- Cold Fusion -

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16 November 1992

Mr. Walter M. Polansky
Director
Division of Advanced Energy Projects
Office of Basic Energy Sciences, ER-16
Department of Energy
Washington, DC 20585

Dear Mr. Polansky:

As per your request, please find attached to this letter information on Japan's "'New Hydrogen Energy' Research and Development Project." You should be aware that Japan uses the English term "New Hydrogen Energy" instead of "cold fusion." An explanation for this is given in the summary.

Also, if you would like any further information, you may contact the following person directly:

Mr. Tomihiro Taniguchi, Director *or*
Mr. Taizo Nakatomi, Deputy Director
Electric Power Technology Division
Agency of Natural Resources and Energy
Ministry of International Trade and Industry
1-3-1 Kasumigaseki
Chiyoda-ku, Tokyo, JAPAN
telephone: 03-3501-1742
facsimile: 03-3580-8486.

Sincerely,

Robert Chiappetta
Research Assistant

"New Hydrogen Energy" Research and Development Project

In August 1992, MITI decided to request budget for the next fiscal year starting from April 1993 on the research and development of the "new hydrogen energy" (*1). If the budget is approved by the Ministry of Finance and passed by the parliament before the new fiscal year begins, national budget of 300 million yen, or approximately about $2.4 million would be appropriated to the prbject.

This budget would be used to fund the research and development of the new hydrogen energy for the first year of the project. MITI is also tentatively planning to appropriate about 3 billion yen ($24 million) of the national budget in the four years from 1993 to 1996 on the project. (*2)

F.Year	93	94	95	96	Total
Excess Heat Experiments	←	—	—	→	TD
Basic Researches	←	—	—	→	TD
International Cooperation	←	—	—	→	TD
Total	300	TD	TD	TD	3000

At present, the body to carry out this research is not determined, but most possibly, an existing non-profit research organization would be chosen to coordinate the whole project.

The funds would then be used to design, assemble, operate and test experimental apparatus to realize stabler and more effective way of generating excess heat. A part of the funds would be used to support more basic research activities by keeping close coordination with university researchers. Another part of the funds is to be used to encourage international cooperation in this field by supporting symposiums or information exchanges.

Therefore, right from the beginning, this project has international cooperation in mind.

(*1) Why "New Hydrogen Energy" and not "Cold Fusion"
Although there are many hypotheses proposed trying to explain the phenomenon, still more study is necessary to ascertain which explanation is satisfactory. Therefore, it is thought too early to refer the phenomenon by the name of "Cold Fusion" at this

stage, and it's better to keep wider possibility open. Therefore, the name " New Hydrogen Energy" was chosen.

(*2) MITI's Position on the "New Hydrogen Energy"
Whatever the mechanism behind the phenomena, excess heat has been observed, and it's getting increasingly evident that something important is happening in the "pot". So, therefore, it is concluded research on the phenomenon is worth challenge where significant technological potential of energy production is expected, and the adequate budget "to keep the pot boiling" is required.

For further information, please contact:
Tomihiro Taniguchi　Director
Taizo Nakatomi　Deputy Director
Electric Power Technology Division
Agency of Natural Resource and Energy
Ministry of International Trade and Industry

1-3-1, Kasumigaseki, Chiyoda-Ku, Tokyo, Japan
Tel 03-3501-1742
Fax 03-3580-8486

Cold Fusion

FACSIMILE COVER SHEET

Department of Energy
Washington, DC 20585

DATE: 10-30-92

TO: Robert Chiappetta
212-997-0400
212-997-0464 Fax

Sent 10/30/92 @ 10:35 Sue Ellen

FROM: Walt Polansky

Division of Advanced Energy Projects
ER-16, GTN
Washington, D.C. 20585
301-903-5995

Message:

This document consists of 2 **pages (including this cover).**

TRANSMIT: 301-903-6067
VERIFICATION: 301-903-5995

Department of Energy
Washington, DC 20585

OCT 3 0 1992

Mr. Robert Chiappetta
Japan External Trade Organization
212-997-0400
Fax 212-997-0464

Dear Robert:

Recent articles in U.S. newspapers suggest that MITI is planning to increase funding for "cold fusion" research. However, to my knowledge, these plans have not been disclosed by MITI.

I would appreciate receiving information from MITI about their plans for research in this area, if possible. If appropriate, the information can be faxed to me on 301/903-7363 (or -6067).

Thank you for your assistance.

Sincerely,

Walter M. Polansky, Director
Division of Advanced Energy Projects
Office of Basic Energy Sciences, ER-16

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10/30/92

ER-16
WPolansky
10/30/92

OCT 3 0 1992

Mr. Robert Chiappetta
Japan External Trade Organization
212-997-0400
Fax 212-997-0464

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Sincerely,

Walter M. Polansky, Director
Division of Advanced Energy Projects
Office of Basic Energy Sciences, ER-16

UH **Texas Center for Superconductivity**

University of Houston
Science and Research One
Houston, Texas 77204-5506
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713.747.7724

February 13, 1990

Dr. Ryszard Gajewski
US Department of Energy
Basic Energy Sciences, ER-16, GTN
Washington DC 20545
PHONE: (301) 353-5995
FAX: (301) 353-6594

Dear Dr. Gajewski,

This letter is a brief note to update you on the progress in preparing a report of the NSF/EPRI Workshop on "Anomalous Effects in Deuterated Metals."

Most of the speakers' as well as the volunteers' presentations have been received in manuscript form. We are still missing a few and hope that those of you who have not yet responded will do so shortly.

The lengthy transcript of the meeting is in the final stages of being turned into a readable discussion of the presentations. A summary of the Wednesday morning session is nearly complete. Over the next few weeks these various parts should be assembled into a working draft. We will forward this draft, as promised, for your review.

As the workshop has been the subject of considerable public comment, we are now soliciting any supplemental technical contributions which you may wish to submit for inclusion in the working draft by the first week of March. We also invite more general, written comments to be included. When we circulate the working draft, we will want to receive both your overall comments, and your comments on or corrections of your individual contributions.

