FUSION facts

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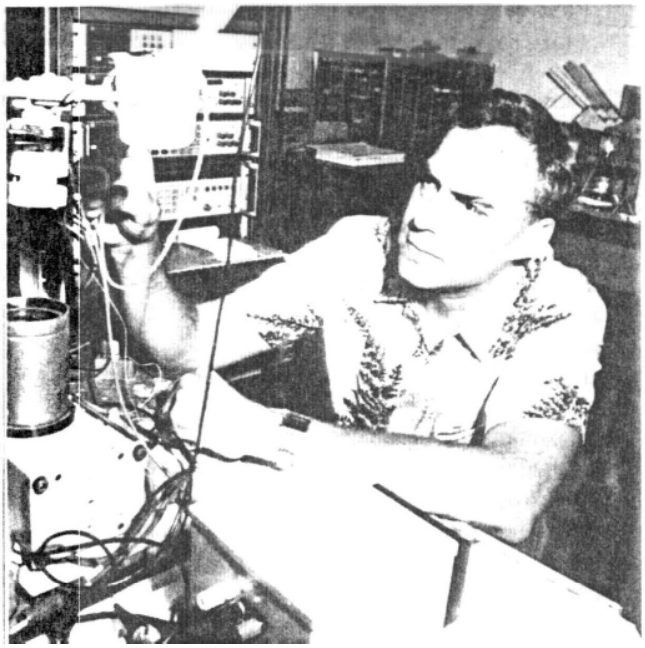
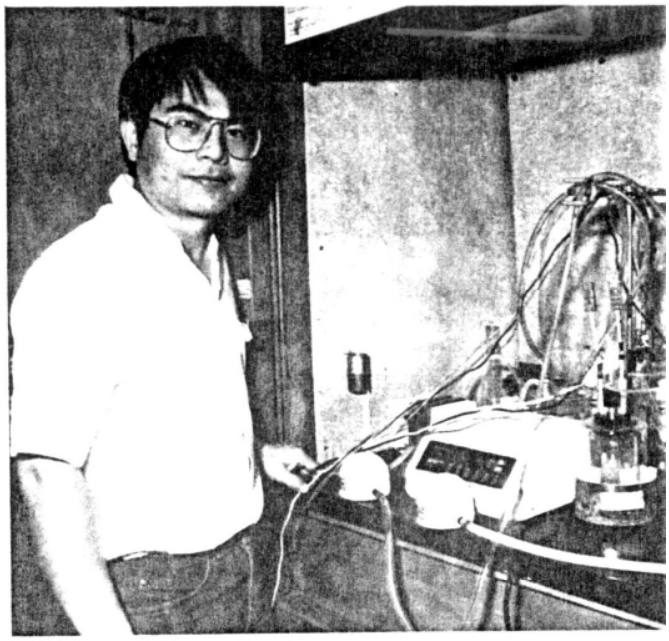
A. LIEBERT AND LIAW NAMED AS FUSION SCIENTISTS OF THE YEAR



Dr. Bruce E. Liebert, Prof., Univ. of Hawaii



Dr. Bor Yann Liaw, Hawaii Nat. Energy Inst.

Fusion Facts ANNUAL YEARLY AWARD GOES TO DRS. B. LIEBERT AND B. Y. LIAW FOR MOLTEN SALT COLD FUSION INVENTION

Professor Bruce E. Liebert, Department of Mechanical Engineering, and Professor Bor Yann Liaw, Hawaii Natural Energy Institute, both at the University of Hawaii, are acclaimed as *FUSION SCIENTISTS OF THE YEAR.*

These two eminent professors are the inventors of an improvement on the Fleischmann-Pons cold fusion discovery in which they produce nuclear reactions in a palladium electrode immersed in an electrolyte of molten salts. The experimental proof of their invention was carried out at the University of Hawaii with the assistance of Peng-Long Tao and Patrick Turner. Their work was first reported in a paper presented on July 23, 1990 at the Special Symposium on Cold Fusion in conjunction with the World Hydrogen Energy Conference #8 in Honolulu, Hawaii. The first publication of their paper appeared at about the same time in the proceedings of the symposium and in the October 1990 issue of *Fusion Facts.*

OVER 1000 PERCENT EXCESS ENERGY

In one of the Liaw-Liebert molten salt fusion cells, they achieved levels of heat ranging from 6 to 16 times the input energy over a period of about 100 hours. As with the early Fleischmann-Pons experiments, the molten salt fusion cells also have been troubled with problems of reproducibility. During 1990 at least three groups solved the problems of reproducibility in heavy water cells. It is expected that during 1991 similar progress will be made in resolving the problem of reproducibility with the palladium/molten salt fusion cells.

STRONG COMMERCIAL IMPORTANCE

The production of over 300 percent excess heat is deemed to be the minimum requirement for successful commercialization of the new cold fusion technology. Until the success of the molten salts fusion cell, no one had reported the achievement of over 300 percent continuous excess heat (not sporadic or burst events). The achievement by Liaw et al. in their Hawaiian experiments of large amounts of excess heat was the first real evidence that early commercialization of cold fusion could be a reality.

It is important to note that 500 to 1500 percent excess heat has (as of this report) only been achieved once and has not been fully replicated. This fact may prolong but not diminish the ultimate commercialization of molten salt fusion cells. It was several months after the announcement by Pons and Fleischmann before anyone reported that they had solved the problems of reproducibility with the P-F fusion cells.

INVENTORS BOTH FROM STANFORD

Both Dr. Liebert and Dr. Liaw did their Ph.D. dissertations at Stanford University and both were under the tutelage of Professor Robert A. Huggins in the Department of Materials Science and Engineering. Dr. Liaw's thesis was "Several Materials Aspects of Advanced Lithium- and Hydrogen-Based Electrochemical Systems". This thesis work was completed in February 1988. Dr. Liaw joined the Hawaii Natural Energy Institute at the University of Hawaii in April 1989 and is now an Assistant Researcher. Dr. Liebert is an Associate Professor of Materials Science in the Department of Mechanical Engineering, University of Hawaii. We congratulate these two scientists on their novel cold fusion invention and reduction to practice.

B. TOP FUSION EVENTS IN 1990

1990 FUSION YEAR IN REVIEW

By Michael Dehn

CONFERENCES AND PUBLICATIONS

The year was marked by three international conferences in the U.S.:

1. The First Annual Conference on Cold Fusion was held on March 28-31 in Salt Lake City, Utah. It was sponsored by the National Cold Fusion Institute. (A second annual conference is scheduled for the spring of 1991 in Italy.)

2. The World Hydrogen Energy Conference (WHEC) #8, Special Cold Fusion Symposium, was held on July 23-24 in Honolulu, Hawaii. It was sponsored by the Hawaii Natural Energy Institute of the University of Hawaii.

3. The Anomalous Nuclear Effects in Deuterium/Solid Systems conference was held on October 22-24 at Brigham Young University (BYU) in Provo, Utah. It was sponsored by the Electric Power Research Institute (EPRI), the U.S. Department of Energy (DoE), and BYU. (A second conference is tentatively scheduled to be hosted by the Italian Physical Society in the fall of 1991 in Italy.)

Local cold fusion conferences were also held in China and Japan.

Many of the groups who reported success in 1989 have now seen their reports published in 1990. For example,

the experimental details of the 1989 molten salt invention of Drs. Liaw and Liebert (U of Hawaii) were published in *Fusion Facts* [October 1990] and also in the *Proceedings of the World Hydrogen Energy Conference #8*. The extensive work done at the BARC laboratories in India was reprinted in a special August 1990 cold fusion issue of *Fusion Technology*.

Many groups (Los Alamos, BARC, BYU, U of Utah/NCFI, etc.) have reported new work. For example, Drs. Fleischmann and Pons have published more detailed analyses of calorimetric results in *Fusion Technology* and the *Journal of Electroanalytical Chemistry* [FF July and September 1990].

THE EXPERIMENTAL DATA

The volume of cold fusion experimental data increased dramatically during 1990. As noted by Dr. Worledge of EPRI at the BYU conference [FF November 1990], the overall quality of experiments was also seen to have improved considerably. For example, careful experiments using very sophisticated neutron detectors were described by Dr. Menlove and several others at the conference. This trend is expected to continue in 1991. For instance, at the BYU conference Dr. Totsuka indicated the availability of an extraordinary particle detector at the Kamioka facility in Japan for cold fusion experiments in 1991. Dr. Worledge also noted that the fraction of negative reports was starting to diminish. (Incidentally, at the BYU conference, Dr. Scaramuzzi also reported a historical curiosity: the possible observance of cold fusion in Italy in the 1950's, when highly sensitive neutron measurements and purification of deuterium using palladium as a filter were being performed in adjacent labs.)

The total number of groups in various countries reporting possible excess heat production and/or nuclear effects has now reached over 100 groups in 15 countries [FF October 1990 and elsewhere]. It was also particularly evident at the BYU conference that the number of international collaborative efforts has increased.

Reproducibility generally still remains a severe problem, hindering parametric experiments aimed at optimization. For example, a new Ti gas-loading experiment at the BARC facility in India provides a particularly striking example of the difficulties; only 4 of 1000 chips generated tritium, even though all chips were from the same source and were all treated the same. Several reports this year have discussed the effects of metallurgical factors which may be involved. These reports include presentations by Dr. Storms (Los Alamos) at the BYU conference [FF November 1990] and by Dr. Huggins (Stanford) at WHEC#8 [FF August and December 1990].

Gradual improvements in reproducibility have continued in 1990. For example, Los Alamos presentations at the BYU conference [FF November 1990] reported good reproducibility of low-level neutron bursts in Dr. Menlove's gas-loading experiments and of low-level tritium production in Dr. Claytor's gas/solid system. Reproducibility was also indicated by other researchers such as Dr. Yang of the Tsing Hua U. in Taiwan [FF August 1990] and Dr. Eagleton at Cal Poly. (Complete information from these and other researchers is expected to be released for publication during early 1991.)

Although the levels of heat and nuclear products reported in most experiments have remained relatively low, some new 1990 experiments were even higher than reported in 1989. In the molten salt invention by Drs. Liaw and Liebert, heat output was 7 to 16 times greater than the electrical energy used in the electrolysis, and the cumulative excess heat output during the experiment, 6.26 MJ/mole D_2, clearly indicated a nuclear source rather than stored chemical or mechanical energy. At the BYU conference, it was also announced that ^{4}He levels, 14 standard deviations above background, were found in the electrode that produced this excess heat [FF Nov 1990].

At the BARC facility in India, tritium levels high enough to give over 10^7 disintegrations per second in an individual chip were reported in new Ti gas-loading experiments [FF November and December 1990]. Drs. Arata & Zhang (Kinki U. and Osaka U., Japan) reported bursts of up to 10^8 neutrons/second in a Pd electrolysis experiment [FF September 1990]; Drs. Yamaguchi and Nishioka (NTT, Japan) reported bursts of up to 10^6 n/s during outgassing of Pd covered with a surface coating [FF August and November 1990].

TYPES OF EXPERIMENTS

The variety of cold fusion experiments has continued to increase significantly. In addition to Pd in electrolysis experiments and Ti in gas-loading experiments, various other metals and alloys have been tested. Besides Drs. Liaw et al., at least 3 other groups are preparing to conduct new molten-salt electrolysis experiments. A number of groups are also performing ion implantation (ion bombardment), plasma focus loading, cluster impact, and spark gap discharge experiments.

Among the most unusual new types of experiments described at the BYU conference [FF November 1990] were the Pd deuteride electrodeposition technique of Dr. Szpak (described by Dr. Barrowes of NCFI), the LiD dissolution experiments performed at Novosibirsk in the USSR (described by Dr. Danos of NIST), and the gas-loading experiments on high temperature superconductors described by Dr. Celani (Frascati, Italy) and by Dr. Jones (BYU).

Investigations into the possibility of geological cold fusion are also continuing. Finally, increased interest continues in alternative approaches such as muon-catalyzed fusion (an earlier "cold fusion" process suggested in the 1940's and demonstrated in the 1950's, but unable to achieve energy breakeven), and in possible new warm fusion mechanisms [FF December 1990].

THEORY AND TRENDS

Much of the theoretical work of 1989 was expanded, and some additional theorists have contributed new ideas. Two particularly prevalent types of theories have involved collective quantum-mechanical behavior of deuterons and greatly enhanced screening of the repulsion between deuterons in metal lattices under particular conditions. Experimental work is in progress to test the predictions of certain of these theories, such as that of Dr. Bush of Cal Poly [FF November 1990]. While no consensus has emerged, sufficiently high levels of experimental reproducibility will begin to provide answers in 1991.

The sensitivity of experimental results to metallurgical conditions and the potential metallurgical complexities in all types of cold fusion experiments have become widely appreciated but not yet specified. The frequent reports of successful experiments with highly nonequilibrium conditions has continued. In electrolysis experiments, the importance of high deuterium loading has continued to be supported. Measurements of tritium many orders of magnitude greater than neutrons, and heat greater than accounted for by both neutron and/or tritium production, have continued to be observed. The importance of bulk and surface effects are still being explored.

