. As a demonstration of the validity of the technique, the total number of atoms at each of three points in time were estimated and compared to measured values. The counts were conducted at the points in time labeled 1^{st}, 2^{nd}, and 3^{rd} in Fig. 4. Table II contains the measured and calculated number of atoms for each of the three isotopes at each of the three count times. The calculation predicts the resulting number of atoms in very close agreement to the number of atoms actually measured.

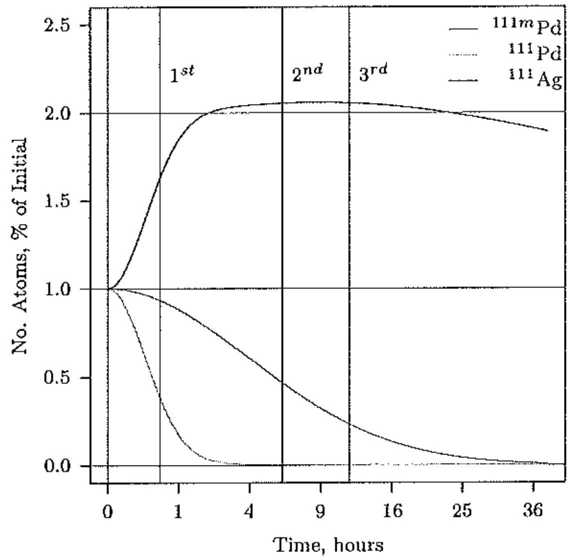

FIG. 4. Time evolution of the number of atoms of the isotopes of palladium and silver resulting from the (d,p) and (d,n) reactions on ^{110}Pd, and subsequent decay.

TABLE II. Measured and calculated values of the number of atoms of the isotopes of palladium and silver resulting from the (d,p) and (d,n) reactions on ^{110}Pd, and subsequent decay.

Isotope	Count	Number of Atoms, % of Initial: Calculated	Measured
^{111m}Pd	Initial	100	n/a
	1^{st}	93.3	93.3
	2^{nd}	46.7	30.5
	3^{rd}	23.2	15.3
^{111}Pd	Initial	100	n/a
	1^{st}	38.6	37.9
	2^{nd}	0.48	3.26
	3^{rd}	0.24	0.00
^{111}Ag	Initial	100	n/a
	1^{st}	162.8	162.8
	2^{nd}	205.4	198.1
	3^{rd}	205.6	203.4

V. RESULTS & DISCUSSION

One of the main purposes of the experiment was to verify the activation branching ratio of the ^{110}Pd(d,p) reaction channel. The relative branching ratio of the (d,p) reaction channel was computed using (5), where $I_{a,n}$ represents the fraction of the reactions leading to the activation of the n^{th} product, and m represents the number of possible branches; $m = 2$ for this evaluation. The summation in (5) represents the total number of transmutations associated with the particular reaction channel and N_n represents the number of transmutations associated with the n^{th} product.

$$I_{a,n} = N_n \sum_{i=1}^{m} \frac{1}{N_i} \tag{5}$$

The experimentally derived branching ratio is summarized in Table III for the 1^{st} palladium foil in the target stack, where the total number of transmutations resulting from the (d,p) reaction channel was 4.89×10^8. The resulting ground-state activation is shown to be nearly 85 %, or roughly 5.5 times greater than the metastable branch, which has a branching ratio of only about 15 %.

The equivalent activation branching ratio, $\bar{I}_a$, was computed using a combination of TRIM-2012 Monte Carlo modeling of the deuteron energy profile and TALYS-1.4 nuclear reaction modeling of the differential branching ratio[12,13]. A discrete equivalent of the integral in (6) was evaluated by sectioning the target into thin layers, computing the average energy in each of the layers, and then using that energy to predict the differential branching ratio, I_a. In (6), the value T represents the thickness of the target, and I_a is explicitly shown to be functionally dependent upon the deuteron energy, and the subscripts m and g represent the meta-stable and ground-state branching ratios. The results of the calculation are summarized in Table III, where the TALYS values are directly compared to the experimental values. The error bars associated with the calculated equivalent brancbing ratio, $\bar{I}_a$, were due to the uncertainty of the exact energy of the incident deuterons.

$$\bar{I}_a = \frac{\int_0^T I_a\left(E\left(x\right)\right)dx}{\int_0^T I_g\left(E\left(x\right)\right)dx + \int_0^T I_m\left(E\left(x\right)\right)dx} \tag{6}$$

TABLE III. Comparison of experimental and calculated activation branching ratios for the ^{110}Pd (d,p) reaction channel[13].

	Branching Ratio	
Isomer	Experimental	TALYS, $\bar{I}_a$
^{111m}Pd	0.1535	$0.4029^{+1.35\,\%}_{-0.00\,\%}$
^{111}Pd	0.8465	$0.5971^{+0.00\,\%}_{-1.64\,\%}$

Another of the experimental goals was to evaluate relative activation ratios for the (d,p) and (d,n) reaction channels. The relative activation ratio analysis is essentially a relative cross section analysis. The (d,p) reaction resulted in a total of 4.89×10^8 atoms of palladium, and the (d,n) reaction resulted in the production of 4.11×10^8 silver atoms. The ratio of palladium atoms produced per silver atoms is thus 1.19, or approximately 20 % more. Therefore, the relative cross section for the (d,p) reaction appears to be on the order of 20 % greater than the cross section for (d,n).

VI. CONCLUSIONS

We have extended a mathematical technique to apply compound corrections to complex nuclear decay schemes and have experimentally verified the method using measured data. We have measured the branching ratio for the ^{110}Pd(d,p) reaction channel. The measured branching ratio was not found to agree with the TALYS-1.4 calculated branching ratios. We will next apply these techniques to fully characterize the (d,p) and (d,n) reaction channels using a similar material system, but with thinner individual foils for increased energy resolution.

[1] E. Lawrence, E. McMillan, and R. Thornton, *Phys. Rev.*, **48**, 493 (1935).
[2] J. Oppenheimer and M. Phillips, *Phys. Rev.*, **48**, 500 (1935).
[3] H. Bethe, *Phys. Rev.*, **53**, 39 (1938).
[4] S. Takács, F. Tárkányi, M. Sonck, A. Hermanne, M. G. Mustafa, Yu Shubin, and Youxiang Zhuang, *Nucl. Instr. Meth.*, **B 174**, 235 (2001).
[5] F. Ditrói, F. Tárkányi, S. Takács, A. Hermanne, A. V. Ignatyuk, and M. Baba, *Nuc. Inst. Meth.*, **B 270**, 61 (2012).
[6] A. Hermanne, S. Takács, F. Tárkányi, and R. Bolbos, *Nuc. Inst. Meth*, **B 217**, 193 (2004).
[7] T. A. Aweda, O. Ikotun, T. Mastren, C. L. Cannon, B. Wright, W. J. Youngs, C. Cutler, J. Guthrie, and S. E. Lapi, *Med. Chem. Comm.*, **4**, 1015 (2013).
[8] C. Fairfax, *pers. comm.* (2013).
[9] H. Bateman, *Proc. Camb. Phil. Soc.*, **15**, 423 (1910).
[10] L. Moral and A. F. Pacheco, *Am. J. Phys.* **71** 684 (2003).
[11] American National Standards Institute, Standard N42 (1999).
[12] J. F. Ziegler, M. D. Ziegler, and J. P. Biersack, SRIM-2012.01, (2012).
[13] A. J. Koning, S. Hilaire, and M. C. Duijvestijn, TALYS-1.4, (2012).

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Attachment C1.

Year 3 Annual Report, 2014: Part 1

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

Progress Report to Mr. Sidney Kimmel October 27, 2014

Graham K. Hubler, Ph.D.
Director, Sidney Kimmel Institute for Nuclear Renaissance (SKINR)

SKINR Staff

O. Azizi, J.H. He, W. Isaacson, G. Hubler, D. Pease, A. El-Boher, T. Bruner, B. Davis, K. Lenhard, B. Bolin, S. Zou, D. Patterson

SKINR Staff

Graham K. Hubler, Ph.D. (Director, Physicist)
Arik El-Boher, Ph.D. (Research Group Leader, Mechanical Engineer)
Orchideh Azizi, Ph.D. (Electrochemist)
JingHao He, Ph.D. (Materials Scientist)
William Isaacson (Technician) (DECEASED, Oct. 19, 2014)
Dennis Pease, Ph.D. (Physicist)

Rob Duncan, Ph.D. (former Chancellor for Research at MU)

- + 4 undergraduate students, 1 Graduate student and 4 Post-Doctoral Fellows
- 5 faculty collaborators
- One professor dismissed for lack of performance

Cathode Development Plan

Empirically guided cathode modifications

Cathode Production SKINR

Aerospace Corp

ReResearch Coolesence SRI NRL SKINR ENEA

Cathode Electrolysis

Electrochemical cell

With collaboration partners, run hundreds of fabricated cathodes in parallel using NRL designed *common equipment and common protocols.*

Expected Progress: Improved Reproducibility

Cell in calorimeter

Seminal Meeting

Meeting in April, 2013, SKINR suggested that RF and acoustic stimulation and magnetic polarization should be performed.