Sincerely,

C. W. Chu
Texas Center for Superconductivity
University of Houston

J. Appleby
Texas Engineering Experiment Station
The Texas A&M University System

CWC:JA/jma

Cold Fusion

Travel Report:
Sixth International Conference on Cold Fusion (ICCF6)
Hotel Apex Toya, Hokkaido, Japan
13-18 October 1996

Scott R. Chubb, Code 7252

Background and Particulars Concerning the Conference

ICCF6 was sponsored by a single organization, the New Energy and Industrial Technology Development Organization (NEDO). Only once before, during the previous five international conferences on Cold Fusion, has a single organization been solely responsible for organizing the conference. This occurred in 1990, when the National Cold Fusion Institute was the sponsor of the First International Conference on Cold Fusion. The largest groups of sponsors have occurred during ICCF3 and ICCF5, when, respectively, there were 10 and 11 sponsoring organizations involved.

Organizationally, NEDO, which is funded directly by the Japanese Ministry of Trade and Industry, oversees the officially sanctioned, Japanese government Cold Fusion program. A single page organizational chart, depicting the structure of NEDO, which has been provided by the Japan-based portion of NEDO, the New Hydrogen Energy (NHE) Program, is included as a separate attachment at the end of this report.

The conference was held in a location (Hotel Apex Toya) in the outskirts of the town of Toya, approximately 100 km southwest of Sapporo, on the northern most island of Japan. According to the preliminary listing of conference attendees (included as an attachment following the report), 175 individuals attended the conference, although it was reported unofficially that a somewhat higher number (~200) of people were in attendance.

There were approximately 130 papers. Of these, as in the previous ICCF3 Japanese Cold Fusion conference, a large (~65%) number were presented as posters, while approximately 45 of the papers were presented as 20 minute talks, during six sessions. In addition, there was a special, initially unscheduled, session, involving a series of five minute talks associated with possible evidence for "non-conventional" nuclear transmutations, through "Ultra Low Energy Nuclear Reactions."

Overview of Significant Results

Of the six ICCF conferences, this was the first in which quantitative evidence of a nuclear by-product, ^4He, substantiated by measurements of excess heat, was reported by more than one laboratory. In particular, results from Osaka University by Arata and Zhang, the University of Rome by Gozzi et al, and by Miles et al from *NAWC were presented that indicate ^4He accompanies anomalous Cold Fusion heat experiments at levels that can not be accounted for by

* NAVAL AIR WARFARE CENTER (USA)

the "normal" laws of physics and chemistry. At Rome and at NAWC, where the ^{4}He is sampled from the gases above heat-producing electrodes, the amounts of ^{4}He quantifiably correlate with the heat: as the heat goes up, the amounts go up; as the heat goes down, the amounts go down; and the amount of heat quantifiably correlates with the amount that would be expected from the known, D+D->^{4}He, reaction, namely 24 MeV/reaction. At Osaka University, where a significantly different geometrical arrangement is used involving Pd crystalline structures that are much smaller than in these other experiments, extremely large amounts of ^{4}He are found trapped within the interior regions of the Pd powder-composite matrices. The amounts of ^{4}He that are found simply can not be explained in any other way than as being the result of a D+D->^{4}He nuclear reaction. At the close of the conference, in three summarizing talks, each speaker expressed the opinion that the heat and ^{4}He measurements in these and two other experiments provide conclusive evidence that a low temperature, nuclear reaction has been identified and is responsible for the observed Cold Fusion excess heat phenomenon that occurs in heavy hydrogen-based systems.

Also in this conference, there were at least 20 reports from groups in which anomalous heat was observed, and for the first time, it was reported that heat could be produced reproducibly, all-the-time, by four groups (Arata and Zhang, Osaka University; Celani et al, INFN, Frascati, Italy; Miley et al, University of Illinois; Patterson et al, Clean Energy Technology Inc, Dallas, TX). In this context, an additional point came out both formally and informally during the conference: both electrode preparation and the distribution and size of the crystals that are used seem to be important in initiating and sustaining the anomalous heat effect. In particular, both from theoretical and experimental considerations, it is plausible to believe that crystals that possess characteristic dimensions of <~ .5 micron seem to provide an environment that significantly improves the prospect of producing anomalous heat and other effects.

It is worthwhile noting that not only were excess heat results presented by an officially sanctioned, Japanese government-supported program, for the first time since 1990. Now, positive excess heat measurement results were presented through a program that was officially sanctioned and sponsored by a second foreign government (France) through its agency, the French Atomic Energy Commission.

It is important to note that a large number of negative results were reported by IMRA, Japan, and by researchers from the New Hydrogen Energy (NHE) program. These results clearly indicate that additional effects beyond the loading criteria identified by SRI play an important role in initiating Cold Fusion phenomena. It is also worthwhile noting that the protocol used by both IMRA, Japan (which previously was successful in obtaining excess heat), and by the NHE laboratory, which led to these negative results, deviates significantly from a protocol that has been documented in the literature. This suggests that progress is being made (in programs outside IMRA and NHE) in understanding the materials properties and triggering phenomena that are required to produce excess heat. However, a number of points associated with excess heat generation, although documented, have not been generally accepted. Two of these are the presence of small crystals (ordered domains) in the metal and use of procedures that allow significant temperature excursions to occur in the cathode during electrolysis runs. The protocols

that seem to have been applied by NHE and IMRA appear to have achieved good loading in chemically well-defined metal, but apparently at the expense of conditions that favor heat generation.

This was also the first conference since 1990 in which papers that include the NRL affiliation were presented. The papers, which were well-received, provide documentation about the science associated with loading D into Pd, and of precision calorimetric measurements.

Finally, provocative (albeit inconclusive) evidence for a new category of anomalies was presented, that have been referred to as "Ultra Low Energy Nuclear Reactions," or "Ultra Low Temperature Nuclear Reactions." These results clearly are inconclusive because of the many uncontrolled variables that are involved, but they suggest that a variety of anomalous, low-level nuclear phenomena may be involved in experiments that have been associated with "Cold Fusion." As a consequence, the initial findings associated with "Cold Fusion" may fall under a more general category of phenomena. This fact may partially explain the very different effects that were observed by Pons-Fleischmann (PF) and by Jones, as well as some of the subsequent confusion about nuclear by-products that resulted during the initial stages of the "Cold Fusion" controversy.

Below, in four separate sections, the most important talks and topics that were covered during the conference are summarized. This includes detailed summaries (in the next two sections) of the ^{4}He measurements and excess heat, followed by overviews of talks presented in sessions concerning "Ultra Low Energy Nuclear Reactions" and the remaining sessions of the conference. The report concludes with a summary of the talks, followed by material that was presented during a separate tour of the NHE laboratories that took place at the conclusion of the conference.