The summary of experimental work in cold fusion, as of the fall of 1990, has been carefully presented in two articles by Dr. Bockris: at WHEC#8 in July and in the August 1990 issue of *Fusion Technology*.

In addition to *Fusion Technology*, the *Journal of Radioanalytical and Nuclear Chemistry* and the *Indian Journal of Technology* are now regularly featuring cold fusion articles. Turnaround times for both journal articles and conference proceedings are typically several months. *Fusion Facts* will continue to provide you with unpublished results and results submitted for publication whenever such information is ethically available.

1990 TOP TEN FUSION RESULTS
By the Staff of *Fusion Facts.*

Your choice may be different for the top ten best cold fusion results of 1990; however, here are our choices:

1. The experimental evidence for the steady production of large amounts of excess heat at about 370 C using the Liaw, Liebert molten salt invention at the University of Hawaii [1].

2. The demonstration of good replicability in D_2O electrolysis experiments with the simultaneous measurement of tritium and heat by C.S. Yang et al. of National Tsing Hua University, Taiwan, R.O.C. [2].

3. The production of tritium (repeatably) as reported by Claytor at Los Alamos [3].

4. Dr. Szpak's clever plating-out of PdD (quickly and repeatably) on a nickel-wire mesh and photographing by X-Ray emission [4].

5. The production of large amounts of neutrons from plated Pd reported by Yamaguchi [5]. The scientific importance is the emphasis on the boundary between Pd and (in this case) Mn & O. See summary page 14.

6. The identification of only 4 out of 1,000 titanium chips as being involved in nuclear reactions in gas-loading experiments and the high amounts of tritium generated from such chips as reported by Srinivasan of BARC [6].

7. The production of large numbers of neutrons using a large Pd electrode as reported by Arata [7]. This experiment measured the largest numbers of neutrons as yet reported in a cold fusion experiment.

8. Preparata's theory involving classical quantum electro-dynamics to explain cold fusion [8].

9. The close explanation of several observed experimental findings by Bush and Eagleton [9].

10. The report that even normal water could support low-level nuclear reactions by Matsumoto [10].

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C. PONS-FLEISCHMANN PATENTS & SCIENCE REVIEW OF NCFI

PONS-FLEISCHMAN INTERNATIONAL PATENTS
Courtesy of Dr. H. Aspden & Dr. Bob Bass

The first published announcement of the surfacing (into public accessibility) of the patents being filed by the University of Utah on cold fusion came in the English publication *New Scientist* in its November 10, 1990 issue. Barry Fox, the science writer, titles his report "Patents blow the lid on cold fusion". Barry Fox states that the international patent application was filed in March 1990 and is based on the seven U.S. patent filings that were made between March 13 and May 16, 1989.

The patent was filed under the World Intellectual Property Organisations's Patent Cooperation Treaty and consists of over a hundred pages of text, drawings, tables, and claims. Barry Fox claims that the wording of the patent application reveals that the inventors are still unclear about the scientific mechanism of cold fusion. The application covers the use of the metal (such as palladium) as a rod, sheet, powder, or thin film. The metal can be charged with an isotope of hydrogen by electrolysis of water containing a high proportion of heavy isotopes of hydrogen (deuterium or tritium).

The list of inventors include Stanley Pons, Martin Fleischmann, Cheves T. Walling, and John P. Simons. The latter two names were apparently included because of an early paper written by Walling and Simons ["Two Innocent Chemists Look at Cold Fusion", *J. Phys. Chem.* **93**, pp 4693-6, 1989].

Barry Fox notes that the patent office examiners say that because of an article in the journal *Fusion Technology*, [Vol 16, No 2, Sept 1989], "the claimed invention cannot be considered novel or cannot be considered to involve an inventive step". After all of the unjust criticism laid on Pons and Fleischmann for not revealing more details of their invention or discovery, it is apparent that it is not difficult to lose some patent rights by early publication. Pons and Fleischmann have made repeated comments on the legal limitations that prevented them from acting in the role of true scientists (which they prefer) because of stringent advice and counsel (or insistence) on the part of the legal staff of the University of Utah and the patent attorneys. The legal defense of claims made in the patent application by the U of Utah patent attorneys will likely be based on the fact that the dates of invention preceded the cited publication.

Dr. Aspden makes the following comments:

"The disclosure aims at covering almost any techniques that can be found workable but essentially what is

disclosed are the chemical aspects. The ideas extend to thin film electrodes charged by heating and also fused metal salts. There is very little circuit or apparatus structure detail suggested apart from the multimembrane host metal intermediate electrode structure between the main electrodes and the circuit schematic of two figures.

"The disclosure contains test details, i.e. experimental data of cell parameters, temperature, etc. over time, showing the anomalous cell temperature, potential variation etc., much of which has probably been updated in onward scientific disclosures. Note that the International Filing Date of this patent application was 12 March 1990 and that it runs to about 106 pages, when the unnumbered sheets of drawings are included. The main patent claim is a little obscure. As presently worded it says nothing more than that energy is generated in a lattice containing isotopic hydrogen by catalyzing nuclear reactions and that the products of those reactions are utilized."

The first two claims in the patent application state the following:

1. An apparatus for generating energy, comprising: (a) a lattice structure capable of containing isotopic hydrogen and catalyzing nuclear reactions involving said isotopic hydrogen, and (b) means for utilizing a product of said nuclear reactions.

2. The apparatus as claimed in claim 1, wherein said means for utilizing includes means for conducting heat generated by said nuclear reactions.

If these claims are allowed, the patent is granted, and the technology becomes commercially viable, then this patent will be an extremely valuable property. There will be lots of room for specific embodiments, improvements, and applications of cold fusion, however, all such will have to recognize that this patent is the predecessor. With the latest dramatic results (some not yet released for publication) leading to early commercialization of cold fusion, the future cash flow from the Pons-Fleischmann patents may make the University of Utah the richest university in the United States.

Dr. Bob Bass shared with us the following comments made by Harry Dart: "The attached article from *New Scientist* for 11/10/90 shows the dilemma that Pons-Fleischmann find themselves in. If they fail to divulge everything they know, they are criticized for being excessively secretive. And if they publish everything they know, then they are denied a patent on the ground the idea has been previously published.

"The article criticizes the patent application on the ground that it fails to spell out the physical theory underlying the production of excess heat. Apparently the author [Barry Fox] is not aware that patent law prohibits patenting a law of nature. **What is patentable is a device that is new.** All that is required is a description of the device. It is not even mandatory to show that the device works...

"If it [a device] fails to do what the inventor claims, no one will ever make, sell, or use the device, and the inventor will never be able to license it. If the inventor persists in making false public claims that the device does do what it does not do, then he may be prosecuted under some other law that protects the public from being duped by false advertising. But this is an entirely different area of law beyond the scope of patent law."

The earlier work of Pons and Fleischmann is now a matter of public record (for patent purposes). It must be recognized that other patents have also been filed based on the continued work by Pons and Fleischmann. It is to be expected that, on advice of their attorneys, neither Pons nor Fleischmann will discuss the continuation of their earlier work. However, it can be expected that both of these eminent scientists will discuss the materials that have now been made a matter of public record.

In view of the enormous interest worldwide in cold fusion (except for the American Physical Society and CERN) and the dramatic developments that have ensued, we expect that Pons and Fleischmann will enjoy chuckling at their critics. *Fusion Facts* is pleased to have played a small role in the dissemination of ethically available information during its 19 monthly issues. We will be around to share our enjoyment with you and to report on the soul-searching by critics and opponents. We will especially be pleased to be able to report, at some future date, that the Department of Energy has included cold fusion in the nation's energy policy. Editor.

LATE NEWS FLASH: The University of Utah has announced that Dr. Pons resignation from his regular faculty position has been accepted and that Dr. Pons will be appointed as a research professor in the Department of Chemistry. This action will free Dr. Pons from teaching and provide him full time for research.

SCIENCE REVIEW OF NCFI
Courtesy of Dr. Fritz Will

The "Report of the Committee for the Review of the National Cold Fusion Institute" was received at press time. The document will be reviewed in greater detail in the February issue of *Fusion Facts.*

The science review of the NCFI was made on November 7, 1990 at the NCFI laboratories by four eminent scientists: Dr. Robert Adair (Physics, Yale); Dr. Stanley

Bruchenstein (Chemistry, St Univ of NY, Buffalo); Dr. Loren G. Hepler (Chemistry, U of Alberta, Canada); and Dr. Dale F. Stein (President, Michigan Tech U.).

Due to insufficient time for executive sessions, the reviewers submitted separate reports. Dr. Adair's report was the most critical and strongly flawed by his obvious unfamiliarity with the many scientific reports on cold fusion. He is still citing equal branching ratios for deuterium fusion and one in a million production of ^{4}He in spite of the numerous scientific findings of many cold fusion experiments.

Dr. Bruckenstein remarks favorably about the NCFI development of a "closed system" tritium analysis methodology and comments favorably on Dr. Pons solution to the problem of experimental irreproducibility. Bruckenstein's summary concludes with, "The work at the NCFI has reached a critical stage and an unambiguous answer to the *cold fusion* question should be possible in the next year."

Dr. Hepler makes the following cogent note in his summary, "...it appears that recent improvements in cell operation will permit researchers at NCFI and elsewhere to make better calorimetric measurements as soon as patent considerations cease to interfere with transfer of information to other researchers."

Dr. Stein accurately notes, "If cells can be designed that reproducibly generate excess energy and if the mechanism responsible (nuclear or otherwise) can be identified, then the NCFI has a very promising future."

The forty-four page report will be more adequately reported to our readers in the February 1991 issue.

D. MORE NEWS FROM U.S.

CALIFORNIA: CAL POLY - INTERVIEW

"A Cold Fusion Model That Matches Experimental Data," *21st Century Science and Technology* 3(3), Summer 1990, pp 21 and 62.

EDITOR'S COMMENTS

This interview with Drs. Robert Bush and Robert Eagleton of California State Polytechnic U in Pomona, CA, and an accompanying article on Dr. Bush's model, may be of interest because of the apparently good reproducibility produced in Dr. Eagleton's electrochemical experiments.

The electrochemical cells used by Dr. Eagleton have Pd cathodes and Pt anodes in a closed system with D_2 and O_2 recombined. The cell temperature is measured relative to that of a constant-temperature bath, and tritium is also measured. It was reported that upcoming experiments could involve many more cells (eventually as many as 40), and tests will compare results from polycrystalline Pd electrodes (1 cm long and 3-4 mm in diameter) with those from single-crystal electrodes grown by Los Alamos National Laboratory from 99.8% pure Pd. The Bush theory suggests the polycrystalline bars should perform best.

CALIFORNIA: EPRI - HIGH TEMPERATURE SUPERCONDUCTIVITY & COLD FUSION
Courtesy of Dr. Rabinowitz

Mario Rabinowitz (Electric Power Research Institute), "High Temperature Superconductivity and Cold Fusion," *Modern Physics Letters B* 4(4), 1990, pp 233-247.

ABSTRACT

There are numerous historical and scientific parallels between high temperature superconductivity (HTSC) and the newly emerging field of cold fusion (CF). Just as a charge carrier effective mass plays an important role in SC, the deuteron effective mass may play a vital role in CF. A new theory including effects of proximity, electron shielding, and decreased effective mass of the fusing nuclei can account for the reported CF results. A quantum-gas model that covers the range from low temperature to high temperature SC indicates an increased T_c with reduced dimensionality. A reduced dimensionality effect may also enhance CF. A relation is shown between CF and the significant cluster-impact fusion experiments.

EDITOR'S COMMENTS

The author notes similarities between factors involved in cold fusion and high-temperature superconductivity. Rabinowitz also states that HTSC had generally been viewed to be theoretically impossible prior to its demonstration. The factors which may be involved in cold fusion as well as HTSC are as follows:

1. Reduced dimensionality or degrees of freedom (deuteron motion which is confined to only 1 or 2 dimensions) can increase both collision frequencies and typical center-of-mass energies of the collisions, and possibly also allow a significant probability for 3-body collisions. It is also noted that the one-dimensionality of bombardment experiments such as the cluster impact method of Beuhler et al. [Fusion Facts, December 1990] may play a role in the unexpectedly high "lukewarm"

fusion rates observed, which are stated to be 10-25 orders of magnitude higher than expected.

2. The effective masses of deuterons as well as electrons in a lattice can be less than their masses in free space, due to quantum mechanical effects possible in a lattice with periodic potential wells. A ten-fold decrease in the effective mass, (increasing the fusion rate by 45 orders of magnitude), could account for the highest reported cold fusion rates. If reduction of the effective deuteron mass plays a role, certain predictions are possible: Heavy electrode loading with tritium and deuterium should give higher fusion rates than deuterium alone. Also a strong dependence on local deuterium loading would be expected, **possibly leading to poor reproducibility.** Finally, the rate would not increase strongly with increasing temperature.