Meeting attended by:

ENEA - Vittorio Violante, Frascati, Italy
SRI – Mike McKubre, Palo Alto, CA

Cathode Fabrication

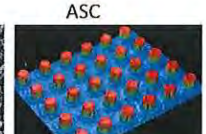
Shubhra Gangopadhyay's group in Electrical Engineering is producing new types of cathodes:

Single wall carbon nanotube (SWCNT) coated Pd
Pd nanoparticle coated graphene on Pd (PdNP G)
Artificially structured Pd cathodes (ASC)

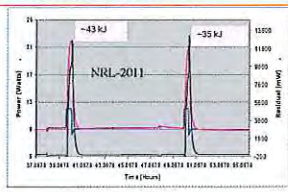
SWCNT

PdNP G

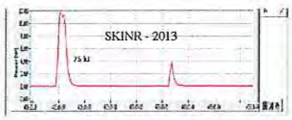
ASC



November 2013 Burst Behavior



SWCNT



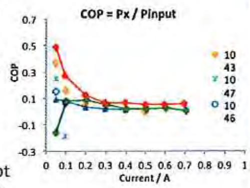
Pd Nanoparticle Deposition

Prof. Kattesh Katti, Dept. of Radiology, produces Pd nanoparticles suspended in EGCG (natural ingredient of green tea),

When the suspension is added to LiOD electrolyte, highly reproducible 10-50% excess heat is observed in open cells

The EGCG is acting as a super recombinator of H_2 and O_2. We are exploring this unusual system and do not have definite conclusion whether of not this is the anomalous heat effect.

The EGCG may be useful by itself as a catalyst. This is still under exploration



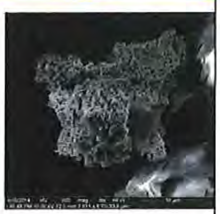
A patent has been submitted on fabrication of the Pd nanoparticles

Exploding Wires

With Prof. John Gaul and graduate student Jullian Baker, trying to reproduce and extend the exploding wire experiment of McKubre at SRI. We have fabricated nanoporous Pd that may be useful for catalysis including automobile converters

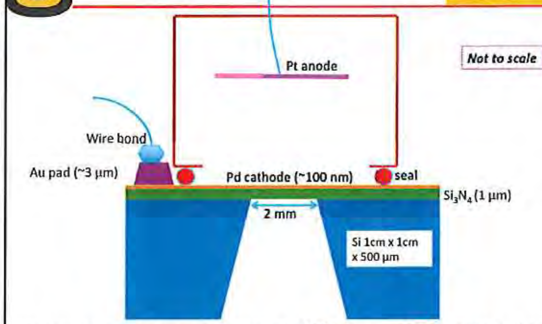
Nanosecond 3000 Amp pulses into a Palladium wire loaded with hydrogen to >0.9 atomic fraction

Also performing calorimetry and have found anomalous heat output in preliminary experiments – 2 papers submitted



A patent has been submitted on fabrication of the Pd nanoporous particles

Membrane Experiment Schematic



Improves sensitivity for nuclear process by 10^{12}! No signal for 9 months at SKINR and 3 months at ENEA and 3 months at ReResearch

In situ Particle Detection in Gas Loading

Professor M. Prelas, Department of Nuclear Engineering

- Very high sensitivity to energetic particle emission from nuclear reaction
- No signal after may runs

SKINR Experiments

Gas Reactors:
- *-Plasmons launched on PdD strip*
- *-Femtosecond laser triggering*

Electrochemical cells:
- -Cathode development (many choices)
  - -Self assembled Pd nanoparticle cathodes (Kattie)
  - -Pd coated carbon nanotube cathodes (Gangopadhyay)
  - -Pd nanoparticle coated graphene (Gangopadhyay)
  - -Artificially structured Pd cathodes (Gangopadhyay)
  - -New alloy compositions
  - -Pd metallurgy (ENEA, Coolesence)
- -Magnetic field – effect on loading
- -H loading studies
- -Hydrogen permeation kinetics
- *-Low energy in-situ radiation detection (thin membrane, ≥1 keV x-rays)*
- *-Triggering (acoustic, magnetic, RF, laser, stress)*

Related studies
- -Current pulse exploded PdD wires
- ~~-Neutron scattering in situ of PdD~~
- -MeV bombardment of D on Pd
- -Thermal shock of TiD_2
- *-Diamond in situ radiation detection*

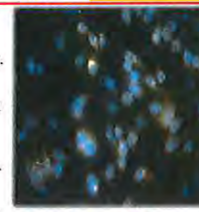
**Red Italics
Experiment aimed directly at discovering nuclear mechanism

Medical Research Initiative

The Pd nanoparticles created for the SKINR energy program by Professor Kattesh Katti in the Radiology Department at MU have an important medical application

SKINR's Innovative Approach for Prostate Tumor Therapy

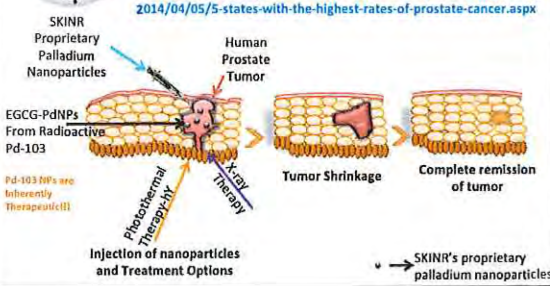
- 95% fatalities resulting from prostate cancer are confined to the prostate region.
- Our innovative approaches provide the best opportunity for the effective ablation of primary prostate tumors through
  - Laminin receptor targeted and inherently therapeutic palladium nanoparticles (PdNP-EGCG).
- Concomitantly, we will control/eliminate metastatic lesions through systemic delivery of DNA methylation inhibitor Epigallocatechin gallate (EGCG),
  - allowing realistic synergy of treating both primary and metastatic prostate tumors.



Electronic microscopic Images of EGCG-palladium nanoparticles inside the prostate cancer cells of human prostate tumor origin; Showing prostate tumor specificity of SKINR's Nanomedicine Product!!!

SKINR's Foray into Nanomedicine: Unprecedented Multiplexed Tumor Therapy (CONFIDENTIAL)

Prostate Cancer Drug Market Valued at over $26 billion; Expected to Rise to > 50 Billion by 2017: http://www.fool.com/investing/general/2014/04/05/5-states-with-the-highest-rates-of-prostate-cancer.aspx



Scientific Productivity

6 papers submitted/published:

1. J. Baker, J. Gahl, P. Norgard, O. Azizi, A. El-Boher, G. Hubler, J. He, W. Isaacson, and D. Pease, *"A Low Energy, Fast, Pulsed Power System for Analysis Characterization of Deuterium Loaded Wires,"* submitted to Pulsed Power Conf. Proc.
2. J. Baker, J. Gahl, P. Norgard, O. Azizi, A. El-Boher, G. Hubler, J. He, W. Isaacson, and D. Pease, *"Production of Nanoporous Palladium From a Deuterium Loaded Wire Driven By a Low Energy, Fast Pulser."* submitted to Pulsed Power Conf. Proc.
3. O. Azizi, A. El-Boher, J.H. He, G.K. Hubler, D. Pease, W. Isaacson, V. Violante and S. Gangopadhyay, *"Progress Towards Understanding Anomalous Heat Effect In Metal Deuterides."* submitted to Current Science.
4. G.K. Hubler, A. El-Boher, O. Azizi, D. Pease, J.H. He, and W. Isaacson, *"Sidney Kimmel Institute for Nuclear Renaissance (SKINR) Overview."* submitted to Current Science.
5. V. Violante, E. Castagna, S. Lecci, F. Sarto, M. Sansovini, A. Torre[1], A. La Gatta, R. Duncan, G. Hubler, A. El-Boher, O. Aziz, D. Pease, D. Knies, and M. McKubre, *"Review of Material Science for Studying the Fleischmann and Pons Effect."* submitted to Current Science.
6. Violante, E. Castagna, S. Lecci, F. Sarto, M. Sansovini, T. D. Makri[1], A. Torre , D. Knies, D. Kidwell, K. Grabowsk[2], D. Dominguez, G. Hubler, R. Duncan, A. El-Boher, O. Azizi, M. McKubre, A. La Gatta *"Excess of Power During Electrochemical Loading: Materials, Electrochemical Conditions and Techniques."* published in ICCF18 Conf. Proc.