^{4}He Measurements

Overview

1. "X-Ray, Heat Excess and ^{4}He in the Electrochemical Confinement of Deuterium in Palladium"
P.L. Cignini[1], G. Gigli[1], D. Gozzi[1], M. Toomellini[2], E. Cisbani[3], S. Frullani[4] and G. M. Uriciuoli[3]
([1]Chemistry Department, University of Rome, La Sapienza; [2]Department of Chemical Science and Technology, University of Rome, Tor Vergata; [3]Institute Nazionale de Fisica Nucleare (INFN), sez. sanità, Laboratorio di Fisica, Instituto Superiore di Sanità, Rome; [4]Laboratorio di Fisica, Instituto Superiore di Sanità, Rome)

2. "Mass Spectroscopic Search for Helium in Effluent Gas and Palladium Cathodes of D_2O Electrolysis Cells Involving Excess Power"
Shigeru Isagawa, Yukio Kanda, and Takenori Suzuki
National Laboratory for High Energy Physics, KEK, 1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305 Japan

3. "Achievement of Solid State Plasma Fusion ('Cold Fusion')"
Y. Arata and Y. C. Zhang
Osaka University

4. "Heat and Helium Measurements Using Palladium and Palladium Alloys in Heavy Water"
Melvin H. Miles[1], Kendall B. Johnson[1], and M. Ashraf Imam[2]

[1]Chemistry and Materials Branch, Research and Technology Division, Naval Air Warfare Center Weapons Division, China Lake, CA;
Heat Measurement; [2]Physical Metallurgy Branch, Materials Science and Technology Division, Naval Research Laboratory, Washington, DC 20375-5320)

5. "Further Measurements on ^{4}He Production from Pd/D_2 Systems in Gas Phase"
E. Botta[1], T. Bressani[1], D. Calvo[1], C. Fanara[1], and F. Iazzi[2]
[1]Dipartimento di Fisica Superiore, Universita' di Torino, and Instituto Nazione di Fisica Nucleare (INFN) - Sezione di Torino, Italy; [2]Dipartimento di Fisica, Politecnico di Torino, and INFN-Sezione di Torino, Italy

6. "Study of Excess Heat and Nulcear Products with Closed D_2O Electrolysis System"
K. Yasuda, Y. Nitta, and A. Takahashi
Department of Nuclear Engineering, Osaka University, Osaka, Japan

The material covered in talks 1, 3, and 4 includes observations of ^{4}He in excess heat experiments that can not be explained from the "known" laws of physics. In talk #1, mass spectroscopy measurement results from 382 independent, on-line measurements of effluently collected gas samples were discussed. These samples were collected at set intervals ($\geq$ 900s) during a 1000 hour long excess heat excursion, using a high resolution and high sensitivity ($\approx$7 pA/ 10^{12} atoms of ^{4}He) quadrupole mass spectrometer. In this sampling, air contamination was continuously monitored (and definitely avoided) through measurements of $^{20}Ne^{++}$. The peak excess power (P_{ex}) in these runs was 12 Watts ($P_{ex}\approx$80% input power). The electrolysis cathode consisted of a bundle of 150 fine (250 micron diameter) wires. In these measurements not only was significant ^{4}He found, but 1) the amounts of ^{4}He that were observed to be present quantitatively agree with the amounts of heat that were measured, and 2) sufficient sampling was done to demonstrate quantitatively that heat release and ^{4}He accumulation were correlated as a function of time: as the heat was observed to be increasing, after a period of time consistent with the kinetics of the released ^{4}He, the amount of ^{4}He that was measured was found to increase in quantitative agreement with the observed increase in heat, and as the heat was found to decrease, after a period of time consistent with the associated kinetics, the amount of ^{4}He that was observed was found to decrease, again in quantitative agreement with the measured decrease in heat. Also, through these measurements, it was possible to identify and quantify a small residual component of ^{4}He that was present initially. Also, x-rays, which might or might not be related to the heat and ^{4}He, were observed at low levels (< 1/200 calorimetrically measured excess energy observed during time of x-ray measurements) using a single x-ray film that was positioned outside the cell. (Classical modelling of the x-ray emission was used to infer the associated energy, which may be overestimated, and to infer that the emissions are hard x-rays/ soft γ-rays with energies>~89 KeV.)

In talk #3, results were reported from an arrangement significantly different than those used in other experiments. Here, a double-structure cathode was used (which by now, has been extensively documented: Y. Arata and Y. C. Zhang, Proc. Japan Acad., 70(B), 106, 1994; ibid, 71(B), 98, (1995), and Ibid, **71(B)**, 304 (1995).), in which D_2O is first electrolyzed onto an outer cathode consisting of a sealed bottle made of Pd metal filled with a fine Pd powder, called Pd black. The mass of fine Pd grains is called the inner cathode. The D atoms produced by electrolysis diffuse through the Pd pressure-containment bottle wall and spread out over the surfaces of the fine Pd grains, diffusing into the grains. During the process, D_2 gas accumulates

in the space between the grains and in the space above the grains. This space had been evacuated prior to the sealing of the bottle. After a significant D_2 pressure (>~1000 Atmos) is obtained, excess heat is observed. This technique has successfully produced excess heat 100% of the time six times, and the resulting heat has been observed for extended periods of time. As a result, the technique has been used to obtain significant heat (~36 kilowatt-hours in one case, for example). Also, because of the particular arrangement that is employed, at the onset of the observation of excess heat, the characteristic dimension of the crystals contained in the powder is ~0.4 micron. This is many times smaller than the typical characteristic sizes that are present in the electrodes used in PF (and many other) experiments.

In the Arata-Zhang results, sampling of gases above the powder was not done. However, significant levels (10^{21}-10^{20} atoms) of ^{4}He were obtained by heating the Pd-black powders from heat-producing electrodes. These amounts of ^{4}He account for a large fraction (~50%) of the observed heat. A precise accounting of the correlation between the amounts of ^{4}He and excess heat has not yet been obtained because the mass spectroscopy has been performed using only the gases that have been liberated from the Pd-black after it is heated up. This procedure excludes ^{4}He that could be released into the gases above the powder during the time the experiment is conducted.