3. The source of superconductivity is a condensation of a Bose-Einstein gas, and cold fusion may also stem from this. (Similar collective behavior of a boson condensate consisting of deuterons has been proposed by Drs. Chubb and Chubb.) Pd is unusual in that it becomes a superconductor when loaded with hydrogen isotopes, and also unusual because the resulting compounds show an inverse isotopic effect: the maximum temperature for superconductivity is higher for deuterium than for hydrogen. Also, a recent model by the author suggests that Pd deuteride has the potential for room-temperature superconductivity under conditions of reduced dimensionality.

Previous articles by Dr. Rabinowitz are: Mario Rabinowitz, "Cold Fusion: Myth Versus Reality," *IEEE Power Engineering Review*, January 1990, pp 16-18; and Mario Rabinowitz and David H. Worledge, "An Analysis of Cold and Lukewarm Fusion," *Fusion Technology* 17, March 1990, pp 344-9. Experimental work on cold fusion in deuterium-loaded high-temperature superconductors is reported by Dr. Jones and by Dr. Celani at the Anomalous Nuclear Effects conference at BYU conference in October, reviewed in the November 1990 issue of *Fusion Facts.*

INDIANA: PURDUE - THEORY

Yeong E. Kim, Robert A. Rice and Gary S. Chulick, "The Role of Low-Energy Proton-Deuteron Fusion Cross Section in Physical Processes," *Fusion Technology* 19(1), January 1990, pp 174-7.

ABSTRACT

We calculate the proton-deuterium (p-D) fusion reaction rate at low energies ($E \leq 2$ keV in the center-of-mass frame) for a Maxwell-Boltzmann velocity distribution and compare it to those for other reactions involving hydrogen isotopes. It is shown that p-D fusion dominates competing reactions for $E \leq 8$ eV in the center-of-mass frame. The implications for various physical processes are discussed.

EDITOR'S COMMENTS

The authors state this paper may be the first rigorous theoretical calculations of the fusion rate for the reaction p + d --> ^{3}He + gamma (5.5 MeV) at energies less than 1.5 KeV (in the center-of-mass frame). It is such energies which are expected to be of relevance in cold fusion. The authors note the possibility of deuteron acceleration during arcing across D_2 gas bubbles on a cathode surface, or due to entrainment of deuterons by electrons under conditions of very high current densities.

The calculations presented for the p + d, d + d, and other reactions are extrapolated from available experimental thermonuclear fusion rate data, assuming a Maxwell-Boltzmann velocity distribution for the reactants (i.e. the typical statistical distribution seen for thermal motion). However, experimental data for the p-d reaction is only available at energies above a few KeV, and the authors note that they have previously raised the question of whether the extrapolation remains valid at very low energies, especially in light of data from the Beuhler cluster-impact experiments. (Collision energies in the paper are based on the center-of-mass frame. This frame of reference or system assumes that the origin of the coordinate system is located at the center of mass of the particles involved in the nuclear reaction.)

It is suggested that p-d fusion may be the predominant cold fusion reaction in the Earth's interior, and that p-d fusion may also be a significant contributor in electrochemical cold fusion experiments since commercial D_2O typically contains on the order of 0.1% HDO. [See also Gary S. Chulick, R.A. Rice and Y.E. Kim, "The Effect of Electron Screening and Velocity Distribution on Proton-Deuterium Fusion Rates in Physical Processes," *Proceedings of Anomalous Nuclear Effects in Deuterium/Solid Systems*, Brigham Young University, October 22-24, 1990 and *Fusion Facts* November 1990].

INDIANA: PURDUE - WADA SPARK GAP THEORY

Yeong E. Kim (Purdue U),"Neutron Burst from a High-Voltage Discharge Between Pd Electrodes in D_2 Gas," *Fusion Technology* 18(4), Dec 1990, pp 680-2.

ABSTRACT

A recent experimental observation of a neutron flux burst at a rate of 2×10^4 times the background rate during a high ac-voltage stimulation between two deuterated palladium electrodes in D_2 gas is explained in terms of the experimentally measured deuterium-deuterium (D-D) fusion cross sections. Theoretical criteria and experimental conditions for improving D-D fusion rates with the use of pulsed high-dc voltages are described.

EDITOR'S COMMENTS

The subject experiment is reported in N. Wada and K. Nishizawa, "Nuclear Fusion in Solid," *J. App. Phys. Japan* 28, 1989, p L2017 [*Fusion Facts*, December 1989]. An abbreviated presentation of Dr. Kim's theory was also presented at the Anomalous Nuclear Effects conference at BYU in October 1990 [*Fusion Facts*, November 1990].

In the Wada experiment, a neutron rate of 692 counts in 63 secs. was measured at the start of a 12-kV, 60-Hz discharge between Pd electrodes loaded to D/Pd = 1/3 in deuterium gas. Based on data on the energy dependence of the cross-section for conventional d-d fusion (described in the paper), calculations are made suggesting that acceleration of an expected 10^{14} or more D^+ ions formed in each discharge to energies of up to 12 KeV could give rise to conventional d-d fusion rates sufficient to explain the observed count rates (if reasonable assumptions are made about the efficiency of the detector used).

The pressure rises noted in the experiment were consistent with such dissociation, ionization and acceleration of the deuterium by the discharge, followed by outgassing of part of the deuterium in the bombarded electrodes. Cessation of the neutron emission later in the set of discharges, and much smaller neutron emission during a subsequent set of discharges, was attributed to damage to the electrodes by the discharge. It was suggested that analysis of the electrode surfaces would reveal other nuclear products formed by the d-d fusion reaction and from secondary reactions. (At 12 KeV, the ranges of these products in Pd would be several microns, while conventional d-d fusion would be expected only within the surface 1/4 micron.) Also, some of the elevated neutron background of 4-20 counts/hour measured between the two sets of discharges could also be explained if secondary reactions of such products with other species (such as impurities in the Pd) give rise to species with short half-lives.

Pulsed dc rather than ac voltages, with durations of 1-100 microseconds, in combination with voltages, up to about 100 kV, are suggested to increase fusion rates by many orders of magnitude. Higher D_2 gas pressures, electrode surface asperity (pointedness), and electrode surface area may be helpful. Finally, a magnetic field to divert the electron flux and a pulsed X-ray source to better initiate ionization are suggested.

MASS. - ELECTRODE CHARACTERIZATION

K. Kumar (Charles Stark Draper Laboratory, Cambridge MA), I.S. Hwang, R.G. Ballinger (MIT), C.R. Dauwalter and A. Steyck (Draper), *Fusion Technology* 19, January 1991, pp 178-187.

ABSTRACT

The sporadic nature of the excess heat reported from heavy water electrolysis has been widely attributed to variability among the different palladium cathodes used. Experimental reproducibility should, therefore, be enhanced if the microstructure of the palladium can be controlled. Toward this end, palladium rod samples from two heavy water electrolysis experiments were compared to a sample representative of the as-installed condition. The samples examined showed equiaxed grains and significant abnormal grain growth. The rod axes had strong textures, which were attributed to their prior thermomechanical history. The postelectrolysis palladium rods were sampled at two locations that were suspected to have operated at different average current densities. The suspected higher current density regions consisted of single-phase Pd-$D_{0.7}$ microstructures. Surface-originated cracks were seen along the grain boundaries in one of two such specimens. Cracks were absent in samples from the suspected lower current density region, which showed two-phase microstructures with Pd-$D_{0.7}$ as the dominant phase. The minor phase, indexed as palladium in the X-ray pattern, was dispersed nonuniformly, mostly in the form of stringers, across the grain boundaries. It is concluded that high current densities resulted in high deuterium loadings in palladium. Smoothing effects from the electrolytic process, resulting in preferential material removal from the grain boundaries, were seen on the cathode surface. A number of high-mass impurities were seen to have deposited on the electrode surface. An initial secondary ion mass spectrometry examination of the specimen interior indicated a significant presence of mass 2 species and considerably lower concentrations of mass 3 and 4 species. Repeat analyses failed to confirm the presence of the mass 3 and 4 species. This work shows that the Pd-$D_{0.7}$ phase is reasonably stable at room temperature and that metallography could be a powerful tool for studying the deuteriding process in palladium at high concentrations.

EDITOR'S COMMENTS

The authors hope that examination of the bulk microstructure of Pd cathodes following cold fusion

experiments may provide valuable information to help establish conditions favoring successful experiments. (Metallographic changes would occur due to deformation such as cold-working, heat treatments such as annealing, and deuterium loading.) Polished and etched sections of the electrodes were examined under a metallographic microscope, and the contents of the alpha and beta deuteride phases measured by X-ray diffractometry. The analyses were in addition to more commonly performed post-experiment analyses of the electrode surface morphology (dendrites, etc.) by scanning electron microscopy and analyses of surface contamination (metal deposition, etc.) by various methods.

It was noted that the cathode with the higher loading ratio may have generated anomalous heat bursts during the first 2 weeks of electrolysis. This cathode had also been significantly deformed as a result of the loading.

MINNESOTA - EXCESS HEAT

R.A. Oriani, John C. Nelson, Sung-Kyu Lee and J.H. Broadhurst (U of Minnesota), "Calorimetric Measurements of Excess Power During the Cathodic Charging of Deuterium into Palladium," *Fusion Technology* 18(4), December 1990, pp 652-8

ABSTRACT

A Seebeck-effect calorimeter was used to establish that generation of energy, in excess of the electrical energy input, can occur during the electrolysis of D_2O. The magnitude of the excess power is measured with respect to the electrolysis of H_2O as the baseline. The excess power levels of > 60 W/cm^3 palladium and excess energies of 74 kJ cannot be understood in terms of recombination of D_2 and O_2 within the calorimeter, other chemical reactions, or a storage-and-relaxation mechanism.

EDITOR'S COMMENTS

The calorimeter contained 1,961 copper-constantan junctions in series occupying the annular space between its concentric cylindrical metal walls, which are electrically and thermally insulated from each other. The heat generated by the electrolysis cell in the cavity at the center of the calorimeter sets up a radial temperature gradient that produces a Seebeck electromotive force in the thermopile. Any temperature inhomogeneity within the energy-producing object is of no consequence. The calorimeter is immersed in a constant-temperature water bath, and gases evolved from the cell are passed through a water vapor trap, then through a heat exchanger, before the vapors leave the calorimeter. The calorimeter requires over 1 hour to stabilize after large T changes.

The cells used 1-mm-diameter Pd cathodes (vacuum-annealed 99.9% Pd from Johnson-Matthey, and cleaned but unannealed 99.999% Pd obtained from Dr. O.J. Murphy of Texas A&M) and a Pt anode. The electrolyte contained 0.1 M LiOD, acidified with approximately 0.3% D_2SO_4. A cell with H_2O and LiOH served as a control. Additional electrolyte was not added during a run. Power levels could be measured to within a few hundredths of a watt, and calibration was accurate to about 0.3%. Comparison of data for the H_2O cell in a previous test and data obtained with an equivalent resistor indicated that recombination of gases was minimal. A small length of palladium wire was also welded to the anode in order to cause deposition of additional Pd on the cathode in the form of protuberances, thus hopefully enhancing local deuterium uptake (and possibly also causing fractofusion due to cracking).

The cell was operated in a constant-voltage mode, and the voltage was alternately increased and decreased. Comparison of the curve generated with the calibration curves indicated both periods of excess power generation and periods during which the output (at the same current densities) matched the calibration curve over periods of hours. Current densities at which excess power were observed were 820-1630 mA/cm^2. Excess power generally increased with current density, to a maximum of 3.6 W [approximately 25%] at the highest current density for the unannealed rod. This latter value was in excess of the 3.4 W which could be produced by the complete recombination of the gases at a rate corresponding to the current density. (Pd or Li deuteriding reactions could account for considerably less excess.) Excess power was often accompanied by fluctuations in the measured output over periods of a few hours. Integration of the excess power during one episode (1.8 W for 560 minutes and 2.3 W for 103 minutes) gave an excess energy of 74 kJ, equivalent to 67 W/cm^3 Pd; another episode gave 106 W/cm^3 Pd. No points significantly below the calibration curve were observed, thus ruling out periodic energy storage and release as an explanation.

No neutrons above background were seen with a BF_3 monitor. No significant increase in tritium levels were found in the electrolyte nor in the gas released by heating of the electrode to 1000 C for 5 minutes. In future experiments, monitoring for X-rays resulting from excitation of the Pd is also planned.

UTAH: BYU - ELECTROLYSIS NEUTRONS

John N. Harb, William G. Pitt and H. Dennis Tolley (Brigham Young U.), "Statistical Analysis of Neutron

Burst Size During Electrolysis of LiOD Solutions," *Fusion Technology* 18(4), December 1990, pp 669-677.

ABSTRACT

Experiments are conducted to examine neutron emissions associated with electrolysis of 3 M LiOD in heavy water with a palladium electrode. The data show evidence of an increase in the number of neutrons detected during heavy water electrolysis relative to light water background experiments. No anomalous heat, tritium, or helium is detected.