2 Patents submitted:

1. Pd nanoparticle synthesis for excess heat and medical applications
2. Synthesis of Nanoporous Pd for catalysis applications

RF spectrum Screen shot – no heat

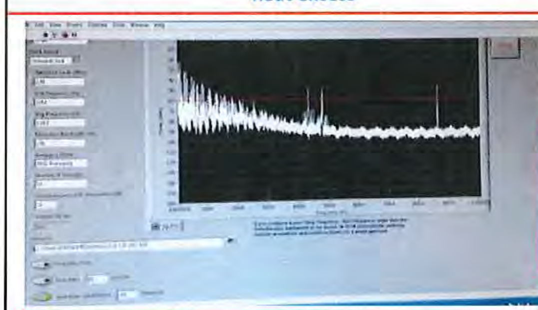
ENEA

Heterodyned RF emission
X-scale 80-81 GHz
Sensor between cathode and anode in electrolyte

Proprietary Information

RF spectrum Screen shot – during heat excess

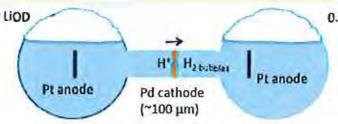
ENEA



Proprietary Information

Emission between 80-81 GHz
Confirms NRL finding of RF emission during excess heat events

Hydrogen Permeation Kinetics



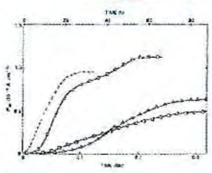


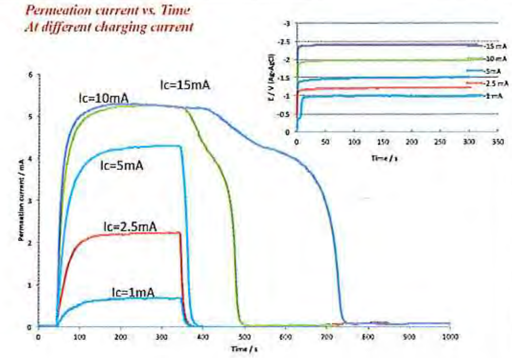
Fig. 7. Hydrogen permeation transients of nickel implanted with a fluence of 3×10^{15} Pt^{+} cm^{-2} before and after treatment with aqueous 0.2! HF: ○, t = 0 s, △, t = 60 s; □, t = 180 s.

$D_{lag} = L^2/6\ t_{lag}$
$P = D_{lag} \times C_H \times F/L$

<u>Obtain:</u>

D_{Lag} - Diffusion constant
C_H - H conc. Just below surface
P - relative surface activity

Permeation current vs. Time
At different charging current



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Attachment C2.

Year 3 Annual Report, 2014: Part 2

Report to Mr. Sidney Kimmel — October 27, 2014

Graham K. Hubler, Ph.D.
Director, Sidney Kimmel Institute for Nuclear Renaissance (SKINR)

In 2009 I had an idea for the Anomalous Heat mechanism. It was revolutionary and for a long time seemed very improbable

Now, in 2014, this theory has risen to the category of being possible

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If true, with this theory......
The Sidney Kimmel Institute for Nuclear Renaissance
will change the world!

Why?

Anomalous Heat, or LENR is not a nuclear effect, it is has a cosmological origin

After 25 years of research, there is No compelling evidence that Anomalous Heat is a *nuclear* effect

Hypothesis: We are converting Axion dark matter into photons that are absorbed in the Palladium Deuteride lattice as heat

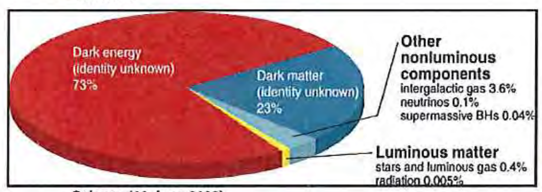
---

Cosmological Implications

The universe is composed of dark matter and dark energy

But we don't know what the dark energy or what the dark matter is

- **A particle relic from the Big Bang is strongly implied for DM**
  - —WIMPs ?
  - —Axions ?



Science (20 June 2003)

CTEQ 2006 Summer School – Rhodes, Greece — G. K. Fanourakis - Demokritos

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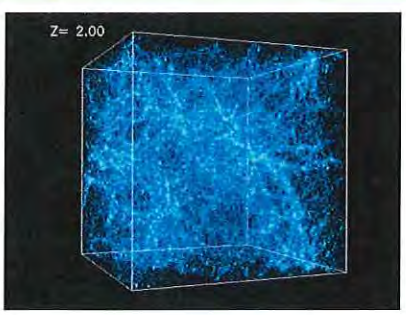
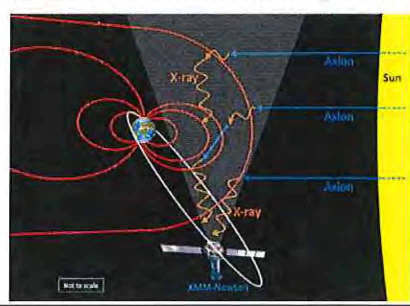
Dark Matter Everywhere in the Universe

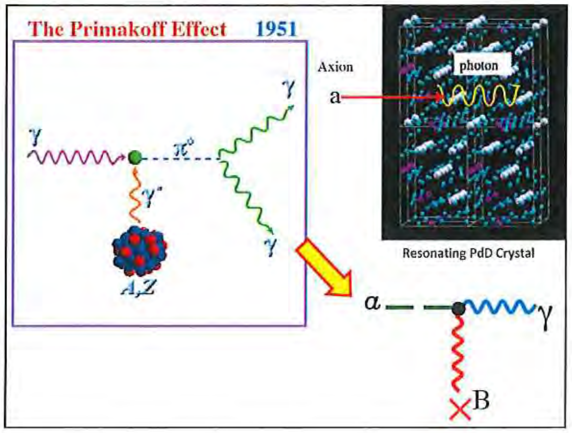


Axions Generated in Sun Detected

New research paper published on October 10, 2014

Dark Matter suggested to be Axions





Hypothesis

- Anomalous Heat Effect is the solid state Primakoff Effect conversion of cosmological Axion cold dark matter into Photons that absorb in the Palladium Deuteride lattice as heat $E = mc^2$

- Triggered phonon resonances in deuterium-charged Palladium cathodes induce very large (16,000 Tesla) volume-filling, oscillating magnetic fields by means of an electronic phase instability at the resonant frequency of the Axion Mass

- The Axion Mass is on the order of 80 meV (millielectron volts) and its characteristic frequency is equal to the deuterium phonon resonance in the reduced phase-space of phonons in the special surface morphologies on Palladium Deuteride cathode surfaces

This hypothesis does not create any new physics

Technology Implications

- Unlimited energy available anywhere:
  - on earth
  - in our solar system
  - in our galaxy
  - in the universe

- Less fossil fuels needed
- Global warming ameliorated
- Compact power
- Star Trek technology pillar - impulse drive equivalent

Space travel and planet colonization facilitated

Why Go Public Now?

- Lack of evidence that the Anomalous Heat Effect is Nuclear
- SKINR and collaborator results
- Talk given at collaborator workshop on October 10
- Theory paper in preparation for submission to journal

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Attachment D.

Year 4 Annual Report, 2015

Highlights of SKINR achievements in the fourth year

Prepared by:

Graham K. Hubler, Director

and

Arik El-Boher, Research Group Leader

Sidney Kimmel Institute for Nuclear Renaissance

March 10, 2015

EXECUTIVE SUMMARY

Our most promising results continue to be the Pd nanoparticle suspensions that co-deposit on the surface of Pd along with deuterium. *Reproducible heat up to 50%* excess heat is being vetted to determine if it is real. This is very necessary before we report the results. The SWCNT on Pd cathodes gave the largest excess heat results, *5500% COP,* but was only obtained in 1 of 20 cathodes. These cathodes are being pursued but with the addition of triggering methods.

The thin membrane experiment that can measure down to 1 keV x-rays emitted from a cathode showed zero x-rays after more than one year of constant running. We had high hopes that this first–of-a-kind experiment would lead us quickly to the mechanism of the AHE, if it was nuclear in origin. This is very significant in that it adds to the growing mystery to the question, "Is the AHE a nuclear process"? While not a definitive experiment, it *adds to the accumulating evidence that the AHE is not a nuclear effect.*

Based upon the results of experiments in Padua, Italy, in early 2014, SKINR embarked upon triggering mechanisms to force the AHE to turn on very early in experiments. These experiments have the *highest priority* in plan including RF, acoustic, magnetic pulse, laser, and stress triggering. These techniques are being installed on most of our electrolysis cells. Early results for RF triggering have shown anomalies but it is too early to know if the effects are real.

Our fundamental investigations on loading have reached a *profound conclusion* – that ability of a cathode to load to high deuterium/Pd ratios is entirely *governed by impurities* introduced by the materials used in the systems. Previously we did not know if the loading was governed by metallurgy, etching and surface morphology, or impurities.

This will allow us to focus on the problem and make rapid progress to solve one of the most vexing problems in the field.