A very important point is that the observed levels of ^{4}He are only obtained after each heat-producing powder is heated to temperatures in excess of ~850° C after the electrolysis. In the absence of electrolysis, no ^{4}He is found. Because the ^{4}He is observed only after heating each sample, it must be liberated from the sample, meaning that in each case, the ^{4}He must be trapped in the interior of the powder. The discovery of ^{4}He within the interior locations of the Pd-Black powders that was obtained in these experiments either 1. violates the known laws of chemistry, or 2. is the result of a D+D->^{4}He nuclear reaction.

The results discussed in talk #4 are fully-documented (through the ONR-sponsored report NAWCWPNS TP 8302 by Miles, Bush, and Johnson, Sept. 1996). In this talk, results of 33 experiments involving excess heat and ^{4}He measurements were reported. In 30 out of 33 experiments, ^{4}He was found at levels that quantifiably accounts for the observed excess heat. In the three experiments where ^{4}He was not seen, the associated electrode was made from a PdCe alloy in which it is possible that ^{4}He may have been trapped within the interior or in a surface region location. Best results occurred with a PdB electrode. The work includes results derived from electrodes developed at NRL. (The PdB electrode was prepared by A. Imam [Code 6323]. It is potentially of consequence that concurrent discussions between Imam, Talbot Chubb, Scott Chubb, and Bhakta Rath suggested that the associated alloy, which could form a structure containing many small Pd crystals embedded in a larger structure, potentially could result in improved excess heat generation.)

In talks #6, #5 and #2, results of efforts to measure neutrons, ^{3}H, ^{3}He, ^{4}He, γ-rays, D-loading, and heat simultaneously were reported. In talk #5, precision measurements of ^{4}He, effluent in the gases, were also made, with significant heat (~10 megajoules), and ^{4}He observed. In talk #6, the alternative, Takahashi-pulsing technique was used, which is susceptible to large fluctuations in

heat, in which low-level neutron measurements are typically used to monitor the possibility of significant excess heat results. In the reported results, heat excess was not large (3 standard deviations above background heat fluctuations were measured, based on 45 Watt input power, and 4 Watt P_{ex} was obtained); significant levels of by-products (low-level neutrons or ^{4}He) were not detected. In talk #2, marginal amounts of excess heat (~5.3 kJ, derived from 10% excess power) were obtained; no neutrons were detected, but there was evidence of ^{4}He from measurements derived using a high resolution mass spectrometer. However, in these results it was reported that ^{4}He may be an artifact because of possible contamination from air leakage through teflon.

Assessment

Six excellent mass spectroscopy experiments were described. In four of them, very significant evidence of ^{4}He was reported. In three of these cases, large amounts of ^{4}He were obtained and were found to be correlated with heat in a manner that can not be explained from the normal laws of physics. These experiments are non-trivial and seem to be providing conclusive evidence of a nuclear by-product. In a fifth experiment, performed in 1992 by NTT laboratories in Japan, significant evidence of a ^{4}He by-product was also obtained.

The Arata-Zhang experiment in particular seems to be providing the most conclusive evidence of ^{4}He, and, it always seems to work. This experiment also makes use of crystals that are significantly different than those in the other experiments. Because of the experimental arrangement, the associated crystal sizes and distribution in the Arata-Zhang experiment, which is governed by the build-up of D_2 gas that evolves during electrolysis, seems to be more regularly controlled in the sense that the same kinds of crystals are present during each run, and each run is successful. The experiments from the University of Rome also appear to provide conclusive evidence that ^{4}He is the primary by-product since results from this experiment strongly indicate correlation between excess heat and ^{4}He as a function of time over a prolonged (1000 hour) period of time.

It is clear that the experiments summarized in these talks should be thoroughly investigated. In particular, if these results are correct, the controversy is over: there is a nuclear by-product and a nuclear reaction for one particular set of (heavy water) Cold Fusion-related phenomena. (It should be clear that a wide-range of phenomena have been categorized as being related to Cold Fusion; many of these, if they exist, are the result of low level nuclear activity at best. But in the case of D-loading experiments in which D is loaded into Pd, there is a clear-cut signal: heat, and a by-product: ^{4}He.) During his closing summary, Tullio Bressani, who has been involved with one of the D gas-loading experiments in which ^{4}He has been obtained, was more emphatic: he began his comments with (my paraphase), "*Finally, we are doing real science*; excess heat is of nuclear origin, as confirmed in 5 different laboratories." He then re-iterated the various points about the ^{4}He measurements that are summarized above, emphasizing that these results provide conclusive evidence that the heat from D-loading experiments is of nuclear origin and that the by-product is ^{4}He. He also summarized why it has taken so long to obtain these results.

In particular, it has been difficult to obtain the excess heat; it has taken time to develop and perfect the techniques for obtaining reliable ^{4}He measurements.

Excess Heat Measurements

Overview

A number of new and old techniques for obtaining excess heat results were presented. Because of the previous success of the SRI model of PF cold fusion, considerable emphasis both at SRI and in the other New Hydrogen Energy (NHE) sponsored laboratories has involved working with variants of the initial SRI model. Unfortunately, because of a number of changes in protocols and procedures, the results of these efforts have been mixed, and there have been many failures. Given the past history of the SRI effort, it is plausible that materials-related aspects of the problem have been responsible for the difficulties. In particular, much of the focus of the NHE program and also work at IMRA, Japan, has been in identifying effects that lead to high-loading. As a result of this focus, a number of procedures have been followed that assist in the process of loading that may be detrimental to obtaining excess heat. These have included the use of a number of different surface-additive treatments, replacement of Pd by Pd-alloys in some studies, and the use of vacuum annealing at high temperature as a metal pre-treatment. The vacuum annealing procedure improves metal loading characteristics, but at the same time causes a loss of small crystals, which may have a negative effect on the production of excess heat.