A rigorous statistical analysis is used to describe the distribution of both the neutron burst size and burst rate, each of which is characterized by a single parameter. The background neutron emission can be characterized by a burst size of 2 and a burst rate of 0.123 s^{-1}, although some variability is observed. Analysis establishes the statistical significance of increased neutron emission during foreground (heavy water) runs, even when background variability is taken into account. In one case, the neutron emission is characterized by large but infrequent bursts. In the other case, only the burst rate increases to 0.203 s^{-1}. Although the data are limited, the need for careful statistical analysis and the importance of experimental design are shown.

EDITOR'S COMMENTS

This paper presents a detailed statistical analysis of an experiment in order to determine the statistical significance of apparent increases in neutron burst rates and sizes during D_2O electrolysis. Results were indicated to be comparable to those of Menlove et al. (LAUR 89-1974 and LAUR 89-3633, Los Alamos National Laboratory). The need for statistical analyses is noted to be especially great in cases in which sample and background count rates cannot be measured simultaneously. It is also noted that experiments may be set up to measure either more frequent burst events, larger sizes of burst events, or both.

Electrolysis conditions in the experiment referred to are described in W.G. Pitt et al., "Observation of Neutrons During Electrolysis of LiOD Solutions," presented at the NSF/EPRI Workshop on Anomalous Effects in Deuterated Metals, Washington DC, October 16-18, 1989. A 0.5-mm-diameter Pd cathode (from Johnson Mathey, annealed at 600 C in Ar) and a Pd anode were used. Gases were recombined externally; recombination within the cell was prevented by placing a suitable ion exchange membrane between the electrodes. Electrolysis was performed at constant voltage, with a current density of 640 mA/cm^2. Two D_2O experiments totaled 177 hours, and three H_2O experiments totaled 261 hours. It was noted that degradation of the Pd used as the anode limited the lengths of the experiments. Excess heat above the detection limit of 0.1 W was not observed, although it was noted that this limit was significantly higher than that achieved in some other experiments. No tritium above background levels was found by liquid scintillation in either the electrolyte or the recombined gases.

Both neutron burst sizes and rates were estimated using the coincidence spectrometer described by Dr. Czirr at the Anomalous Nuclear Effects conference at BYU (based on proton recoil scintillations followed by neutron capture by ^6Li, as reported in the November issue of *Fusion Facts*) operated in conjunction with a neutron flux monitor (based on neutron moderation in mineral oil and capture by ^6Li). Detector efficiencies were 0.5% and 0.9%, respectively. Data from the flux monitor was collected during the 510 microseconds following signals in the spectrometer exceeding a 1-MeV threshold, thus selecting for burst events.

In one of the D_2O runs, the neutron spectrometer count rate started at the same level as that measured throughout the H_2O run, approximately 6 counts/hour, but gradually increased over 120 hours to approximately 10 counts/hour. (No comparable data was available for the other D_2O run.) In addition, the number of bursts of 2 or more neutrons detected in the flux monitor, approximately 5 ± 1 per day in the D_2O runs, was about twice that in the H_2O runs.

Statistical analyses detailed in the paper showed that the burst size distribution was in fact not statistically different during the three different H_2O runs and one of the D_2O runs, but a > 98% probability that the data from the other D_2O run arose from larger bursts, with a best fit for the burst size parameter of 5 rather than 2 being indicated. For the run in which the typical burst size appeared unchanged, the measured burst rate was 7 standard deviations above that in the H_2O runs; in a random distribution the probability of this difference being due to random chance would be less than 0.01%.

MISC: HISTORICAL ARTICLE

Arthur Fisher, "Much Ado About...," *Mosaic* 21(2), Summer 1990

This review article, in the National Science Foundation's magazine, included an outline of developments in both muon-catalyzed and present types of cold fusion. It is fascinating to note that electrolysis experiments using Pd and D_2O in attempts to catalyze nuclear fusion were reported as early as 1932, and deuterium ion bombardment experiments with Pd deuteride as early as the 1940's! The article notes the recent advances in the study of

metal hydrides, and the magnitude of the changes still being made in re-estimations of conventional fusion rates in D_2 and HD molecules by Koonin et al. (CalTech).

In the latter, predicted rates at room temperature were estimated to be 10^{-55} p-d fusions per second in HD and 3×10^{-64} d-d fusions per second in D_2 (10^8 times lower than the p-d rate); the predicted D-D rate is 10^{10} times higher than that which had been calculated previously.

E. NEWS FROM ABROAD

GERMANY - REVIEW

D. Seeliger (Tech. U. of Dresden, Germany), "Physical Problems in Studies of Nuclear Fusion of Condensed Matter," *Isotopenpraxis* 26(8), 1990, pp 384-395 (German).
Courtesy of Dr. Samuel Faile

ABSTRACT

A review with 114 references dealing with the avalanche-like increase of research activities caused by publications and observations of nuclear fusion during the infusion of D into metals. Though the original claims by M. Fleischmann et al. (1989) concerning the observation of macroscopic amounts of heat so far seem not to be proved in a quantitative manner by other groups, there are indications for the start of a new interesting field of research at the border between nuclear physics and solid state physics, investigations of nuclear fusion processes in condensed matter. First conclusions drawn here about possible mechanisms of such processes have to be considered neither complete nor final.

INDIA - THEORY

Lali Chatterjee (Jadavpur U., Calcutta, India), "Could Spectator Electrons Legalize Cold Fusion?," *Fusion Technology* 18(4), December 1990, pp 683-5.

ABSTRACT

The possibility of spectator electrons driving cold d-d fusion in condensed matter to an observation threshold is considered, along with the consequences on the branching ratio of exit channels. The dominance of the t-p channel due to the increased phase space is demonstrated.

EDITOR'S COMMENTS

Transfer of a portion of the energy of the fusion reaction to lattice electrons is suggested as a possible cause of low kinetic energy products, and it is further proposed that this could affect the branching ratio. Calculations show that the tritium/neutron branching ratio could be increased from the normal 1.11 to 1.62 if an electron is one of the final particles, but far higher values are also possible if sufficient energy is transferred to spectator species during the fusion.

ITALY - THEORY

M. Bellini, L. Casetti and M. Rosa-Clot (INFN, Italy), "Nuclear Fusion in Excited Hydrogen Molecules," *Z. Phys. A: At. Nucl.* 337(2), 1990, pp 207-210 (English).

ABSTRACT

The nuclear fusion rates are evaluated in the excited vibrational states of molecules with hydrogen isotopes. The ground state fusion rate is increased by approximately 8 orders of magnitude but even in the most favorable situation is out of any possible experimental test. The effects are discussed due to the nuclear potential in different hyperfine states with the improvements attainable using coherent states and a solid phase.

ITALY - NEUTRON SPECTROMETER

T. Bressani (U of Torino, Italy), seminar presented at the National Cold Fusion Institute, Salt Lake City UT, November 1990.

EDITOR'S COMMENTS

This seminar detailed the sophisticated time-of-flight (TOF) neutron spectrometer and cold fusion experiments presented by Dr. Iazzi at the Anomalous Nuclear Events conference at Brigham Young U. in October [*Fusion Facts*, November 1990]. The TOF instrument is capable of acquiring high resolution neutron energy spectra, and Dr. Bressani indicated that collaborative arrangements with other groups may be possible.

Fusion Facts suggests that such collaborative experiments should fit several criteria: adequate fluxes of fast neutrons, portability of the experiment, reproducibility, and small time requirements.

The spectrometer uses two layers of NE110 scintillators, one of which is divided into a 3-by-3 array of blocks and one which consists of a 5-by-5 array; each block is viewed by a separate phototube (via fiber optics). The apparatus is placed a short distance from the cell, to allow the highest energy resolution. If a neutron causes a scintillation in one block in each of the two layers, the time difference (measured to within 0.1 nanoseconds) and the difference between the locations of the scintillations

allows the velocity, and thus the kinetic energy, of the neutron to be measured. It was noted that any background counts due to thermal neutrons, relativistic particles, and gamma radiation could be eliminated on the basis of the unreasonable times between scintillations. Background count rates depended on the width of the time interval used; values cited were as low as 2/minute in the 1.5-2.5 MeV energy range, and several times lower in the 5-10 MeV range.

Preliminary data from the Ti gas-loading experiment described at the BYU conference was shown; however, count rates have so far been too low to take advantage of the high resolution possible with the instrument. It was suggested that Ti chips be selected by self radiography as was done at BARC (see reference 6, "1990 Top 10 Fusion Results" in this issue).

ITALY - EFFECT OF OXYGEN IN ELECTROLYSIS

Pier Giorgio Sona and Marco Ferrari (CISE, Milano, Italy), "The Possible Negative Influence of Dissolved O_2 in Cold Nuclear Fusion Experiments," *Fusion Technology* 18(4), December 1990, pp 678-8.

ABSTRACT

The negative influence of dissolved oxygen in cold nuclear fusion tests is discussed with regard to the formation of a LiD membrane on the surface of palladium cathodes.

EDITOR'S COMMENTS

Lithium has been observed to have a beneficial effect in Pd electrolysis experiments by A.J. Appleby et al. of Texas A&M (*Highlights of Papers Presented at the Workshop on Cold Fusion Phenomena*, Santa Fe NM, May 23-25, 1989) and by Sona et al. (*Fusion Technology* 17, 1990, p 713). The effect may be due to the formation of a LiD or $LiPdD_x$ film on the surface of the electrode. Initiation of a cold fusion reaction by Sona et al. required only 12 hours exposure of the Pd to the 2.4 M LiOD solution at zero current density, while 1-2 weeks of electrolysis are reported to be necessary in 0.1 M LiOD solutions. The diffusion of Li^+ to the cathode surface may be more important than the current density in forming this layer.

As the Li deuteride film can be consumed by dissolved oxygen (reforming LiOD), the local damage to the membrane by dissolved oxygen may interfere with the cold fusion reaction, and cause irreproducibility. It is suggested that O_2 may be more available in closed cells. Among the countermeasures suggested is the use of a suitable membrane between the anode and cathode.

ITALY/NCFI - SUPERRADIANT THEORY
(Courtesy of Dr. Preparata)

Giuliano Preparata (Dipartminto di Fisica, Universita di Milano, Italy), "Theories of 'Cold' Nuclear Fusion: A Review," presented at National Cold Fusion Institute, November 1990.

ABSTRACT

A review is presented of the main theoretical attempts to describe the phenomenology of "cold" fusion, whose general structure begins to clearly unravel. The main conclusion is that the approaches that are likely to be of relevance must invoke processes where the elementary components (nuclei and electrons) of condensed matter act in a coherent fashion.

EDITOR'S COMMENTS

Theoretical considerations presented by Dr. Preparata at the *First Annual Conference on Cold Fusion* in Salt Lake City were further developed in the papers presented at this seminar and at the *Anomalous Nuclear Effects* conference at Brigham Young U. in October 1990 (see November 1990 issue of *Fusion Facts*). As previously described, a superradiant process involving electrodynamic interactions between condensed matter (matter at densities close to those found in solids, especially a regular Pd lattice) and a quantized, coherent electromagnetic field is proposed to account for the high energies of charged particles measured following fracture of solids, and for the long periods of such fractoemission. This mechanism is also proposed to have the potential for catalyzing cold fusion by accelerating deuterons to a few tens of eV following cracking (fractofusion), or at high loadings in sufficiently regular lattices.

In the latter case, Dr. Preparata's recent calculations have suggested a fusion rate which is proportional to the extent to which the [local] loading exceeds D/Pd=1.0, and of the correct order of magnitude to explain Jones-type cold fusion rates. This explanation requires a reasonable degree of coherency among the electrons in the sample. The d + d --> t + p and d + d --> n + ^{3}He reactions are presumed to be about equally likely (in this Jones-type case), as in conventional fusion.

Under certain conditions of sufficiently long-range coherence and high [local] loading, further enhancement of the fusion rate is expected due to coherent behavior of the deuterons. The predominant d-d fusion reaction under these conditions forms ^{4}He, with the reaction energy being transferred to the lattice by electromagnetic interactions involving the electrons. The predominant side reaction forms tritium plus a proton, leading to a very low branching ratio of neutrons to tritium. Dr. Preparata

notes that since the strong nuclear force does not distinguish between particles with different electrical charge, such as the neutron and proton in deuterium, a mechanism involving an electromagnetic interaction has particular promise. Less ideal coherence results in a greater proportion of side reactions relative to the reaction forming ^{4}He, perhaps up to 1 part in 1000. For example, experiments reporting high levels of tritium may result from less efficient transfer of energy to the lattice by the electron plasma rather than higher fusion rates. In addition, a mechanism is suggested in which the energies of these particles is very low, thus leading to few secondary reactions.

The minimum volume for coherent behavior of deuterons in PdD is estimated to be on the order of 10 microns in diameter (resulting in collective behavior of at least 5 x 10^{13} deuterons), thus requiring some degree of regularity on at least this scale. A calculation of the approximate heat output possible for a D/Pd loading of 1.1 was 20 W/cm^3, again of an appropriate order of magnitude.

The application of the theory to Ti requires additional calculations, as the d electrons in Ti are less symmetrical than in Pd. The question of whether the helium can be readily lost from the electrode, and the implications of the high-temperature (molten salt) invention of Drs. Liaw and Liebert, are not yet clear. Finally, Dr. Preparata suggests that secondary reactions could account for particles with unusual energies (such as the 4-7 MeV neutrons reported by researchers such as Takahashi et al. and the up to 4 MeV tritons reported by Cecil).