Our cathode development will continue but with better focus by *emphasizing impurities and triggering methods.*

A significant event in January 2015 was the creation of a six million dollars (donated by an unknown donor, probably Bill Gates) program similar to SKINR at TTU headed by Rob Duncan. This is a positive development for the recognition of the field worldwide. The experiments that will be *carried out at CERN* will also increase our visibility to the greater scientific community. A major event in the field was a *special issue of the Journal "Current Science" devoted to the AHE*. This is the first major journal to publish reviewed articles on this subject. SKINR submitted three articles that were reviewed and accepted for the issue that came out in early March 2015. *The legitimacy of the field is growing rapidly.*

Part of SKINR's mission is to check the promising results of other researchers. We will shortly begin experiments on the hydrogen/nickel gas loading system, following two European groups who claim success in obtaining excess power. This is of interest since such a system would have useable thermodynamic efficiency and, therefore, *make a viable commercial reactor from inexpensive materials.*

SKINR continues to work closely with our collaborators at Coolesence LLC, ReResearch, ENEA, NRL, SRI, and Aerospace Corp.

Much has been learned in 2014. We look forward to a more productive year in 2015.

In June, our friend and colleague William Isaacson passed away at the age of 52. This was a serious blow to our operation. Martin Di Stefano, a recent engineering graduate with a bachelor's degree, replaced him.

Highlights of SKINR achievements in the fourth year

SKINR has moved forward with our plans in the last year, modified by the events described above. I will describe the various experiments we are performing including their motivation, results, and connections to our collaborators, and finally, list the output in the last year in terms or papers, patents and talks.

Cathode development for electrolysis

A very important task in performing anomalous heat experiments is the development of cathode materials.

Pd coated carbon nanotube cathodes

Andre Lipson from Russia (passed away in 2011) provided Pd coated single-walled carbon nanotubes (SWCNT) on Pd cathodes to Energetics and SRI that produced excess heat. These cathodes gave robust levels of excess heat with promising reproducibility at Energetics, ENEA and SRI in 2006-2008. This cathode is pursued due to the fact that similar cathodes were successful in producing heat in the past. Shubhra Gangopadhyay's group in the Electrical Engineering Department at MU is reproducing these cathodes for SKINR by drop casting at a relatively low density of 0.1 mg/cm^2 using an aqueous dispersion of SWCNT onto pre-treated Pd foils.

Over a period of 1 year, 20 cathodes were tested to search for excess heat in electrolysis cells. Only one of these cathodes showed strong excess heat production and that heat appeared in two separate bursts. The first burst lasted for about three hours and released 75 kJ of excess heat with a peak coefficient of performance (COP) of 5500%. The second heat burst lasted for about one and a half hours and released 13 kJ of excess heat with a peak COP of 2700%. Several of these cathodes were shared with our collaborators at ENEA and Coolesence, Inc., who were not successful in obtaining excess heat. This has been our best result at SKINR. This cathode is under further research where external triggers (to be discussed below) are used to produce excess heat.

Figure 1. SEM image of SWCNT/Pd'/Pd foil, on which SWCNT are deposited by EPD.

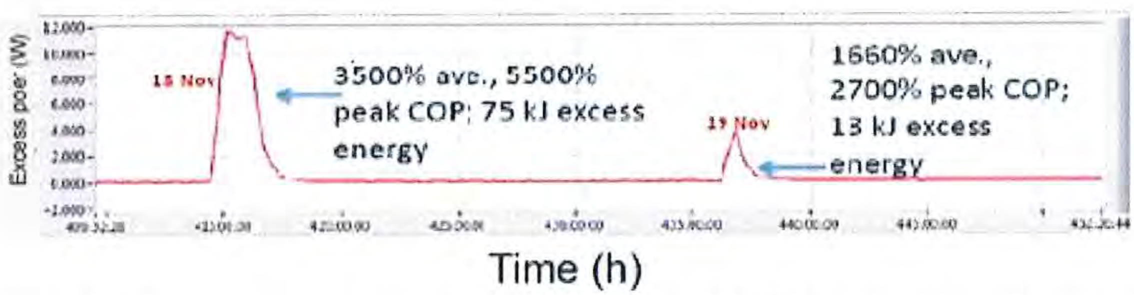

Figure 2. Excess power versus time for cathode of Pd foil coated on both sides with single walled carbon nanotubes (SWCNT) over-coated with Pd. Two bursts are evident for a total of 88 kJ excess energy.

Pd NP coated Graphene Oxide

A new initiative is graphene-coated Pd foils and decorated with Pd nanoparticles. Shubhra Gangopadhyay suggested that we try this material. Graphene is the newest form of carbon that is being researched for its promising properties for catalysis, electronics, and structural applications. Coupling graphene to Pd nanoparticles may produce large changes to the catalytic properties of the Pd that could be beneficial for production of excess heat. This is an exploratory research task just beginning.

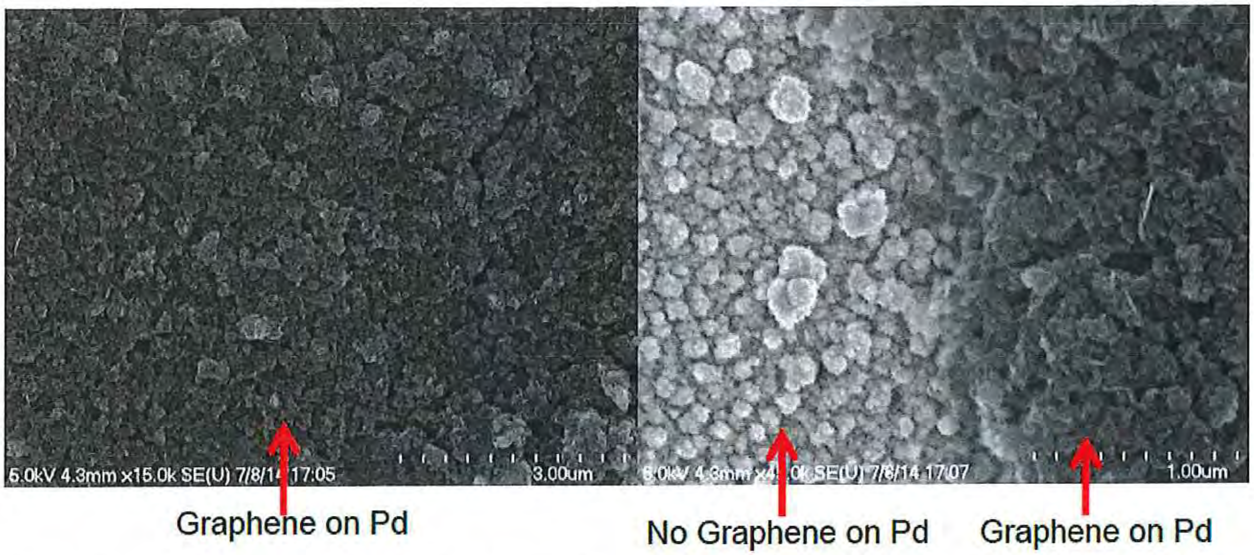

Figure 3. SEM images of Graphene on Pd.

Artificially structured Pd cathodes

The surface morphology of the L64 cathode that produced MJ of excess heat at Energetics in 2005 is difficult to reproduce by chemical etching. SKINR is producing artificially structured Pd cathode surfaces using VLSI and imprinting techniques conducted in Shubhra Gangopadhyay's group in the Electrical Engineering Department at UM. Secondly, the structured cathodes are designed to resonate with THz frequency RF. This will be further discussed under techniques below.

Figure 4. SEM image of Pd pillars deposited on Pd foil.

New alloy compositions

Our collaborators have been producing Pd-Rh alloys. SKINR has obtained several of these cathodes but with null results so far.

In situ deposition of Pd nanoparticles (PD NP)

We began in the fall of 2013 to deposit palladium nanoparticles (PdNP) on Pd cathodes with promising results. This is a collaboration with Dr. Kattesh Katti in the Medical School at UM where NP are produced for use in cancer treatments. In January 2014, the ability to produce excess heat disappeared for 8 months. In questioning a student on the project, it was found that he changed the process that synthesized the NP without informing anyone. Now, after restoring the original process, we have reproducible excess heat as of the fall or 2014.

The Pd NP are externally synthesized and then mixed them uniformly into D_2O + 0.1 M LiOD electrolyte. Post experiment SEM images showed that the Pd NPs are uniformly distributed across the surface.

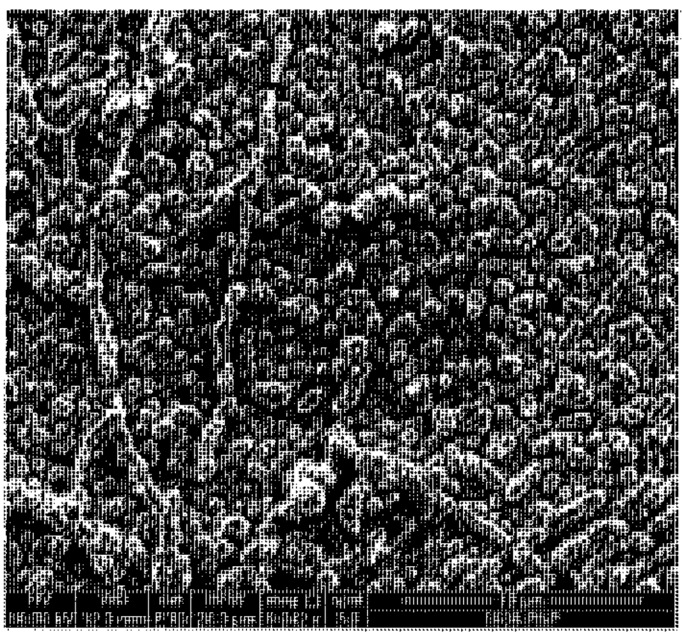

Figure 5. SEM image of Pd nanoparticles deposited in situ on a Pd foil.