Replicability, which seems to be tied, however, very much to particular "batches" of Pd, is clearly related to loading (but not necessarily in a simple, non-trivial way), and still remains poorly understood. On the other hand, important new developments have occurred through new innovations involving the use of smaller crystals, and interfaces, in which excess heat phenomena seem to be reproducible all the time. Also, Storms has pointed out that much of the materials problem seems to be closely tied to problems associated with loading, and he has provided a prescription (E. Storms, "How to Produce the Pons-Fleischmann Effect," *Fusion Technology*, 29, 261-268 (1996)) for obtaining excess heat that is strongly tied to identifying when particular samples of Pd satisfy criteria associated with loading. Taken together, these criteria, the application of these new techniques, and the failures suggest that progress is being made (in programs inside and outside IMRA and NHE) in understanding the materials properties that are responsible for triggering excess heat. However, a number of points associated with triggering excess heat generation, although documented, are not generally accepted. As a consequence, a fixed protocol simply is not being followed, and the failures in IMRA and NHE may very well be tied to the fact that important criteria associated with pre-testing the loading characteristics of the cathode materials that are being used elsewhere are not being followed in these two laboratories. It is also possible, as suggested above, that the pre-treatment procedure, involving high temperature, vacuum annealing of the electrodes, that is used by these laboratories, has had a negative impact on their excess heat results. This is because this pre-treatment procedure reduces the abundance of small crystals in each electrode, which may negatively affect excess

heat generation since (as suggested by results by a number of groups at this conference) the presence of small (micron-size) crystals may be required in order to obtain excess heat. Below, the most important, excess heat oral presentations are summarized. Each of these is associated with electrolytically-induced excess heat generation. A number of posters and presentations dealt with gas loading procedures; and other forms of excess heat generation, involving Pd and Ni. These are not covered in this report.

Key Presentations

1. "Excess Heat in Fuel-Cell Type Cells for Pd Cathodes Annealed at High Temperatures"
H. Kamimura, T. Senjuh, S. Miyashita, N. Asami
NHE Laboratory, Institute for Applied Energy, Sapporo, Japan

2. "Development and Experiments on a Flow Calorimetry System"
A. Kubota, S. Takama, T. Saito, S. Sukenobu, N. Hasegawa, M. Sumi, N. Asami,
NHE Laboratory, Institute for Applied Energy, Sapporo, Japan

3. "New Hydrogen Energy Research at SRI International"
M.C.H. McKubre, S. Crouch-Baker, F. L. Tanzella
SRI International, Menlo Park, CA

4. "The Icarus 9 Calorimeter: Summary of Three Years Designing, Testing and Operation of this Device at the IMRA Europe Science Center"
T. Roulett, J. Roulette, S. Pons
Centre de Recherche Scientifique, IMRA Europe, S.A., Sophia Antipolis, Valbonne, France

5. High Power μS Pulsed Electrolysis Using Long and Thin Pd Wires in Very Diluted LiOD-D_2O Solution: Observation of Anomalous Excess Heat
F.Celani[1],A.Spallone[1],P. Tripodi[1],D. DiGioacchino[1],S. Pace[1],P. Marini[2],V. Distefano[2], A. Mancini[3]
[1]Instituto Nazione Fisica di Nucleare, Laboratori Nazionali di Frascati, Frascati, Italy; [2]EURESYS, Rome, Italy; [3]ORIM S.r.L., Macerata, Italy

6. "Reproduction of Fleischmann and Pons Experiments"
G. Lonchampt[1], L. Bonnetain[2], P. Hicter[2]
[1]Cerem/Ceng, Avenue des Martyrs, 38054 Grenoble Cedex 9, France; [2]ENSEEG, BP 75, 38402 Saint Martin d'Hères, France

7. "Design Considerations for Multilayer Thin-Film Patterson-Type Microspheres"
G. H. Miley[1], G. Narne[1], M. J. Williams[1], J. A. Patterson[2], J. Nix[2], D. Cravens[2], H. Hora[3]
[1]Fusion Studies Laboratory, University of Illinois, Urbana, IL; [2]Clean Energy Technologies, Inc., Dallas, TX 75240; [3]University of New South Wales, Kensington, NSW, Australia

8. "Excess Heat Measurement at High Cathode Loading by Deuterium During Electrolysis of Heavy Water
T. Nakata, M. Kobayashi, M. Nagahama, H. Akita, and K. Kunimatsu
IMRA Japan Co. Ltd. 2-3-6 Techno-Park Shimonopporo, Atsubetsu-ku, Sapporo 004 Japan

Talks #1 and #2 summarized the status of excess heat measurements in the New Hydrogen Energy program. Talk #8 summarized similar results from IMRA Japan. The three talks, and

earlier IMRA Japan talks from ICCF3 provide evidence of an important set of pitfalls that can occur in the PF-forms of Cold Fusion, making it difficult to reproduce the excess heat effect: when/if the protocol that is used in measuring the excess heat is altered significantly (resulting, for example, in a reduction in the amount and frequency of potential temperature excursions), if it then becomes difficult to obtain excess heat, it also becomes difficult to isolate the potential reasons for the failure.

In particular, during ICCF3, IMRA Japan presented results that were based on a particular (Fuel Cell/Heat Flow) form of calorimetry that provided significant evidence that loading and excess heat are correlated. Since that time, IMRA has attempted to repeat these experiments using a very different (mass flow) form of calorimetry, based on the working hypothesis that by sustaining high-loading for sufficiently long enough periods of time, excess power will be produced. In the NHE laboratory (located in the same building as IMRA Japan), the same hypothesis has been applied. The result of this combined effort has been a failure; neither group has produced excess power, based on the new design. Specifically, at both IMRA and at NHE, excess heat has been successfully obtained when the initial (Fuel Cell/Heat Flow) form of calorimetry has been applied (as summarized in talks #1, #8, and previously during ICCF3); while when the new (mass flow) calorimetry (which is very similar in the two laboratories) has been applied, no excess heat has been obtained. As summarized in talk #8, at IMRA Japan, 36 attempts have been made to achieve excess heat involving situations with loadings D/Pd$\geq$0.85, in which mass flow calorimetry has been used, with no success. As summarized in talk #2, in the NHE laboratory, there have been 50 attempts to obtain excess heat with D/Pd$\geq$0.85, using mass flow calorimetry, with no success.

Two important problems seem to have plagued both laboratories: 1) experimenters have applied a single criteria (attainment of high loading) for prolonged periods of time, and 2) implementation of major changes in protocols and instrumentation, including major environmental changes in the materials that house the electrodes. An additional point is that as a pretreatment, vacuum annealing of the electrode materials has been used. This has been done to improve loading. However, as emphasized above, this procedure also reduces the numbers of small crystals, which could adversely affect excess heat generation, if (as suggested by other results at this conference) the use of small crystals is important for obtaining excess heat.