Dr. Preparata discussed drawbacks in various other cold fusion theories. First, it was suggested that Coulomb barrier penetration difficulties, which represent a severe constraint on cold fusion theories, have been underestimated by other theorists. Specifically, Preparata states that the potential in the barrier-well system could not be represented by a square wave. Similarly, he states that virtual-neutron-transfer models have not demonstrated how such a transfer could occur without the deuterons having to approach unreasonably closely. Theories based primarily on enhancements of classical electron screening under equilibrium conditions, such as those of Dr. Kim (Purdue), will be limited by experimental data on the behavior of helium in Pd.

Other theories need to account not only for greatly enhanced fusion rates but also the much lower neutron/tritium branching ratio often reported. It was pointed out that the time scale, distance scale, and type of force involved in classical nuclear events are quite different from those ordinarily involved in the behavior of a lattice. Thus, such an effect on the branching ratio would not necessarily follow from increased screening or similar effects, whereas Dr. Preparata's prediction of a low n/t branching ratio has since been supported by considerable experimental evidence.

The possibility of fusion rates enhanced due to particularly narrow resonances was questioned. It was suggested that low-energy resonances would still be of widths sufficient to affect measured reaction cross-sections at higher energies. As an example, in the case of the higher-energy resonance suggested by Dr. Schwinger (UCLA) at the First Annual Conference on Cold Fusion, Dr. Preparata calculated that the width of the intermediate 0^+ ^{4}He state in this model should be on the order of 300 KeV for a typical resonance state lifetime of 10^{-20} second, thus predicting a neutron/tritium branching ratio of only 10^{-1} rather than 10^{-7-9} that has been experimentally measured.

JAPAN - YAMAGUCHI EXPERIMENT
Courtesy of Dr. Yamaguchi

Eiichi Yamaguchi and Takashi Nishioka (NTT Basic Research Laboratories, Tokyo), "Nuclear Fusion Induced by the Controlled Out-Transport of Deuterons in Palladium," *Proceedings of Anomalous Nuclear Effects in Deuterium/Solid Systems*, Brigham Young U, October 22-24, 1990.

EDITOR'S COMMENTS

This experiment was reviewed in both the July and November 1990 issues of *Fusion Facts.* The preprint, furnished by the author, of the paper presented by Dr. Yamaguchi at the BYU October conference gives further details regarding the experiments in which estimated neutron production rates of over 10^6 n/sec were reported during outgassing of gas-loaded Pd coated with manganese and oxygen to impede deuterium transport.

In the original experiments, plastic deformation and neutron emission occurred in only one of twenty samples after 3 hours of evacuation. When repeated (using the sample which gave the neutron emission), the second episode of neutron emission occurred after only 150 seconds of pumping. A third (and puzzling) episode was noted at 150 seconds into the evacuation after repressurization using N_2 rather than D_2 gas.

In the original experiment, the calculated neutron emission rate was approximately 10^5 times background, although actual detector count rates were not indicated. The counter was run from a battery to prevent spurious signals from power line noise, and no spurious spikes were observed during an additional several months of operation of the neutron detector.

Further experiments using negative current injection through the Au-coated (deuterium-impervious) side greatly improved the reproducibility of the deformation, heating, outgassing events, but at levels 10^{3-4} times lower than in the original experiment, and without neutron emission. Both D_2- and H_2-loaded samples showed the same behavior, and positive current injection had no effect.

It was suggested that deuteron kinetic energies on the order of 1 KeV could be created as a result of a coherent phase transition during outgassing of the deuteride, and that the process could be sensitive to the exact characteristics of the impeding oxide surface coating. (SEM evidence supported the hypothesis that essentially no outgassing occurred through the Au coating on the opposite side.)

JAPAN - FRACTOFUSION?

Tatsuo Izumida, Yoshihiro Ozawa, Kunio Ozawa, Shigeru Izumi, Shunsuke Uchida, Tomohiko Miyamoto, Hisao Yamashita and Hiroshi Miyadera (Hitachi Ltd.), "A Search for Neutron Emission from Cold Nuclear Fusion in a Titanium-Deuterium System," *Fusion Technology* 18(4), December 1990, pp 641-6.

ABSTRACT

Experiments on cold nuclear fusion are performed on titanium deuteride (TiD_2) crystal warmed from liquid nitrogen temperature to room temperature. Fusion with an estimated thermal energy output much smaller than the expected level (10^{12} to 10^{13} fusion/s/g) is confirmed by neutron burst emission, but without excess heat production.

By analyzing the temperature dependence of the neutron emission in the titanium-deuterium system, it is concluded that so-called cold nuclear fusion may actually be hot-spot fusion caused by a localized high voltage generated, along with fracture formation, in the TiD_2 by lattice strain.

EDITOR'S COMMENTS

In this Frascati-type experiment, 48-gram samples of spongy Ti metal were D_2-loaded to a composition near TiD_2 in 20-50 atmospheres of D_2 gas at elevated temperature (to increase the rate of uptake). The samples were then repeatedly cooled to 77 K and allowed to warm to room temperature over a period of a few hours. (After several cycles, the Ti deuteride became powder.)

Neutron emission was measured in 5-minute intervals, using several ^{3}He counters (efficiency 0.5%, background 1.7×10^{-2} counts/second) and a BF_3 counter (efficiency 0.02%, background 2.8×10^{-4} counts/second) with water and polyethylene as moderators. Background counts closely matched the expected Poisson distribution and did not exceed 3 standard deviations above the indicated values over a 120-hour period, while counts above this level were observed during sample warming in at least 10 of 36 trials (6 temperature cycles each for 6 samples). For example, one sample showed 15-35 counts per 5-min. interval with the ^{3}He counter during 4 successive intervals while the sample was at about 220-250 K, compared with 0-7 counts per interval during the remainder of the 2-hour period. From the neutron measurements, fusion rates up to approximately 10^{-23}/second/d-d pair were calculated. Other samples also showed emission strongly concentrated near 243 K (with 8 episodes between 220 and 270 K, 2 at 150-170 K, and none at other temperatures).

Based on the temperature dependence, a fractofusion mechanism was proposed, with conventional d-d fusion resulting when deuterons are accelerated to energies greater than 10 KeV by electrical fields created as a result of fracture formation. It was noted that emission of accelerated D^+ ions from fractured TiD_2 has previously been reported by J.T. Dickinson et al. ["Fracto-Emission from Deuterated Titanium: Supporting Evidence for a Fracto-Fusion Mechanism," *J. Mat. Res.* 5, 1989, p 109], and that voltages of over 100 kV have been reported during fracture of LiD by V.A. Klyuev [*Sov. Tech. Phys. Lett.* 12, 1987, p 551].

A figure shows the strain rates expected along different crystal axes during the warming of gamma Ti deuteride, showing a peak in the extension rate along the c-axis direction at about 150 K and a maximum in the compression rate along the a- and b-axes at about 220 K. Thus, both periods of neutron emission corresponded to periods during which high strain rates, and thus a higher probability of fracturing, would be expected.

JAPAN - NATTOH THEORY

T. Matsumoto (Hokkaido U, Sapporo), "Prediction of New Particle Emission on Cold Fusion", *Fusion Technology* 18(4), December 1990, pp 647-651.

ABSTRACT

The energy distribution of cold fusion products is analyzed based on the Nattoh model. A new hydrogen-catalyzed fusion reaction is proposed to occur in a metal. From the differences in the Q value and other parameters, a new particle, the "iton," is predicted to be emitted, with a rest mass 2 to 26 times that of an electron.

EDITOR'S COMMENTS

Calculations were performed to explain the proton energy distribution in the charged-particle/electrolysis experiments by Taniguchi et al. (*Jpn. J. Applied Phys.* 28, 1989, p L2021; reported in the January 1990 issue of *Fusion Facts*), which was more complex than that expected from the classical 2-body d-d fusion reaction (expected initial energy 3.04 MeV). In the Nattoh model, 3 or more deuterons participate in a reaction in which two form ^{4}He. For example, if 3 deuterons are involved, conservation of momentum should result in the kinetic energy of the ^{4}He nucleus being 1/3 of the energy release for the reaction, while the remaining deuteron would carry off 2/3 of the energy. Assuming that the fusion occurs predominantly at the foil surface, it is suggested that multibody reactions with up to 6 deuterons do not give the observed spectrum unless energy yields of only a few MeV, rather than 23.85 MeV for d+d-->^{4}He, are assumed. It is on this basis that the mass of the additional "iton" particle is proposed.

(Previous versions of this model have been described by Dr. Matsumoto in *Fusion Technology* in December 1989, May 1990 and September 1990; the latest version of the theory was also presented at the Anomalous Nuclear Effects conference at Brigham Young U. in October.)

JAPAN - INTERVIEW
Courtesy Marge Hecht

"Cold Fusion Proceeding 'Calmly' in Japan, *21st Century Science and Technology* 3(3), Summer 1990, pp 22-3 and 58.

EDITOR'S COMMENTS

In the March 3, 1990 interview reported in this article, Dr. Nobuyuki Inoue (U of Tokyo) indicated that at that time there were over 30 research teams at universities in Japan investigating cold fusion, with some government funding, as well as teams at private companies. [Other sources have estimated the number of groups to be considerably larger. Ed] The major research lines were listed as electrolytic cells, high-pressure D_2 gas loading, low-energy D-D cross-section measurements, and discharge between Pd electrodes in D_2 gas [i.e. presumably experiments similar to those of Wada]. Theoretical work was also being performed by researchers including Prof. Satsuo Ichimaru of the U. of Tokyo (screening) and Dr. Tatsuoki Takeda of the Japan Atomic Research Institute (fractofusion).

It was indicated that most experiments involved detection of neutrons rather than tritium or heat. However, the charged particle experiments of Taniguchi et al. (Osaka U) were noted in which protons were detected from 6 D_2O experiments (of 31 D_2O and H_2O experiments).
This experiment [*Fusion Facts*, December 1989] used a 12.5 micron thick Pd foil cathode as the bottom of the cell, thus giving a detection efficiency 10 times higher than typical neutron detection efficiencies, and a signal-to-noise ratio 100 times better. (An upcoming neutron detection experiment at the Kamioka underground laboratory was also mentioned involving Dr. Jones of Brigham Young U, the Institute of Cosmic Ray Research, and the U of Tokyo.)

Dr. Inoue noted the difficulties encountered with reproducibility, leading to careful and high-sensitivity experiments with many negative results, but he also stated that it is also equally difficult to deny the results of positive experiments. Proof of cold fusion, Dr. Inoue stated, would be a tremendously important discovery, even though he questioned the possibility of using cold fusion as a commercial power source. [The latter conclusion, and the predominance of neutron measurements, may be due to doubts of the high tritium/neutron branching ratios reported in experiments in other countries. Ed.]

POLAND - THEORY

Wladyslaw Zakowicz (Polish Academy of Sciences, Warsaw), "Possible Resonant Mechanism of Cold Fusion," *Fusion Technology*, 19(1), January 1991, pp 170-3.

ABSTRACT

A hypothesis of resonant deuteron-deuteron interaction under cold fusion conditions is discussed. The resonance may exist due to a combination of an attractive nuclear interaction at close distances and a repulsive Coulomb potential at large distances. The energy of such resonances may be very low. This effect may increase the reaction rates in high-density deuteron hydrides.

EDITOR'S COMMENTS

This paper investigates the possibility of resonant enhancement of d-d fusion rates at extremely low energy matching that of deuteron kinetic energies in cold fusion experiments. Unfortunately, since resonance energies are measured from the bottom of the nuclear potential well and are thus in the MeV range, a match to within eV of deuteron thermal energies would be most fortuitous.

Slightly more recent results were also presented at the BYU conference [W. Zakowicz and J. Rafelski, "Low Energy Nuclear Resonance and Cold Fusion," *Proceedings of Anomalous Nuclear Effects in Deuterium/Solid Systems,*

Brigham Young University, October 22-24, 1990, reported in *Fusion Facts* November 1990].

SPAIN - SAMPLE CHARACTERIZATION

Joaquin Sevilla, Francisco Fernandez, Beatriz Escarpizo and Carlos Sanchez, "Some Characteristics of Titanium and Palladium Samples Used in Cold Fusion Experiments," *Fusion Technology* 19(1), January 1991, pp 188-191.

ABSTRACT

Most recent papers on cold fusion have been devoted to experimental procedures and the results of nuclear product detection efforts. There is a lack of data on the state of the sample after the experiments. These data may shed some light on the process that leads to nuclear reactions. An attempt is made to relate the composition and surface morphology of deuterides to the observed anomalous nuclear events.

EDITOR'S COMMENTS

Average deuterium loading was measured by thermal desorption (TD), measurement of gas release during heating; and information on local loading was inferred by differential scanning calorimetry (DSC), calorimetric measurements during heating. With titanium, deuterium diffusion is not as rapid as in palladium; significant desorption of gamma Ti deuteride (D/Ti ratio near 2) did not begin (DSC data) until a temperature of about 400 C.