Electrolysis with suspensions of PdNPs at a variety of concentrations and in two types of is cells performed. One experiment in a closed cell had an internal H_2-D_2/O_2 catalytic recombiner and did not produce excess heat. The other type, an open cell, had an external recombiner and always showed excess heat persisting for several days with an average coefficient of performance (COP) of 15 to 50%. This excess heat was most evident at low electrolysis currents and decreased as the current was increased. The source of the anomalous excess heat measured in the open cell with or without an internal H_2-D_2/O_2 catalytic recombiner remains unknown and is under further investigation. It is SKINR's most reproducible result at present.

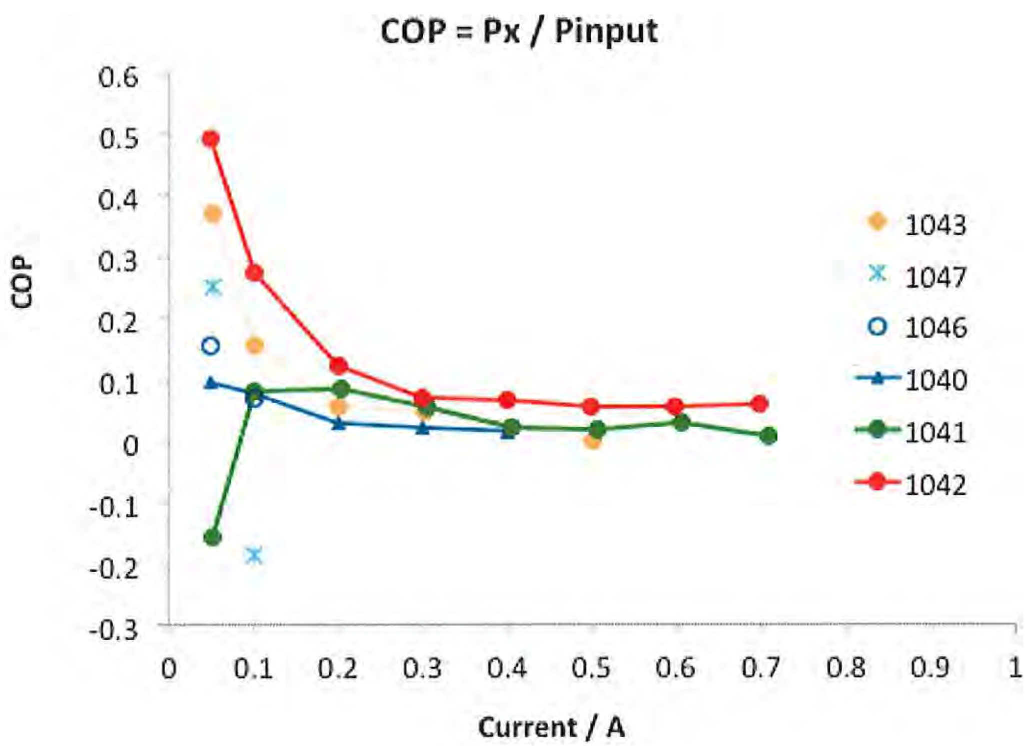

Figure 6. Coefficient of performance (COP) as a function of current for Pd nanoparticle suspension on a Pd foil. The excess power decreases with applied current but is very reproducible.

Gas Loading of hydrogen in Ni

Sensitive mass flow calorimetry was used in a series of tests to evaluate eight coated NiCuMn (Constantan) wires in a gas-loading cell. The goal of this testing was to reproduce and confirm the production of excess heat when using an experimental setup similar to that demonstrated in 2013 by Dr. Francesco Celani at National Instrument's NI week and ICCF 17. Six of the eight Constantan wires used in the SKINR tests were provided by Dr. Celani and the remaining two were obtained from Mathieu Valat from France.

Initial tests in the series closely followed the set-up, operation, and heating protocols used by Dr. Celani but used a significantly modified stainless test cell to enable the use of mass flow calorimetry. Later tests used the same modified test cell but added additional heating protocols using pulsed or highly modulated electric currents (Superwaves) to enhance loading and create additional thermal gradients within the Constantan wires. No excess heat was observed in running either the initial or later test protocols during ~ 200 days of testing with a calorimetric sensitivity of < 10 mW. We conclude that Dr. Celani's methods for producing excess heat were in error.

High temperature loading of hydrogen into Nickel powder

For several years, a group in Italy has made controversial claims of excess heat using nickel powders loaded with hydrogen at high temperature. Recently, they revealed additional information about the material used in these experiments so SKINR will attempt to determine if the Italian results are real. The gas reactor in the above experiment has been modified to accept powder samples instead of wires at temperatures up to 600C. SKINR will begin similar experiments after the ICCF19 conference in May.

Fundamental studies - Hydrogen permeation and hydrogen loading

Achieving consistently high loading of Hydrogen (H) and Deuterium (D) in Palladium (Pd) is one of the most challenging issues in the field of Anomalous Heat Effect (AHE). SKINR has conducted loading studies of 50 µm thick Pd foils in an attempt to enhance the electrochemical activity of palladium and increase loading by using various pretreatment methods and chemical additives. Pretreatment methods include thermal annealing, cold rolling, acid etching, and electrochemical oxidation/reduction.

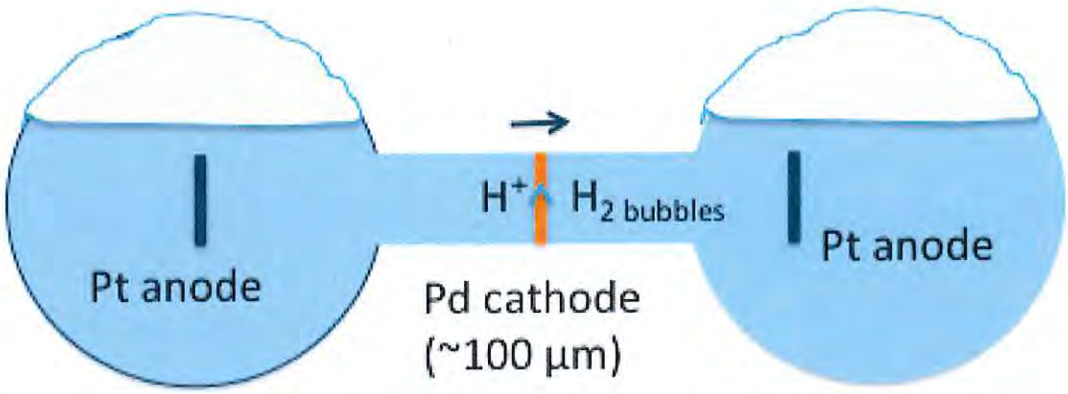

Figure 7. Schematic of hydrogen permeation cell. Hydrogen enters from left chamber and is measured as oxidation current in the right chamber after diffusion through the Pd membrane (orange color).

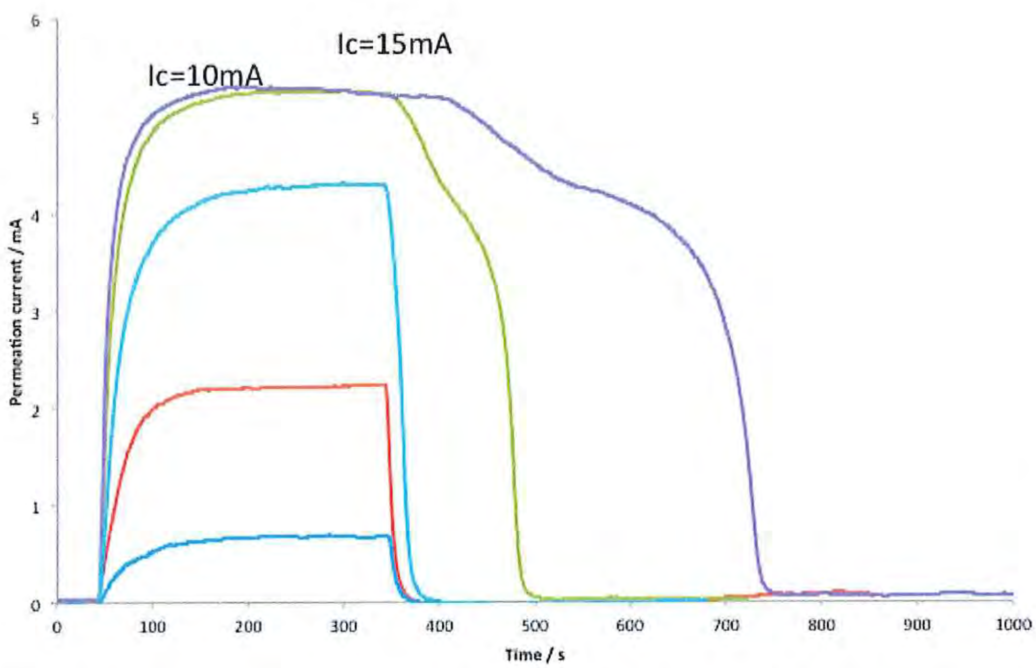

Figure 8. Permeation current (measure of hydrogen that has diffused through foil) versus time for 5 different charging currents. After 400 seconds, hydrogen is removed from the cathodic side. Green and purple curves indicate greater absorption of H at higher currents.