In talk #3, McKubre summarized efforts at SRI International to obtain better replicability. They have explored different designs in order to be able to sustain high loading for prolonged periods of time with high (~300 mA/cm^2) current densities. Although high loadings (D/Pd>0.97 in PdD_x) have been obtained, results have been mixed at best: *they have been unable to reproduce earlier results in 8 out of 12 attempts*, even when they have used precisely the same protocols (cells, electrodes, and charging procedures). To obtain some perspective associated with improving the reproducibility problem, they have adopted two procedures: 1) Force replicability, starting from situations that have worked in the past, 2) Explore new methods that appear to work.

Towards accomplishing the second goal they have set-up/purchased experiments that mimick the NAWC (Miles/Bush) efforts, the cavitationally-induced heavy water procedure developed by E-

Quest (Stringham/George), the Fleischmann/Pons Boil-off results (M. Fleischmann and S. Pons, "Calorimetry of the Pd-D_2O System: from Simplicity via Complications to Simplicity," Physics Letters A 176 (1993) 118.), and the Patterson/Cravens Ni-Pd-Cu bead techniques (which make use of "normal," as opposed to heavy or light, water electrolysis) that have been found to work repeatedly by a number of groups.

In talk #4, Stan Pons summarized the development of a new calorimeter that allows for precision measurements of heat for prolonged periods (up to several months) of time, at high input powers and electrolyte temperatures. This has been motivated by the Boil-off results (M. Fleischmann and S. Pons, Physics Letters A 176 (1993) 118.), where during boil-off, at relatively high input power, efficiency of the calorimetry was low. With this in mind, the calorimeter has been designed to be stable with input powers as high as 350-400 W with pressures that are comparable to atmospheric pressure at the boiling point of the electrolyte, and with negeligble loss of electrolyte due to evaporation. Recombination of the evolved deuterium and oxygen within the cell was also eliminated. The increase in input power maximal tolerance represents roughly a 200% improvement over what was possible in the earlier calorimeter. The resulting ICARUS9 calorimeter, which can be used with varying cell materials, has been used with constant currents (ranging between 20-100 $mAcm^2$) over periods of ~100 days.

Pons reported results from 8 experiments. In five of these, there was no excess power. In 3 experiments, excess power values of 101 W, 17.3 W, and 74 W were obtained. These occurred with input powers that are approximately 80% of P_{ex}; 294 MJ was the maximum excess energy obtained (but, n.b.: 100 KJ was used to heat electrolyte) in an electrode of 1.2 cm^3 volume.

In talk #5, new results associated with the microsecond pulse technique developed by Celani et al were discussed. In this work, as in the past report from ICCF5, they always obtain P_{ex}, with the excess typically in the range of 15-25% of the input power. An important aspect of this arrangement is the pulsing technique in which current is raised to 25A with peak applied voltage of 270V. Pulsing is done with a width ranging between 200 ns and 5000 ns, with a pulse repetition rate ranging between 100 Hz and 50 Hz. The pulsing induces an electromigration of the D^+ ions within the wires (a twisted wire configuration is used), which appears to be important for obtaining large loadings. In one case, from an input power of 50W, P_{ex} was approximately 100W. Experiments were also conducted in which D_2O was electrolyzed initially, followed by electrolysis of "normal" H_2O, and then D_2O, and so forth. In these cases, it was found that excess power was obtained both when "normal" H_2O is used (leading to $P_{ex}\approx3\%$ of the input power) and when D_2O is used (where $P_{ex}\approx8\%$ of the input power).

In talk #6, L. Bonnetain presented results that illustrate the first, publicly-discussed, successful attempt to transfer a set of experimental techniques for obtaining excess heat from one laboratory (Pons and Fleischmann's IMRA Europe laboratory) to a second, government-sponsored laboratory (ENSEEG, Grenoble, France), in a location outside Japan. (In Japan, fuel cell techniques employed by IMRA Japan have been transferred to the government-sponsored, NHE laboratory.)

In these experiments, replications of the PF boil-off experiments were carried out. The work was officially sanctioned and sponsored by the French Atomic Energy Commission. A strictly engineered effort was undertaken in which the original PF experiment was repeated. This involved charging a duplicate system with 0.26 A/cm^2 current for 1-2 weeks, where the temperature (T) was < 40°, followed by running the same system with an increased current (0.66 A/cm^2), which led to an increased T>40°. Near boiling, a large increase in input voltage (and power) is observed, followed by a measured P_{ex} ~150%±50%. In contrast to the PF experiments, the "heat after death" phenomenon (in which excess heat was found after all of the D_2O had boiled away) was not observed.

In talk #7, details concerning the materials characterization of multilayer thin-film, microspheres that have been used in excess heat experiments at the University of Illinois were discussed. These materials, the associated design, and the experimental results are significant for a number of reasons: 1) the associated electrodes, which employ beads constructed from various Ni/Pd layers, are distinctly different from those used anywhere else in the world, 2) materials characterization and engineering considerations have been used to construct these electrodes, 3) the beads always produce excess heat, 4) the apparatus uses "normal water" (not pure H_2O but H_2O with a small D_2O component), 5) the beads and electrolysis are based on the "Patterson-type" of arrangement (which is the only Cold Fusion set-up that has been patented to date), and 6) an analysis of the beads, after excess heat generation, indicates significant, anomalous changes in their material make-up that seem to be occurring as a result of the excess heat production. The associated beads are formed by depositing thin, mulilayer films consisting of alternating Ni-Pd layers or a Ni-Ag-polymer structure. Characteristic thicknesses of the films are .8 μ. These films are deposited onto mm size polymer spheres. In 20 out of 20 runs, excess heat (~15%) is obtained.

An important point associated with the design of the thin films (on plastic beads) is that their characteristic thickness coincides with the characteristic size where mechanical changes in the structure of the film can alter the electronic and chemical properties of the film. This is also true of the characteristic (0.4μ) dimension of the Pd-black materials used by Arata and Zhang. Patterson stated informally that he agrees that the success that Miley and he have had in obtaining excess heat probably is closely-related to their use of a micro-dimension in the bead technique. At this dimension, mechanical changes affect the properties of the materials.

Anomalous Effects in Electrode Materials/"Transmutations?"

Overview

Anomalous changes in the materials, including unusual changes in isotope distribution and isotopic ratios, the "appearance" of new materials, etc. have been reported in a number of experiments, accompanying excess heat generation, in the past. Because these effects have involved very small concentrations of materials, it has been difficult to determine their origin, and most frequently, these effects have been identified with impurity migration ("or contamination") from materials in the anodes and the cell at locations outside the electrodes.