In gas-loaded Ti samples, the only peaks seen in X-ray diffractometry corresponded to the gamma phase. DSC data showed a peak corresponding to the alpha+gamma to alpha+beta phase transition, showing the sample was only fully deuterated near the surface. This was confirmed by the TD data, which showed an average D/Ti ratio of 0.01 for the whole sample. If a simplifying assumption is made that the interior of the sample contained no deuterium, the TD data would correspond to a surface TiD_2 layer with a thickness of 5-15 microns.

Scanning electron microscope photographs were also presented of the surfaces of Ti cathodes after electrolysis experiments. These showed the presence of larger craters on cathodes which had produced excess tritium and/or neutrons than on cathodes from unsuccessful experiments (1-15 micron versus 1-3 micron diameters).

SWEDEN - CALORIMETRY
(Courtesy of Samuel Faile)

Derek Lewis and Kurt Skold (Studsvik Energy and Uppsala U.), "A Phenomenological Study of the Fleischmann-Pons Effect," *J. Electroanal. Chem.* 294, 1990, pp 275-288.

ABSTRACT

This paper reports experiments similar to the initial work by Fleischmann and Pons, on electrochemically induced nuclear fusion of deuterium. The experiments have been concerned with measurements of heat evolution and of neutron radiation in and around a cell in which mixtures of deuterium oxide and tritium oxide have been electrolyzed using cathodes of palladium. The heat measurements have been made by flow calorimetry. For comparison, analogous measurements have also been made of the heat evolution occurring in similar cells in which common water has been electrolyzed under essentially the same conditions. LiOH has been used as electrolyte in all these experiments. The cathodes were made from the bulk metal in a hard-worked condition or after careful annealing to remove structural defects and occluded hydrogen. The data obtained from one experiment with a cathode made of 99.95% palladium, 3.0 x 3.5 x 55 mm, annealed at 900 C are consistent with the generation of an excess energy of about 1 W during a 30 h period of electrolysis of deuterium oxide at a current density of 84 mA/cm^2. Sporadic flares in the count rates indicated by the neutron detector were observed in this experiment. These flares corresponded to emission of neutrons from the cell, in brief pulses leading to counts in 15 min intervals from 2 to 8 times (5 to 40 sigma) higher than background. Some of the pulses have been shown to have extraneous causes. In the congruent experiments on the electrolysis of common water a heat balance was found that is satisfactory in terms of current theory, i.e., with no excess enthalpy. Two further experiments were made, at current densities of 104 and 115 mA/cm^2 respectively, the first of them with a cathode made of cold-worked palladium and the other with one made of palladium annealed at 800 C. Upward thermal ramps were observed in both of them. These thermal ramps occurred when deuterium oxide was added to the cells to make up the electrolyte to its initial volume. Because of an error in the temperature measurements, these experiments must be taken to be inconclusive as regards the magnitude of the enthalpy excess. It is concluded that the data from these experiments in part supports the views advanced by Fleischmann and Pons, regarding anomalies arising in the electrolysis of deuterium oxide at palladium cathodes. It has not been possible to establish any consistent and reproducible pattern in the observations of excess enthalpy and neutron emission. The thermal and the radiation

phenomena observed in this work are at a level very close to the limits of resolution of the apparatus used.

EDITOR'S COMMENTS

The positive result described involved D_2O electrolysis using a rectangular 6.35 g cathode, annealed in Ar, and a Pt anode, with gases recombined externally. The excess heat was an average of 1.0 W above the Joule heat of 1.37 W, and fluctuated between 0.2 and 2.0 W. This excess began within the first hour, lasted 21 hours, and ceased within a half-hour period. This phenomenon was repeated during the remaining 8 hours of the experiment. In contrast, control experiments involving electrolysis of H_2O at Pd gave a measured output of 1.59 W and a calculated Joule heating of 1.64 W.

The neutron detector used consisted of 30 ^{3}He counters (estimated efficiency 8%). Owing to the surface location, the background count rates were quite high and varied over tens of hours between approximately 160 and 230 counts per 15-minute interval. As noted, spurious spikes were also noted during background measurements, and rates during the experiment showed limited correlation with the calorimetric data. Thus, the spikes of up to 2333 counts per 15 minutes could also have been spurious. The final tritium content was consistent with only electrolytic enrichment.

YUGOSLAVIA - NEGATIVE REPORT

Radomir Ilic, Joze Rant, Tomaz Sutej, Mirko Dobersek, Edvard Kristof, Jure Skvarc and Matjaz Kozelj (J. Stefan Institute, E. Kardelj U., Ljubljana, Yugoslavia), "Investigations of the Deuterium-Deuterium Fusion Reaction in Cast, Annealed, and Cold-Rolled Palladium," *Fusion Technology* 18(3), November 1990, pp 505-511.

ABSTRACT

A search was conducted for neutrons, protons, tritons, ^{3}He ions, gamma rays, and ion-induced X rays from deuterium-deuterium (D-D) fusion in cast (36-g), annealed (4-g), and cold-rolled (16-g) palladium specimens and a palladium hydrogen thermal valve (11 g) electrochemically charged with deuterium. The palladium cathodes were charged in an electrolytic cell [0.1 M LiOD, 99.8% deuterium, Pt anode] at a current density of 25 mA/cm^2 from 20 to 140 h. One unique aspect of the experiment was the radiation detection system, consisting of a CR-39 track-etch detector, bare for proton detection (sensitivity limit 4.8 x 10^{-2} fusion/s), combined with a polyethylene fast neutron radiator (0.95 fusion/s), a boron thermal neutron radiator (26 fusion/s), a BD-100 bubble damage polymer detector (5.2 fusion/s), an array of six ^{3}He proportional counters (126 fusions/s), a CaF_2 thermoluminescent dosimeter (11.4 fusion/s), and a germanium semiconductor spectrometer (17 fusions/s). The D-D fusion rate in cast, annealed, and cold-rolled palladium is < 3 x 10^{-22}, < 7.8 x 10^{-21}, and < 1.2 x 10^{-21} (D-Dn) fusion/D-D pair/s, respectively. In the palladium hydrogen thermal valve, this value was < 1.1 x 10^{-22} (D-Dp) fusion/D-D pair/s and < 2.3 x 10^{-22} (D-Dn) fusion/DD pair/s.

EDITOR'S COMMENTS

Although this experiment was negative, it does give an interesting comparison of sensitivities attainable with an wide variety of detectors. The experimenters are to be commended for investigating several types of palladium alloys. Features which may have prevented success are the lower-than-usual current density (25 mA/cm^2) combined with short loading time (a few days), and high background (above ground). The most important factor may have been the experimental geometry. A companion article [Joze Rant et al., *Kerntechnik* 55(3), 1990, pp 165-7] mentions detectors in physical contact with the Pd, but the diagrams shown in the present paper indicate that the detectors were separated from the electrode by several centimeters of D_2O. The ranges of charged particles under such conditions are far shorter. By comparison, Taniguchi et al. [*Japanese Journal of Applied Physics* v 28 pp L2021-3, reported in the January 1990 issue of *Fusion Facts*] described a design in which a foil cathode was used as the bottom of the electrolysis cell, allowing a charged particle detector to be placed immediately below it.

F. SHORT ARTICLES

TRITIUM PRIMER
by Michael Dehn, Associate Editor

Introduction

Tritium, ^{3}H, is the heaviest hydrogen isotope. It is often designated as T (tritium atom) or t (triton nucleus or ion). Tritium is radioactive, with a half-life of 12.4 years, undergoing beta decay (conversion of a neutron to a proton plus an electron), to form ^{3}He. The beta radiation is unusually low-energy, with an energy distribution between 0 and a maximum of 18 KeV. The range of the tritium betas is a fraction of a millimeter except in gas or vacuum. Since most of the beta radiation from tritium decay is stopped by a few sheets of paper, this radiation is not a health hazard if the tritium is not taken internally. [The same is true of battery acid and leaded gasoline.] The beta radiation can excite the emission of X-rays from other atoms, but with low energies and short ranges.

In conventional deuterium fusion, tritium is produced by the reaction d + d --> t + p (Q=4.0 MeV). Some cold fusion experiments have reported tritium (^{3}H) production, although the amounts vary widely. Most T measurements have involved electrolysis experiments, but tritium production has been reported in gas-loading, ion implantation and plasma focus experiments [1,2], and the gas/solid system of Claytor [3].

Tritium levels are normally expressed in disintegrations per minute (dpm), or disintegrations per minute per milliliter (dpm/ml). Data in counts per minute, cpm, can be converted to dpm if the efficiency (generally several tens of percent for liquid scintillation) is known. Dpm/ml values can of course also be converted to total tritium content if the total volume is known. In the case of extremely high tritium levels, values may also be given in Becquerels, abbreviated as Bq, or fractions of a Curie, abbreviated as Ci. One Bq is 1 disintegration per second (1 Bq = 60 dpm), and one Ci is 3.7×10^{10} disintegrations per second.

From the half-life, the number of tritium atoms which give rise to a decay rate of 1 dpm is 9.4×10^6 (approximately 10 million). To generate 1 milliwatt of energy by conventional D + D --> T + P fusion would require the generation of 1.55×10^9 tritium atoms (sufficient to give rise to a decay rate of 166 dpm) per second.

INITIAL TRITIUM LEVELS

Concentrations of naturally-occurring tritium are extremely small (even if possible tritium production by geological cold fusion is taken into account). Nevertheless, tritium has become pervasive during the nuclear age, occurring in trace quantities in all hydrogen- and deuterium-containing compounds unless they have remained isolated since 1945. Thus separation of deuterium from ordinary hydrogen will concentrate tritium.

For example, the tritium content of commercial D_2O is typically 100-150 dpm/ml; the relative tritium content in D_2 gas may be higher (depending on the method of production). Obviously, low initial levels are desirable if tritium production is to be measured. Furthermore, the tritium content may vary widely among different sources, with some levels well over an order of magnitude higher. Considerable variations can occur among different batches from the same source, making analyses of each batch used desirable. One reason for high tritium levels from some sources is that the source of deuterium gas or heavy water could be derived from the nuclear fission industry.

Tritium contamination of metals such as Pd must also be considered. A controversial report [4] has indicated tritium contamination in 4 of 20 electrodes prepared from one batch of Pd, but in a form which was not released from the electrode until after weeks of electrolysis. Other studies have found no contamination [5], and have questioned the possibility of such lasting contamination [6]. Some experimenters have eliminated the possibility of undetected spot contamination by using Pd prepared from a single batch of extremely fine powder [7]. Other experimenters save a sample of their original Pd rod for later analysis in the event that increased levels of tritium are measured during electrolysis.

Finally, tritium contamination from other sources is possible. For example, tritium can be formed from ^{6}Li in lithium-containing reagents if these are exposed to large numbers of neutrons.

The danger of inadvertent tritium contamination is obviously less in experiments conducted at sites in which experiments using tritium have not previously been conducted. However, previous experience in working with tritium analyses (such as the extensive experience of the personnel at Los Alamos and BARC in India) can increase outside confidence in a group's tritium analyses.

TRITIUM BEHAVIOR DURING ELECTROLYSIS

In electrolysis of heavy water (D_2O), D_2 and O_2 gases are formed at the electrodes. The heavier tritium will be concentrated in the electrolyte during this process. Hydrogen, deuterium and tritium behave the same chemically, being isotopes of the same element, however, small differences in reaction rates exist because of the differences in mass.

During prolonged electrolysis, this chemical effect can gradually increase the tritium concentration in the electrolyte. The maximum increase, when nearly all of the solution has been electrolyzed, will be by a factor equal to the gas/liquid separation factor. This factor, and the extent of the enrichment, will depend on the characteristics of the electrode surface. A different separation factor will apply for D_2 evolution on different alloys, and the factor can also be influenced by impurities in the electrode, by the current density, and by the temperature. Separation factors of approximately 2 are reported most often for electrolysis using Pd cathodes in basic solutions. Separation effects cannot, however, increase the total amount of tritium in the liquid plus gas plus electrode, and cannot account for increases in the tritium content of the electrolyte greater than a few-fold.

A second factor which complicates analysis is the partitioning of tritium between T in the electrode, DTO (or T_2O) in the electrolyte and DT (or T_2) in the gas. Tritium in any one of these phases will undergo exchange with the other phases, leading to the appearance of tritium in all phases. Thus tritium levels in the

electrolyte can increase if tritium is suddenly released from the cathode, but then gradually decrease as exchange transfers part of this tritium to the gas phase. Decreased T may result from dilution by added electrolyte introduced during the experiment. Sudden increases in tritium concentration followed by gradual decreases to intermediate values have been reported in various experiments [for example, 7].

The phase into which tritium is first released from the cathode can also depend on its location and the electrolysis conditions. For example, a study has reported that most of the tritium within a Pd electrode normally first appears in the gas phase when the Pd is the cathode, whereas a much greater fraction first appears in the electrolyte if it is initially present on the cathode surface [9]. Thus, such information on the initial form of the tritium may also be of interest in attempting to determine the tritium source.