The initial state of the Pd cathodes is characterized using cyclic voltammetry, electrochemical impedance spectroscopy, and scanning electron microscopy (SEM). A variety of electrochemical techniques, including electrochemical permeation, desorption, potential decay transient and impedance are then applied to determine the hydrogen absorption into palladium during the loading process. Hydrogen diffusion coefficient and the apparent subsurface concentration of H/D in a Pd membrane are obtained using the time-lag method with electrolytic loading on the entry side and having fully oxidized H/D on the exit side.

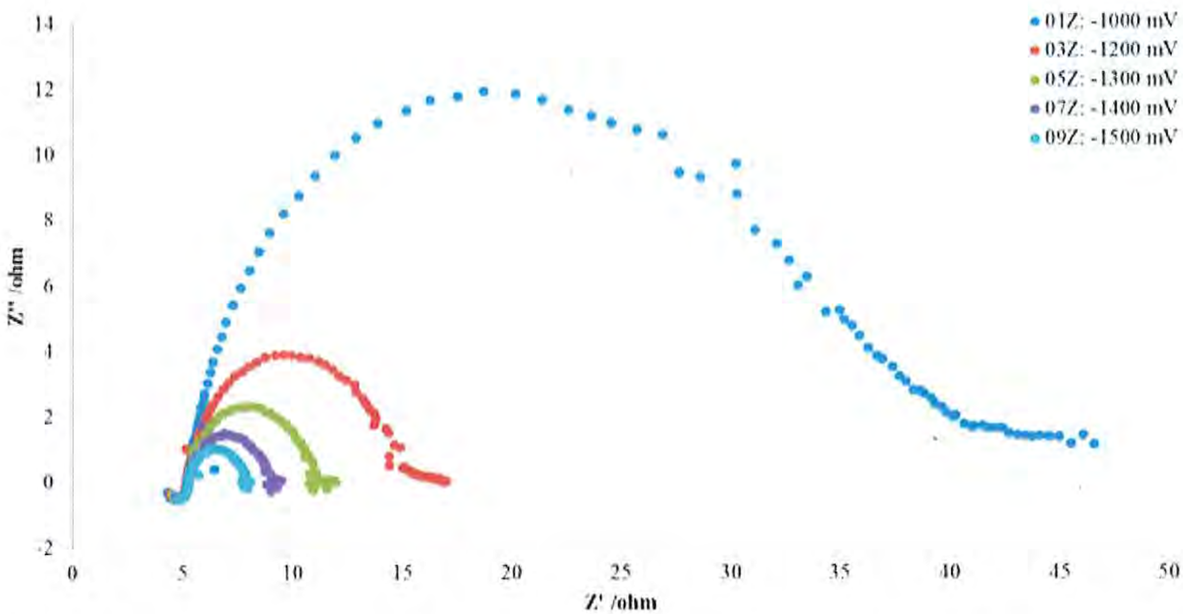

Figure 9. Example of electrochemical impedance spectroscopy (EIS) for Pd-10% Rh alloy versus charging potential. Characteristic curve indicates that the circuit is purely ohmic and that the resistance increases with potential (or H concentration).

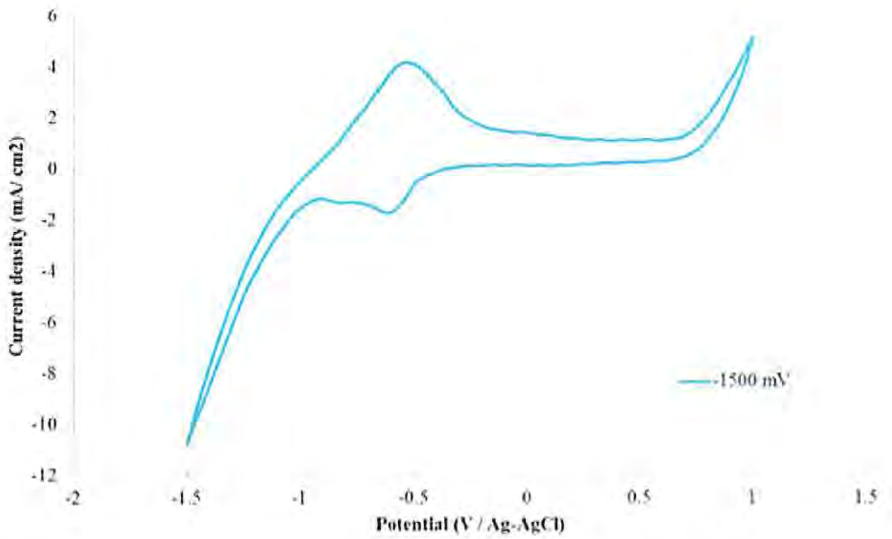

Figure 10. Example of Current versus Potential sweep (C-V) that characterizes oxidation or reduction processes on the Pd surface. Sweep conducted in 0.1M LiOD in D2O on Pr-10%Rh cathode. Peaks are oxidation and reduction PdO and of Deuterium.

The lattice diffusivity of hydrogen as well as the amounts and distribution of the diffusible and reversibly trapped hydrogen are analyzed using the desorption rate of hydrogen. In addition to the above, the effects of additives on the mechanism of hydrogen absorption are investigated by using potential decay data and permeation. Finally, electrochemical parameters of double layer capacitance charge transfer resistance and surface roughness were characterized using electrochemical impedance spectroscopy for both treated and untreated cathodes.

Improved reproducibility in the loading of H into Pd foils was demonstrated when using combinations of chemical and electrochemical pretreatment of cathodes in conjunction with time varying loading currents in a standard three-electrode electrochemical cell.

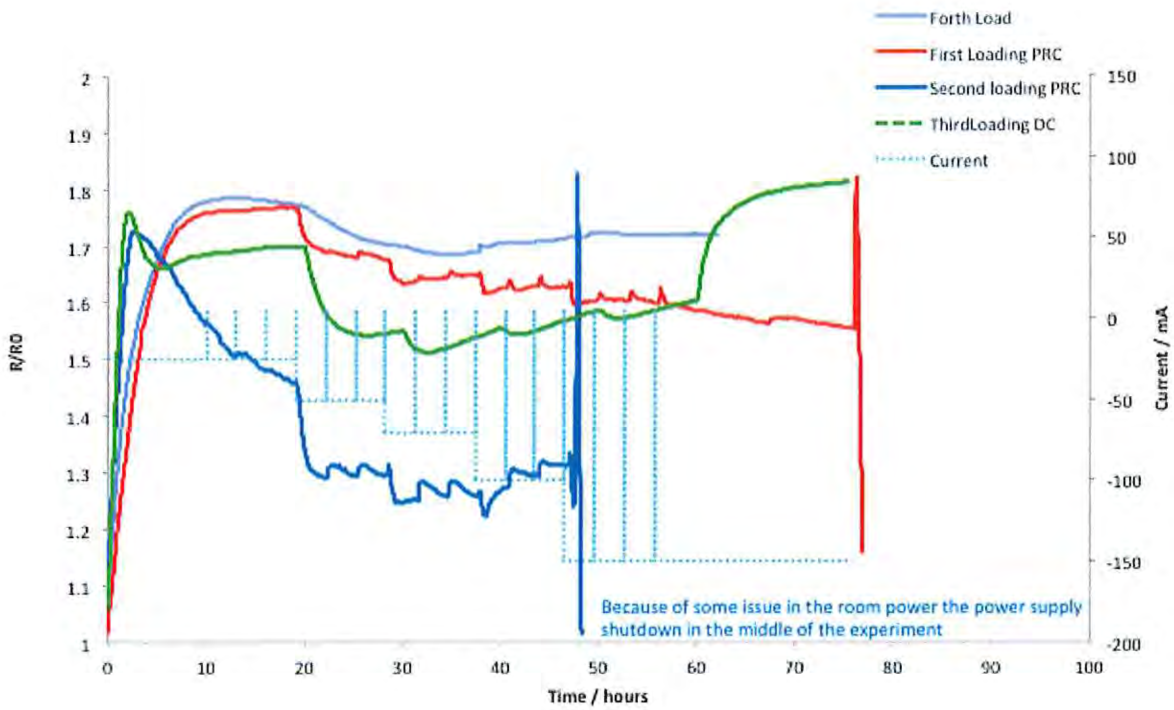

Figure 11. Example of hydrogen loading study. Resistance ratio R/R0 versus loading time for sequential loading tries. PRC is pulsed current where the cathode is deloaded for a short time periodically (green curve). Second loading (blue curve) loaded to H/Pd 0.98. Studies like this led to the conclusion that the parameters governing good loading are unknown, but it appears that the loading is controlled by impurities and not by surface morphology.