In a number of instances, it has been suggested that these effects are the result of "Ultra Low Energy Nuclear Reactions" (ULENR's). This idea was presented in a follow-on talk by George Miley, related to his excess heat talk (discussed in the last section), as being the only possible way to account for the changes in the material-make-up of the heat-producing, multilayer film electrodes, described above. Specifically, he suggested these changes were so extensive that they could not be accounted for by trace contaminants or outside sources. In particular, he used neutron activation analysis (NAA), Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), and Energy Dispersive X-Ray (EDX) techniques to perform a post-electrolysis analysis of the material make-up of his electrodes. He found high concentrations of new elements, replacing as much as 40% of the metal films, and isotopic ratio changes in as much as 70% of each film. He also provided evidence (in the form of exposed film) for 20 KeV x-rays. A number of additional talks, involving what appear to be significantly lower level effects were also presented.

Talks Presented During "ULENR" Session

1. Experimental Observation of Massive Transmutations Occurring in Multilayer Thin-Film Microspheres After Electrolysis
   G. H. Miley[1], G. Narne[1], M. J. Williams[1], J. A. Patterson[2], J. Nix[2], D. Cravens[2], H. Hora[3]
   [1]Fusion Studies Laboratory, University of Illinois,Urbana, IL; [2]Clean Energy Technologies, Inc., Dallas, TX; [3]University of New South Wales, Kensington, NSW, Australia

2. Nuclear Transmutation in Cold Fusion Experiments
   H. Kozima, M. Nomura, K. Hiroe, M. Ohta
   Department of Physics, Faculty of Science, Shizuoka University, Shizuoka 422, Japan

3. Isotopic Distribution for Elements Evolved in Palladium Cathode after Electrolysis in D_2O Solution
   T. Mizuno[1], T. Ohmori[1], T. Akimoto[1], K. Kurokawa[1], M. Kitaichi[1], K. Inoda[1], K. Azumi[1], S. Shimokawa[1], M. Enyo[2]
   [1]Hokkaido University, Sapporo, Japan; [2]Hakodate National College of Technology, Tokura-cho, Hakodate, Hokkaido, Japan

4. Production of Heavy Metal Elements and the Anomalous Surface Structure of the Electrode Produced During the Light Water Electrolysis on Au Electrode
   T. Ohmori[1], T. Mizuno[1], M. Enyo[2]
   [1]Hokkaido University, Sapporo, Japan; [2]Hakodate National College of Technology, Tokura-cho, Hakodate, Hokkaido, Japan

5. Nuclear Reactions Caused by Electrolysis in Light and Heavy Water Solutions
   R. Notoya, T. Ohnishi, Y. Noya
   Catalysis Research Center and General Institute of Radio Isotope, Hokkaido University, Sapporo, Japan

Assessment

An obvious reason for questioning if nuclear processes occur in these ULENR's is the apparent lack of appreciable radioactivity that is associated with them. In particular, although some evidence of low-level x-rays was reported by Miley, and Reiko Notoya reported low-levels of

γ-rays accompanying excess heat generation in "normal water" Ni experiments, in virtually all other cases, in which ULENR's were cited as being possible, no detectable radiation was reported.

Significant evidence for radiationless nuclear reactions has also been provided by heavy-water Cold Fusion experiments. For this reason, it is potentially more believable that "non-conventional" processes could be at work in these ULENR studies, and that the lack of radiation, by itself, should not be viewed as conclusive evidence that nuclear processes are not occurring. However, there is still an additional, more obvious difficulty with assuming that nuclear effects are involved in these studies: to really determine if the changes are the result of nuclear processes, it is necessary to identify quantitatively all of the potential elements and isotopes that may come into contact and interact physically or chemically with the electrodes. This clearly has not been accomplished in a rigorous manner.

A very real difference has evolved in this respect between the heavy-water PF-like results and potential low-level nuclear effects (including the "transmutation" results cited here): in the PF-like results, derived from heavy-hydrogen, a clear-cut, nuclear by-product has been found, namely ^{4}He; while in the ULENR experiments, this has not been the case. On the other hand, the excess heat results that have been attributed to "ULENR's" have been cited as being very reproducible, as have the anomalies in isotopes and elemental distributions. However, the amounts of excess heat are not as large as those observed in many of the heavy-hydrogen experiments.

It is important to recognize that because of the lack of a clear-cut nuclear by-product and the apparent complexity of the resulting anomalies, it is possible that a number of effects could be at work, some of them potentially nuclear. However, it is also clear that a prolonged learning curve probably is involved in isolating nuclear from non-nuclear effects. In the case of the multilayer experiments involving the anomalous redistributions of isotopes and elements, this problem of isolating nuclear from non-nuclear effects is exacerbated by the presence of interfaces and micro-dimensional structures. In particular, because of the sizes and engineering of these structures, a number of complicated processes involving direct and indirect coupling between the mechanical, chemical, and electronic processes of the associated layers and interfaces become possible. This further complicates the problem of isolating nuclear from non-nuclear effects.

Other Talks

1. In Situ Determination of Structural Changes Accompanying the Electrochemical Absorption of Deuterium in Pd Using Synchrotron Wiggler Radiation
   P. L. Hagans, E. F. Skelton, D. D. Dominguez, S. B. Qadri and D. J. Nagel
   Naval Research Laboratory, Washington, D. C.

2. Tritium Production from Palladium and Palladium Alloys
   T. N. Claytor, M. J. Schwab, and D. B. Tuggle
   Los Alamos National Laboratory, Los Alamos, NM

3. Confirmation of Anomalous Thermal Power Generation from a Proton-Conductor Oxide

R. A. Oriani
Corrosion Research Center, Department of Chemical Engineering and Materials Science, University of Minnesota, Minneapolis, MN

4. Solid Protonic Conductors: Conductivity, Structure, Proton Traps, Phase Transitions, Excess Heat and Neutron Anti-Effect

A. L. Samgin, S. V. Vakarin, V. S. Andreev, V. A. Khokhlov, E. S. Filatov and V. P. Gorelov
Institute of High-Temperature Electrochemistry, Russian Academy of Sciences, Ekaterinburg, Russia

5. Optical Theorem Formulation and Gamow Factor Cancellation for Low-Energy Nuclear Reactions

Yeong E. Kim, Alexander L. Zubarev
Department of Physics, Purdue University, West Lafayette, Indiana

6. Radiationless Cold Fusion: Why Small "Crystals" Are Better, N_{cell} Requirement, and Energy Transfer to Lattice

T. A. Chubb and S. R. Chubb
Oakton International Corporation, Arlington, VA

The final two days of the conference dealt primarily with Material Science-related issues, alternative procedures (other than Pd- or Ni- based methods) for initiating heat generation, and new ideas and developments associated with nuclear by-products. Most of the Material Science - related session dealt with issues related to loading Pd and the relationship of loading to current density, overpotential and excess heat.