A third complication arises from the possibility of sudden releases of tritium within the cathode due to deformation of the electrode, either through cracks or carried along by movement of defects in the crystals [10]. Because of this factor, cyclic variations in the degree of deuterium loading or increases in the rate of deformation of the electrode may be able to cause abrupt increases in the tritium content of the electrolyte even if tritium is produced at a steady rate.

Many experiments have measured only the tritium content of the electrolyte. However, to accurately assess the increase in total tritium in a cell, it would be necessary to consider tritium in all three phases. For example, in a cell in which the D_2 and O_2 are recombined to D_2O externally by a catalyst, this liquid can be collected and analyzed separately or as combined with the electrolyte. One way to measure tritium remaining within the cathode, after an experiment, is to temporarily run this electrode as the anode, in order to flush the deuterium and tritium into the electrolyte. (For the U. of Hawaii molten salt design, in which it is the anode which is loaded with deuterium, tritium could be flushed from this electrode afterwards by running it as the cathode.)

Tritium balance calculations in an open cell need to take into account additional tritium introduced if the electrolyte lost during the experiment (by sampling, evaporation and electrolysis) is periodically replenished with additional D_2O.

TRITIUM ANALYSIS BY LIQUID SCINTILLATION

In liquid scintillation, a liquid sample is added to a "scintillation cocktail" composed of a compound which emits light when struck by appropriate types of radiation. The light signal is then measured by a photomultiplier.

Most tritium measurements in cold fusion experiments have involved liquid scintillation counting of the beta radiation (energetic electrons) emitted by tritium decay, generally by procedures similar to those used for tritium measurements in other applications (such as tracer studies in biochemistry). Certain factors must, however, be considered in order to avoid errors.

First, even trace amounts of certain impurities can give rise to spurious counts and thus lead to possible gross overestimation of the tritium content. Such chemical interference, for example, can arise from Li concentrations over a few tenths of a mole/liter [11]. Even part-per-million levels of certain other metals such as Pt have also been reported to give rise to false counts of up to thousands of dpm/ml [5]. Such count rates will be highest when the solution is first mixed with the scintillation compound, and gradually decrease with time; thus counting may be repeated after the sample has been kept for, say, 24 hours in the dark if such a chemiluminescence effect is suspected. A repeat analysis of the solution after it has been purified by distillation is also occasionally used to confirm measurements, although some tritium can be lost during this process. Solutions may also be centrifuged in order to prevent effects from any particulate material.

Second, other constituents in the solution can cause underestimation of the tritium content if not controlled. Both dark solutions and chemical "quenching" effects due to other compounds in the solution can give rise to unusually low counting efficiencies, and thus lower count rates. For example, in the case of some scintillation compounds, especially low or high pH can have such an effect, requiring either neutralization of the LiOD in the solution or calibration at the same pH. Chemical quench can also result in a compression of the beta energy spectrum (i.e. the measured spectrum no longer spans the entire 0-18 KeV energy range of the tritium betas).

TRITIUM ANALYSIS BY OTHER METHODS

In addition to liquid scintillation, a variety of other tritium analysis methods are used, either in place of or as confirmation of the liquid scintillation method. Note that the use of such methods for measuring tritium within solid samples such as Ti chips used in gas-loading experiments may be limited by the short range of the tritium betas; thus different methods can measure tritium to different depths in the sample.

First, in charged particle experiments, energetic tritium nuclei are detected as they are formed [12]. This method avoids the loss in sensitivity involved in measuring the tritium decay, and also allows the level of tritium production to be continuously monitored in the same way

as in neutron measurements. Since the range of charged particles in matter is extremely short, such detection is not possible in most cold fusion experiments.

Second, tritium in gases can also be measured with gas-flow proportional counters or scintillators [2].

Third, sufficiently high tritium levels can also be measured indirectly by the detection of secondary radiation when other atoms are excited by the tritium betas. For example, soft X-rays of frequencies characteristic of the metal used (for example, 4.6 KeV for Ti K X-rays) can be measured using various types of detectors, such as NaI or high-purity Ge detectors, although the number of X-rays excited per tritium beta is only on the order of 10^{-4} [2].

Fourth, in autoradiography, X-ray or similar film is placed in contact with the sample for long periods of time in order to detect the decay of tritium remaining in the metal after the experiment. Both the beta radiation and secondary X-rays excited by the betas can fog the film. This method can also detect localization of the tritium. Such a method was used to demonstrate tritium production in 4 of 1000 Ti deuteride chips cycled between liquid nitrogen and room temperatures [2]. It should be noted that localization of tritium within a sample can also occur after the tritium has been produced, since tritium may concentrate at defects in the metal lattice.

Fifth, tritium in gases released from samples is occasionally measured by mass spectrometry [13]. Unfortunately, a mass resolution close to 1 part in 1000 would be necessary to unambiguously distinguish tritium-containing compounds. For example, measurement of a mass-5 peak in D_2 gas could indicate the presence of DT^+ ions, but such a peak could also be due to formation of D_2H^+ in the mass spectrometer. Formation of such ions through reactions with traces of hydrogen in the instrument is pressure-dependent; thus changes in the ratios of different mass peaks can occur even if the sample composition remains the same, making conclusions based on changes in the unit-mass peaks unreliable.

In some cases, confirmation of tritium contents has been performed by outside laboratories. Confirmation that counts are from tritium may be obtained by comparison of the shape and 18-KeV end point of the beta energy spectrum with that of tritium. Occasionally, tests are run in which tritium contamination is deliberately introduced in order to monitor its behavior (or to test whether pre-existing tritium can promote the cold fusion process).

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HELIUM AS COLD FUSION PROMOTER

By Talbot A. Chubb & Scott R. Chubb

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There has been a further development in the band state theory of cold fusion. The new addition explains heat release without generation of high energy particles. The addition to the theory also explains why Johnson-Matthey Pd cathodes have been more effective in producing cold fusion than cathodes using material from other suppliers.

The new picture is that the most active form of palladium deuteride contains two very low concentration band state systems instead of one, namely, a deuterium band state population and a helium band state population. The original picture assumed band state deuterons only. Both band state populations are delocalized forms of matter uniformly distributed within a region of crystalline lattice order. A nuclear energy release of 23.8 MeV occurs when the deuterium band state population loses 2 deuterium ions and the helium band state population gains one helium ion. The nuclear energy made available is distributed among all ions of both band state populations. As a result, in sufficiently large crystallites energy and momentum are conserved without generation of any high energy particles.

The above cold fusion process is a reasonable interpretation of the nature of matter as provided by quantum mechanics. Quantum mechanics says that particles are objects distributed in space. Such particles can react either locally, i.e. within a small volume, as occurs during Compton scattering, or in a delocalized manner, as occurs in Bragg scattering. In Bragg scattering a delocalized particle within a crystal interacts with multiple layers of atoms over a substantial volume. It reflects from the crystal if the particle wavelength and incident angle match the symmetry of the crystal lattice. The Bragg reflection interaction seems different from the cold fusion interaction in part because the reflected Bragg particle is a traveling wave whereas cold fusion is concerned with matter in the form of standing waves.

It was pointed out at the First Annual Cold Fusion Conference in Salt Lake City that cathodes fabricated from Johnson-Matthey palladium had a higher success record in production of anomalous heat during deuterium electrolysis than cathodes made from palladium from other sources. It was also pointed out by Dr. Nate Hoffman that the one unused Johnson-Matthey cathode tested had unexpectedly high values of internal helium. This "as-received" cathode had never been used in electrolysis and was saved to serve as a control for comparison against used cathodes. It was also stated that Johnson-Matthey palladium, which was obtained from England, has been processed in helium. If some of this helium were in a helium band state, it could share in the energy release accompanying cold fusion events, facilitating heat release via the delocalized interaction mode.

The formation of a helium ion band state seems to be favored by the same free energy minimization requirement that governs the formation of band state deuterium. Band state formation avoids endothermic lattice strain and additional zero point motion terms that accompany the formation of a chemical interstitial unit cell occupation. In palladium the host lattice for cold fusion is PdD rather than Pd metal. The free energy conditions favoring band state formation occur only when the concentration of ions available for occupying the octahedral sites of Pd unit cells is only slightly in excess of unity. (The required concentration may be slightly less at elevated temperature, where some vacancies in the PdD lattice always exist.)

The conversion of 2 band state deuterons into a band state helium does not immediately heat the crystal lattice. The nuclear energy release raises the energy of each ion in the two band state systems, which must subsequently transfer heat to the lattice for heat to be observed. The transfer of energy from the band state populations to the lattice probably occurs at crystal surfaces or other locations where crystal symmetry is violated. The time scale for this energy transfer is unknown. In any case

energy release reactions are possible as long as both band state populations exist in the crystal.

Admittedly, the concept of delocalized matter sounds weird. However, it is no more weird than superconductivity and superfluidity, where common motion is shared by large numbers of particles in delocalized collective states. Another difficulty is the concept of nuclear reaction between widely spread out nuclei. Here the problem goes to the core of quantum mechanics. Nuclear reaction occurs because of the wave-particle duality of matter. The delocalized description of the D^+ band state is the wave-like description. The particlelike description, which is equally valid, describes the band state populations as a sequence of transient whole number occupations of each unit cell of the crystal. When two D^+ ions occupy the same unit cell, they overlap, and fluctuations between chemical and nuclear density occur. These fluctuations make the nuclear energy available. When this energy becomes shared, the nuclear reaction becomes irreversible. There is also the bothersome question: If ionic band states can exist in metals, why haven't they been previously observed? A probable explanation is that the concentration of band state ions is probably always very low. At large concentrations, chemical forms of matter become thermodynamically favored. In the cold fusion case the band state D^+ concentrations may be as small as 10^{-7} ions per unit cell, so that the macroscopic properties of host crystals are almost unaffected. It is only because the fusion reaction liberates such a large amount of energy that the presence of band state deuterons becomes reasonably observable.

EDITOR'S COMMENTS

The authors have offered the above short article to introduce some of the aspects of their theory to the general reader. Some of the statements are made without reference to a more formal presentation. For example, "Nuclear reaction occurs because of the wave-particle duality of matter." is not a satisfying explanation of nuclear reactions in a metal lattice. We hope this type of short presentations will stimulate the reader to increase his/her knowledge in an intelligent search for truth. For some mathematical descriptions and further information on their developing theory see the following references:

[1] T.A. Chubb (NRL) and S.R. Chubb (Bendix), "Nuclear Fusion in a Solid via a Bose Bloch Condensate", *NRL Memorandum Report 6617*, Naval Research Laboratory, Wash D.C. 20375-5000, March 5, 1990.

[2] Scott R. Chubb and Talbot A. Chubb, "Quantum Mechanics of 'Cold' and 'Not-so-cold' Fusion", *The First Annual Conference on Cold Fusion, Conference Proceedings*, March 28-31, 1990, University Park Hotel, Salt Lake City, Ut., published by NCFI, pp 119-129, 8 ref.

[3] S.R. Chubb & T.A. Chubb (Research Systems, Inc.), "Lattice Induced Nuclear Chemistry", *Proceeding of Anomalous Nuclear Effects in Deuterium/Solid Systems,* [in press], Brigham Young University, October 22-24, 1990. [See also review in *Fusion Facts*, Vol 2 No 5, Nov 1990, pp 30-32.]

COLD FUSION RESEARCH DIRECTION
by Hal Fox

LOOKING FOR NEUTRONS

Since Jones and Rafelski [1] discussed the possibility of nuclear reactions in metals and Fleischmann and Pons [2] reported on the possible excess energy from a palladium, lithium, deuterium system, cold fusion has been sought by looking for neutrons. The reasons were simple:

1. There are a lot of laboratories and attending scientists with the equipment and experience to search for neutrons.

2. It is well known in thermo-nuclear physics, alias hot fusion, that deuterium fusion produces neutrons with about an equal probability of producing tritium -- the well-known deuterium fusion branching ratio. (Now shown not to hold in the low energy environment of typical cold fusion.)

3. Therefore, if the Jones-Rafelski-type cold fusion exists and/or if the Fleischmann-Pons type of cold fusion exists, **neutrons must be present and measurable**. (This statement was firmly believed by early workers but has now been shown to be a false assumption in the Fleischmann-Pons electrochemical cell environment.)

Soon after the Fleischmann-Pons paper had been submitted for peer review (March 13, 1989 [2]), the dramatic news was too good to keep and copies of the paper (presumably from copies sent to peers for review) began to proliferate around the world by photocopies and faxes. The University of Utah elected to call a press conference and the media proclaimed "cold fusion in a bottle". (The news conference was held March 23, 1989.)

Dozens of laboratories in various parts of the world, some spurred by science and some by fear that "hot fusion" was threatened, began to attempt to replicate the F-P Effect. Within three weeks, Texas A&M scientist had positive results; ten groups in India had replicated excess heat and produced neutrons and tritium; and **many others failed to measure neutrons.**
By late May 1989, interested scientists at Los Alamos National Laboratory sponsored and held the first cold

fusion conference [3]. Some Japanese scientists announced negative results but came to the conference with open minds. By July 31, 1989 ten groups in Japan had produced positive results. On August 1, 1990 Japanese scientists announced the formation of a number of groups that would be working on cold fusion. That initial group reportedly numbers over ninety experimental groups in Japanese colleges and universities.