Using the same procedures for D loading into Pd foil did not, however, show the same level of improvement in loading. Fundamentally, no correlations were found with the procedures investigated, which imply that the controlling parameter(s) for loading Pd with D/H is still largely unknown. This suggests that impurities in the system control loading.

SKINR also studied the effect of palladium nanoparticles on H/D absorption and diffusion into palladium using a permeation electrochemical double cell with a thin palladium membrane. Hydrogen permeation efficiency, hydrogen diffusion coefficient, subsurface hydrogen concentration and total amount of hydrogen absorbed into the palladium membrane were obtained (or extracted from experimental data) using the time-lag method.

Low energy x-ray emission from Pd cathodes

Several theories explaining anomalous heat production predict the emission of low energy x-rays and/or MeV alpha particles from PdD cathodes in electrochemical cells. Such radiation, however, is not expected to be detectable from outside of a standard electrochemical cell due to absorption within both the electrolyte and cell walls. A custom cell was therefore designed, produced and assembled which allows any x-rays of energy ≥ 1 keV to pass through a thin cathodic membrane and into an Amptek XR-100CR Si-Pin diode detector. This same test cell also allows any emitted MeV alpha particles to be detected via impact-induced fluorescence which can generate Pd-Ka (21.2 KeV) and Pd-Kb (23.8 KeV)x-rays. The detection of X-ray emissions from electrolytic cells potentially allows the mechanism(s) for anomalous heat production to be investigated with great sensitivity. As an example, the above x-ray detector allows 1 keV x-rays to be readily detected at emission rates of less than one per second that corresponds to a heat sensitivity of < 0.2 femtoWatts (0.2 E-15 Watts).

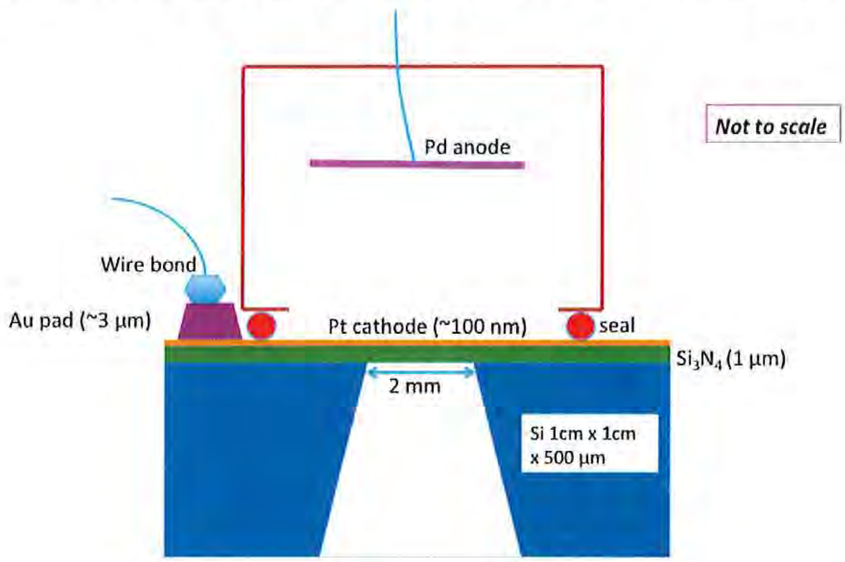

Figure 12. Schematic representation of membrane experiment that allows the detection of low energy x-rays emitted from the electrochemical system. Pd is deposited on the Pt anode and is simultaneously loaded with deuterium. The x-ray detector is placed on the air side of the membrane. No x-rays have been detected in more than a year of running the experiment.

A series of experiments were performed using custom electrolytic cells with two different types of thin membrane cathodes with 0.1M LiOD electrolyte applied to one side and air on the other. One membrane type used 1 μm Si_3N_4 coated with 200 nm platinum by three different methods: 1) deuterium/palladium co-deposition from palladium anode; 2) deuterium/palladium co-deposition from palladium salt solution; and 3) deuterium/palladium co-deposition from palladium nanoparticle suspension. The other membrane type used a 30-μm-palladium foil. We collected x-ray data for over a year using the above test cells and did not observe any x-rays above background levels for any energy from 1 to 35 keV.

Triggering of electrolysis cells

Most experiments over the past 20+ years involve electrolysis for many days and then waiting for the cell to produce heat. It has become apparent in 2014 that a method for triggering the cell to induce the excess is a new direction for research.

Magnetic field triggering

In late 2013 our collaborators in Italy used pulsed magnetic field of 1 Tesla, 40 microseconds at a rate of 1/3 Hz. This induced heat in about an hour after application of the pulses. Actually, the Superwave is a mild form of triggering. Accordingly, SKINR fabricated a 5000 V pulsed current power supply and magnetic coils and applied them to a cell. It has been run on two different cathodes with no success as yet, but is aggressively pursuing this triggering method.

A DC magnetic field has been implemented on two cells. It has not yet produced any influence on loading or excess heat.

Figure 13. SKINR fabricated high voltage pulsed current power supply. It delivers a 3000 Ampere, 40 microsecond rise time, 100 microsecond width pulse at 1/3 Hz. This produces a 1 Tesla magnetic field pulse on the cathode that is placed between two electromagnetic coils. The coils were also fabricated by SKINR.

Radio Frequency (RF) triggering

After SKINR performed a study of the coupling of radio frequency (RF) to PdD, a program was instituted to trigger heat by RF impingement on the cells. Based upon this analysis, the frequencies 40 MHz, 85 MHz, 400MHz, 800 MHz, and 1 and 5 GHz will be used to stimulate the cathode by placing an antenna in the electrolyte in close proximity to the cathode. Our preliminary runs at 5 GHz in March have produced heat anomalies in the cell. It is too early to determine the source of the anomalies but this line of research is on high priority and will be instituted in many of the 20 cells routinely run at SKINR.

Ultrasound triggering

SKINR is running one ultrasound stimulation cell. These cells produced the highest reproducibility of all the experiments at Energetics up to 2009. No excess heat has been observed, so SKINR will implement RF stimulation in the cell in addition to the ultrasound.

Laser triggering

Another trigger is laser impingement on the cathode that has received little attention in the field. Laser pulses will excite very high frequency, high-energy processes on the cathode surface such as optical and acoustic phonons, and plasmons. These excitations will decay to lower energy processes so nearly all solid-state excitations are covered. SKINR began a program to excite the cathode with a femtosecond laser. The hardware (calorimeter for both electrochemical and gas loading of Pd and NI) is nearly completed and experiments will begin in early summer.

The Gorsky Effect triggering

The Gorsky Effect is strong diffusion of hydrogen in Pd induced by the application of constant stress to the Pd foil. A cell was designed and constructed to pull in the foil with a calibrated load. Preliminary data shows a large enhancement in the diffusion as measured by change in the resistance with applied stress. The cell is being modified so that a cyclic stress (0.02 Hz to 100 Hz) may be applied. This experiment will begin in June. It is thought that the ingress and egress (breathing or hydrogen flux in and out) of hydrogen plays a role in the production of excess heat. This method will amplify the flux over that of any past experiments in this field.

Theory

Experimental evidence compiled over the last 20+ years that nuclear reaction mechanisms underlie the anomalous heat effect (AHE) is not compelling. On the other hand, the fact that there is no neutron or gamma ray emission commensurate with the amount of heat released and the fact that there is no activation of materials in heat producing systems can be considered compelling evidence that the AHE does not involve nuclear physics and, therefore, that the explanation may lie elsewhere.

Paschos first suggested the use of large crystal fields for Axion detection in 1985 but there was no discussion of a method to employ them. In addition, there are no ongoing experiments to directly search for dark matter candidate axion-like particles (ALP's) above the mass of 100 μeV due to experimental limitations of RF cavity searches.

Successful searches for scaler ALP's would be a window into physics beyond the standard model.

In this theory, the origin of the hyperfine magnetic field is analyzed with an eye on how to utilize the hyperfine field for ALP searches. It is argued that the magnetic field occupies a significant volume of many crystals and is modulated on short time scales (10^{-13}-10^{-15}s) by phonon resonances and electron resonances through the electron-phonon interaction. These concepts are not discussed in the literature. A resonating crystal can present to the ALP field a large resonating magnetic field. If the resonant frequency matches the mass frequency of an ALP, it will resonantly convert into a photon through the inverse Primakoff effect.