In this session, Pat Hagans (Code 6170) formally presented results (in talk 1) documenting the x-ray diffraction experiments which NRL has conducted using the National Synchrotron Light Source (NSLS). Because NSLS beam time is limited, the focus of this effort was not on excess heat but on the loading characteristics of the Pd wire (which was obtained from SRI International) as a function of location within the wire. In these results, the x-ray beam from the NSLS was stepped through the Pd wire from the edge into the interior. Changes in the lattice spacing were used to distinguish the α, β, and mixed $\alpha+\beta$ phases.

Talk #2 was presented by Edmund Storms in place of Thomas Claytor who apparently was not able to attend the meeting as a result of a DOE management decision. In this work, which is now well-documented in previous ICCF Conference Proceedings (cf Tuggle, Claytor, and Taylor, *Trans Fus Tech* **26**, 221-231 (1994).), Pd and Pd-alloy samples were loaded with D or H plasma in a system that allows for measurement of ^3H. After long run times, because of the sensitivity of the measurement system, measurements of ^3H that are many standard deviations (>10) above background have been obtained.

In talks 3 and 4, results derived from gas-loaded proton-conducting oxides were presented. In particular, in talk #3, Richard Oriani reported reproducing measurements of excess heat derived from experiments (carried out at elevated temperatures>~300°C) in which D_2 gas is dissociated and loaded into specimens of the form $SrCe_{0.9}Y_{0.08}Nb_{0.02}O_{2.97}$. These specimens were provided

by Tadihiko Mizuno, who first observed that excess heat could be produced in this manner. Similar studies were carried using a more generic form of the same compound: $ACe_{1-x}d_xO_3$, with A=Ba or Sr, d=dopant of Y, Nd, or Dy. In this second talk, neutron detection was also attempted; and it was suggested that a decreased neutron signal (an "anti-neutron" effect) occurs with the onset of excess heat.

Talks #5 and #6 were the only theory papers presented during the regular 20 minute oral sessions. (During the "Transmutation/ULENR" session, a five minute theoretical talk, based on a theory of neutron band states, was presented by H. Kozima of Shizuoka University). In talk #6, a number of new ideas were presented associated with important domain size-dependent effects on power density that influence the occupation of ion band states and the possible channels for energy release from ion- band-state-mediated nuclear reactions. The size effects study reported in this talk suggests that larger amounts of heat per unit volume are produced in crystals made of "micro-size" dimension crystals (in which one or more dimensions is <~1 μ). In micro-size dimension crystals, the number of independent, coherently-occupied volumes per unit volume is the controlling parameter, and coupling of potential reactions from each coherently-occupied volume to the external environment provides the rate limiting step for energy release for each crystal domain. In micro-size dimension crystals, this coupling is optimized and occurs through a non-local energy release process that is initiated from the decremental mass difference between two D^+ nuclei and one ^4He nucleus in each crystal. The energy is released through heating of electrons and expulsion of ^4He by-product at the boundaries of the crystal. In fact, the underlying physics of this result is associated with the fact that in crystals of this size, it becomes possible for mechanical changes in the crystal to alter its underlying electronic properties and structure. For this reason, this energy release study suggests that materials preparation may play a critical role in the attainment of an optimal environment for generating excess heat. A number of individuals privately suggested that this is potentially an important theoretical suggestion, which could be responsible for effects observed in the Patterson-cells and in the Pd-black findings of Arata.

Summary

Important evidence of a helium nuclear product was obtained from the University of Rome and Osaka University and reported at ICCF6. These results are in agreement with (and confirm) the results obtained by Miles et al from NAWC. The nuclear product occurs in the form of residual low-energy ^4He that is found in electrolytic, heavy-water experiments at levels and in locations that cannot be explained by the normal laws of physics and chemistry. In the case of Osaka University, the results involve ^4He that remains trapped within the electrode in a manner that can only be explained by a $D+D->{}^4He$ reaction. In the case of the University of Rome, a detailed time-correlation study has been carried out that shows that as the amount of heat goes up, the amount of ^4He that is detected goes up; as the amount of heat goes down, the amount of ^4He goes down. In the NAWC and University of Rome results, the ^4He is found outside the heat-producing electrodes; at Osaka University, a large (~50%) amount is found in the interior. An important reason that the ^4He is found in a different location appears to be due to the very different forms of crystals that are used at Osaka University. In particular, at Osaka University,

a "double-structured" cathode arrangement was employed. It results in excess heat being produced when the underlying powder is of a particular, characteristic dimension ~.4 μ. At the University of Rome and NAWC, the comparable characteristic cathode dimension (~mm) is considerably larger.

Additional findings of anomalous excess heat were reported from a number of insitutions. In four different laboratories, it was reported that excess heat can be obtained in a reproducible fashion. However, a considerable number of failures were reported from the New Hydrogen Energy program and from IMRA Japan. Both sets of failures seem to be associated with adoption of a particular strategy (the need to implement high loading over extended periods of time and to use mass flow calorimetry, which reduces temperature excursions) that has necessitated considerable modification of earlier protocols and arrangements (due to IMRA Japan) which were initially successful. Important evidence was presented that excess heat generation is closely linked to the quality of the materials that are used. For this reason, it has been found that greater reproducibility can be obtained by following alternative approaches in which materials preparation and characterization techniques are applied. These include pre-selecting the materials either by using smaller crystals, engineered in a specific way (for example, as in the Patterson-cells), or by applying specific, cook-book like pre-measurement procedures to assess the physical integrity of a particular palladium sample (as suggested by Storms).

Both from theoretical considerations and from experimental results presented at the conference, evidence is accumulating that micro-dimension engineering, in which crystals within the electrodes are constructed with one or more dimensions to be ~1 μ, may provide an important step in improving excess heat reproducibility.

Acknowledgement

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