Since the De Broglie wavelength must be on-the-order-of crystal dimensions, this method is best suited to ALP masses ˜>1 meV. Suitable crystals can be brought into resonance using pulsed lasers or high GHz to THz RF sources. Calorimetry, gated IR spectroscopy, or both accomplish detection. The expected signal strength is improved over searches in the µeV mass region by >1000x increase in the coupling constant of ALP's to the electromagnetic field, by ~10-30x greater magnetic field, and possibly by the proposed 10^5-10^7 greater dark matter density at the earth than in the galactic halo.

Finally, searching to explain the phenomenology of the anomalous heat effect in PdD materials led to the hypothesis that anomalous heat may be due to solid-state conversion of ALP's to photons in colossal magnetic fields unique to the PdD dynamic phonon/electron band structure system.

The hypothesis is guided by experimental evidence and gives plausible explanations for the difficulty in reproducing the AHE, the appearance of AH in bursts, the necessity for D/Pd > 0.9, why D works and H does not, the lack of any detectible particle and gamma emission, the quadratic dependence of excess heat with D loading > 0.9, and provides a rationale for why NiH may produce excess heat. The hypothesis also makes testable predictions, and, does not create new physics nor does it violate any physical laws. If this hypothesis is correct, the mass of at least one ALP is ~50 meV.

Perturbed angular correlation experiment at CERN

In order to explore the theory outlined above, SKINR contacted CERN in Geneva, Switzerland, and suggested a perturbed angular correlation (PAC) experiment that would possibly detect the large solid-state magnetic fields that are proposed. CERN is one of the few laboratories in the world that can perform such measurements. CERN is the home of the large hadron collider that detected the famous Higgs Boson last year. SKINR will prepare the Pd cathodes, the Missouri University Research Reactor (MURR) will neutron activate the Hf metal that will be ion implanted into Pd in Bonn, Germany. The samples will then be sent to CERN for the experiments. PAC will be performed on pure Pd, Pd loaded with hydrogen and Pd loaded with deuterium. If large magnetic fields are detected, it will support the theory.

Collaborations within the University of Missouri

Six scientific groups are collaborating with SKINR. Dr. Duncan set up this arrangement as SKINR was being founded. Work by Professor Kattesh Kattie (Radiology Department) was already discussed. Work by Professors Shubhra Gangopadhyay, John Gahl, Peter Norgard, and Mark Prelas are described below.

Professor John Gahl

Another new initiative is the reproduction and extension of the "exploding wire" experiments conducted by Mike McKubre at SRI who is collaborating with SKINR. His preliminary results showed that by running a current pulse through Pd when loaded with deuterium AH was produced. SKINR will improve the calorimetry and introduce nuclear radiation detectors. John Gahl and Jullian Baker have made good progress in running this experiment. Mr. Baker will get his PhD on this project. A paper has been submitted to a journal on the initial results that have produced nanoporous Pd after a 100-nanosecond pulse of current into a 250-micron diameter PdH wire. A patent has been submitted for its use as a catalytic material.

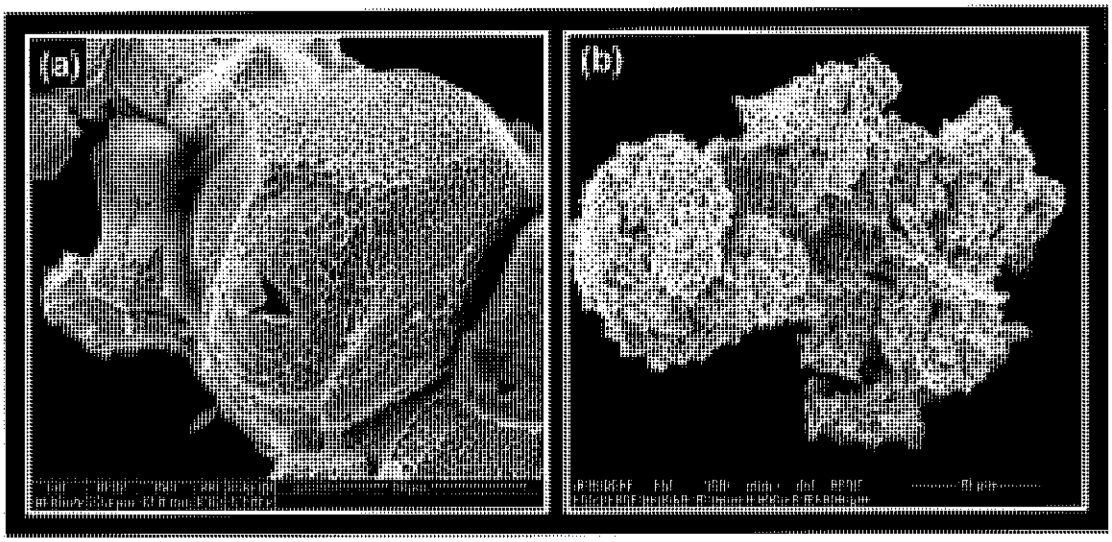

Figure 14. SEM images of exploded PdH wire loaded to a) H/Pd = 0.8; b) H/Pd = 0.96

Professor Shubhra Gangopadyay

Professor Gangopadhyay has a powerful research group in plasmonics with many graduated students. The state-of-the-art capabilities of her institute dovetail nicely with needs of SKINR for fabrication of cathodes. Cathodes structures fabricated include numerous Pd/Pdfilm/CNT/Pdfilm (CNT = carbon nanotubes) cathode structures, Pt thin films on thin Si_3N_4 membranes, and artificially structured cathodes using template and embossing and Pd NP decorated Graphene. This work supports two Post-Docs.

Professor Mark Prelas

The thermal shock of TiD experiments that produced promising results last year have additional data showing mild neutron emission. In this work, TiD shavings are brought to liquid nitrogen (LN2) temperature, then quickly removed from the LN2 and immersed in boiling water. More statistics will allow the publication of a journal paper on the results. The mechanism is not anomalous heat, but cracking of the Ti that is stressed by the large change in temperature. The cracks momentarily produce charge separation making an electric field that ionizes and accelerates the deuterons to a large enough energy to induce d-d fusion. This experiment is of interest in its own right in that it shows that d-d fusion can occur in the solid state.

The second experiment is hydrogen loaded into Ni films that are deposited in a diamond particle detector. The promising results of last year have so far not been reproduced. This is a very sensitive experiment, and if it produced high-energy alpha particles, it could all by itself reveal the mechanism of anomalous heat. For this reason, it is a very worthwhile experiment to continue. Five new diamond detectors have been fabricated and are being calibrated for new experiments in the spring.

Professor Helmut Kaiser

SKINR support for Professor Kaiser was terminated due to lack of performance.

International Ad-Hoc Collaborations

SKINR has forged collaborations with 7 research entities in the last 12 months. The purpose is to share materials and results in order to speed up the expansion of the knowledge base in the field. Figure 14 shows the parties involved. Primarily we exchange Pd cathodes and share the results of running them in calorimeters and we analyze each other's materials.

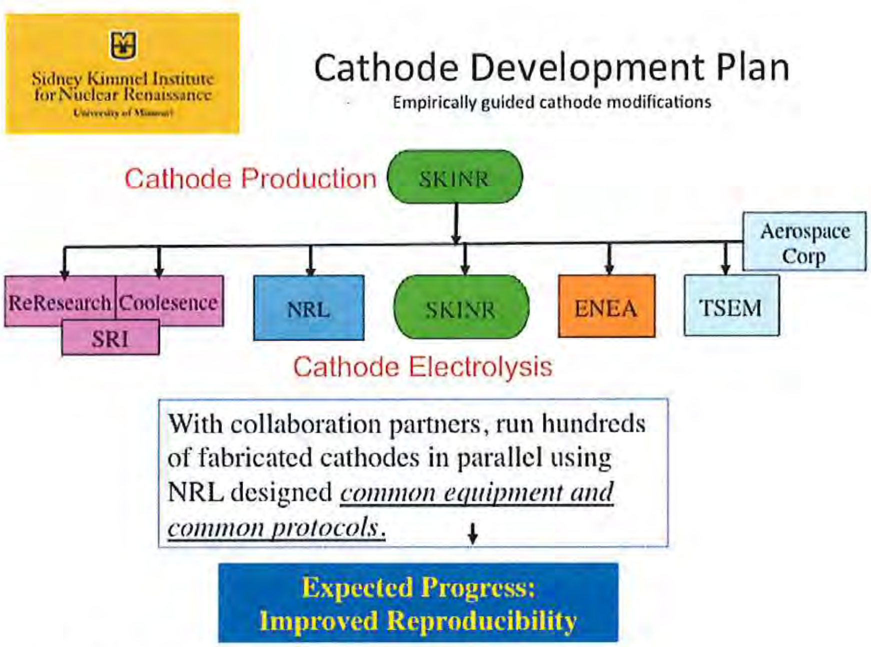

Figure 15