In December 1989 a group of papers published by BARC in India became available. In addition, a special cold fusion session was held in conjunction with the 1989 Winter Conference of the ASME at which several positive papers were presented and some good theory work was reported. By this month, December 1989, strong evidence had been accumulated to show that tritium production in cold fusion reactions was 1,000 to 100,000,000 times more probable than neutron production. [This scientific finding was difficult for the hot fusion nuclear physicists to accept because it meant that **there was new science involved in cold fusion.]** By this time, Bockris [4], Appleby [5], Wolf [6], Schoessow [7], Huggins [8] (all in the U.S.), Noninski [9] in Bulgaria, Scaramuzzi and others [10] in Italy, many in India, and many in Japan, had achieved positive results [11]. **In view of these many experimental facts, it should have been widely accepted that cold fusion need not produce abundant numbers of neutrons.**

FURTHER EXPERIMENTAL EVIDENCE

Near this time, Lewis et al. (Cal Tech) [12]; Albagli et al. (MIT) [13]; and Weismann, et al. (Brookhaven) [14] had all reported negative results. It was later shown by Noninski [15] that all three of these groups had measured excess heat similar to Fleischmann and Pons but either ignored or did not recognize the meaning of their measurements. Also in this time period Morrison (CERN) [16] and many others began a well-funded and well-orchestrated program to destroy the credibility of cold fusion. By studiously ignoring strong positive evidence, the DoE Cold Fusion Panel was able to recommend no additional funding for cold fusion. Some panel members when shown excess heat cited poor calorimetry; when shown tritium cited contamination; when shown neutrons said it had to be background radiation. This negative stand was adopted by panel members who were much less skilled in these areas than the scientists who were being criticized. One reasonable panel member threatened to resign if the unfair report was not made more realistic. Unfortunately, the report from this panel established the current DoE energy policy. **(It is possible that if Secretary Watkins, Chief of Staff Sununu, and President Bush knew the truth about the remarkable developments in cold fusion, that our armies may not be sweating in the sands of Saudi Arabia.)**

By the time of the First Annual Cold Fusion Conference (March 1990), the accumulation of positive evidence [11] was significant in the following areas:

1. Tritium is produced far more often than neutrons in cold fusion reactions.

2. The total amounts of tritium and neutrons produced could not explain the amount of excess heat measured. (This means that nuclear reactions which produce neither tritium nor neutrons are responsible for the most of the excess heat.)

3. There was unusual difficulty in replicating either the Fleischmann-Pons Effect (FPE) or the Jones Ti chip experiments. (The recent report by BARC that only 4 of 1,000 similarly treated Ti chips resulted in nuclear reactions dramatically shows the replication problems.)

4. There was definite evidence of anomalous heat in the Palladium-Lithium-Deuterium system beyond any amount that could possibly be explained by chemical means (megajoules per mole).

5. Theory, based on standard physical principles, could explain much (but not all) of the experimental results. See especially Preparata [17] and Bush [18].

SUMMARIES OF PAPERS

Fusion Facts has prepared special summaries of positive results in the June 1990 issue [11] and in the October 1990 issue. Over 200 papers, usually peer-reviewed, or presented to peers in various cold fusion conference sessions, have been published or presented. **No open-minded scientists, who is willing to review the literature and discuss the technology with the leading cold fusion scientists would fail to recognize the strong evidence that fusion can and does occur in a metal lattice.** These scientists, however, can differ strongly on the future commercial potential of cold fusion.

PROBLEMS TO BE RESOLVED

The following are some of the key problems to be resolved:

1. What is the precise nature of the nuclear reaction(s) occurring in a metal lattice?

2. What is required to properly prepare a metal lattice so that nuclear reactions can take place? (Recall that in an experiment using 1,000 Ti chips from the same titanium source and prepared the same way, only 4 chips showed evidence of nuclear reactions.)

3. What are the promoters or inhibitors that affect the metal electrodes (often palladium) used in an electrochemical cell and how can they be controlled? (Note that these problems are similar to problems encountered in the early days of solid-state semiconductors. It took several years to identify and resolve all of the semiconductor problems. However, commercialization of the semiconductors was achieved long before all of the problems were resolved.)

4. **Most important for commercialization:** The amount of excess heat produced in some molten salt experiments [19] is much higher and less sporadic than has yet been reported from heavy-water cells. In my opinion, replicating the achievement of Liaw et al. is the most important experimental task to be resolved. **The molten salt invention of Liebert and Liaw is, so far, the best approach to commercial cold fusion.**

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[2] M. Fleischmann, S. Pons, and M. Hawkins, "Electrochemically induced nuclear fusion of deuterium." *J. Electroanal. Chem.*, 261, pp 301-308, and erratum, 263, p 187 (1989).

[3] *Proceeding of the Workshop on Cold Fusion Phenomena,* May 23-25, 1989, Santa Fe, NM.

[4] J.O'M. Bockris, G.H. Lin and N.J.C. Packham, (Texas A&M), "Nuclear Electrochemistry Among the Hydrogen Isotopes", *Proceedings of The First Annual Conference on Cold Fusion*, March 28-31, 1990, University of Utah Research Park, Salt Lake City, Utah.

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[17] Giuliano Preparata (U. of Milano), "Some Theoretical Ideas on Cold Fusion", *Proceedings of the First Annual Conference on Cold Fusion*, March 28-31, 1990, Univ of Utah Research Park, Salt Lake City, Utah. [See also Bush, Chubb, Hagelstein, Schwinger, and Kim, all of

whom presented theory papers at the cited conference. Ed.]

[18] Robert T. Bush (Cal State Poly Tech.), "Isotopic Mass Shifts in Cathodically-Driven Palladium via Neutron Transfer suggested by a Transmission Resonance Model to explicate enhanced Fusion Phenomena (Hot and Cold) within a Deuterated Matrix", *Proceedings of The First Annual Conference on Cold Fusion*, March 28-31, 1990, University of Utah Research Park, Salt Lake City, Utah. [Revised version to be published in *Fusion Technology* in early 1991.

[19] Bor Yann Liaw, Peng-long Tao, Patrick Turner, Bruce E. Liebert (U. of Hawaii), "Elevated Temperature Excess Heat Production Using Molten Salt Electrochemical Techniques", *Special Symposium Proceedings - Cold Fusion*, World Hydrogen Energy Conference #8, p 49, July 23-24, 1990, Honolulu, Hawaii.

G. LETTERS FROM READERS

FROM JAPAN

Prof. Kazuo Furukawa

Professor Furukawa of Tokai University is one of the world's leading proponents for the use of molten salts in a variety of electrolytic applications. He recently received a copy of *Fusion Facts* for October 1990 and was excited about the potential of the Liaw-Liebert molten salt fusion cell. These are his comments:

"Thank you very much. I have just received your *Fusion Facts*, Vol 2, No. 4 through Dr. T. Matsumoto. I read the copy yesterday and was quite impressed. I can believe the understandably nice work [on molten salts] and have quickly passed it on to my molten salt friends.

"I have also contacted a member of the Science Division of the newspaper *Asahi*. He expressed a big interest and asked for a detailed explanation.

"However, at the moment, we have a question: What is the reason that it seems that no journalists [in the US] are reporting this [molten salt fusion cell achievement] in their medium?"

We were able to assure Prof. Furukawa that the Wall Street Journal, the Salt Lake Tribune, and the Boston Herald all carried announcements about this remarkable achievement in the advancing science of cold fusion. We did not explain to Prof. Furukawa that the rest of the great American media have not, as yet, awakened to the tremendous potential of cold fusion. Ed.

GLEANINGS FROM DR. SAMUEL FAILE

[Dr. Samuel P. Faile of Cincinnati is our most productive correspondent. The following are gleanings from several of his recent letters to us. Ed.]

Regarding the molten-salt experiments of Drs. Liaw, Liebert et al. (U of Hawaii), described in the October 1990 issue of *Fusion Facts* and the World Hydrogen Energy Conference #8, Dr. Milica Petek (Oak Ridge National Laboratory) has indicated that the amount of helium found by Dr. Hoffman in the Pd electrode from the experiment was 10^9 atoms in 20 mg, or 1 per 10^{11} deuterium atoms. It was also noted that increased helium background values in electrodes of molten salt cells can result from exposure to air at the elevated temperatures used. [Experiments are carried out in an argon gas atomosphere.] Dr. Liaw noted that this amount of helium was 10^8 times less than the amount of heat measured. Also, in an attempt to prevent breakage of the electrodes used in molten salt experiments during deuterium loading, Dr. Liaw has indicated that the use of more porous materials prepared by chemical vapor deposition (CVD) is planned, as are additional comparisons of the alloy microstructure of successful and unsuccessful electrodes. The earlier experiments used Pd supplied by Dr. Huggins of Stanford, which was somewhat impure; in particular, Pt may have been introduced during the preparation.

Dr. Faile suggests a number of other processes which could create more porous electrodes, including sputtering; plasma spray; the CVD/interface technique of Air Products, Allentown, Pa (acquired from San Fernando Labs of California, capable of producing extremely high-strength alloys with an extremely small grain size); nanophase materials developed at Argonne National Laboratory; and sintering of mixtures of very fine Pd powder mixed with another material followed by leaching away of the other component. Preloading with deuterium gas is also suggested. (Phase diagram and other information on possible alloying elements can be found in publications such as Binary Alloy Phase Diagrams, T. Massalski, ed., American Society for Metals, 1986.)

Dr. Y.Y. Chu, a colleague of Dr. Beuhler at Brookhaven National Laboratory, has indicated that a planned second-generation cluster impact experiment will test beams containing other molecules besides D_2O, and will also monitor gamma radiation. However, attempts to measure ^4He have not been performed, since a mechanism related to hot fusion (with the aid of a heavy atom such as oxygen) was expected.

Dr. Faile proposed that cold fusion may also occur during rapid crystallization of amorphous deuterated metals such

as Pd and Ti alloys. Extremely rapid crystallization has been noted in various experiments. For instance, in some cases crystallization of an amorphous Ti-Pd alloy (65 atom % Ti, produced by magnetron sputtering) has appeared to occur almost instantaneously at 315 C [A.F. Jankowski, M.A. Wall and P.E.A. Turchi, "Crystallization of Amorphous Ti-Pd," *J. of the Less-Common Metals* 161(1), June 1990, pp 115-124]. Also, Dr. Russell Messier (Pennsylvania State U. Materials Research Laboratory) has measured crystallization speeds in some amorphous metals reaching the speed of sound in that metal, i.e. explosive speeds; crystallization was initiated in this experiment by scratching the alloy surface.

Dr. Faile noted that some researchers have suggested that the addition of elements such as Hf or Zr to create oxygen-containing inclusions inside the alloy at grain boundaries, or the addition of large alkali or alkaline earth ions such as Ba, may be worth exploring. It was also suggested that traces of halogens (for instance, 100 ppm of BaF_2 or CaF_2) could be tried.

Regarding the believability of cold fusion theories involving new quantum mechanical states such as the collective boson phases of Drs. Bush and Chubb, an article was noted which describes the unexpected and still poorly-understood types of excitations which have been experimentally observed in superfluid ^{4}He, another boson condensate, including the particle-like rotons [P.V.E. McClintock, "Rotons Put Physics in a Whirl, *Nature* 347 (1990) pp 233-4]. The possibility of enhancement of quantum fluctuations in systems with chaotic behavior, noted by Ronald F. Fox of the Georgia Institute of Technology, was also mentioned [*Science News* 138(14), October 6 1990, p 213].

H. CONFERENCES & CALL FOR PAPERS

2ND ANNUAL CONFERENCE IN ITALY IN 1991

The Second Annual Conference on Cold Fusion will be held in Como, Italy, June 29 to July 4, 1991. The co-chairpersons are Prof. Tullio Bressani (Experimental Physics, U of Torino) and Prof. Guillano Preparata (Theoretical Physics, U of Milano). Dr. Fritz Will reported that it was deemed appropriate to hold yearly future conferences in countries heavily involved in cold fusion development. The third annual conference will be held in Japan, India, or China. Further details will be published here as soon as they are available.

NEXT ANOMALOUS NUCLEAR EFFECTS CONFERENCE TO BE HELD IN ITALY IN 1991

Professor Steven Jones, BYU, announced that the next Anomalous Nuclear Effects In Deuterium/Solid Systems Conference will be held in Italy in the fall of 1991.
Fusion Facts will publish further information about time, location, and call for papers as soon as that information is received.

JOURNAL CALLS FOR PAPERS

Courtesy of Subbiah Arunachalam, Editor, IJT

The Indian Journal of Technology (the third journal -- after *J. Electroanal. Chem,* and *Nature* -- to publish an original research paper on cold fusion) invites papers. Both original research papers and critical review articles in all areas of cold fusion are solicited.

Manuscripts may be sent, in duplicate, to Editor, Indian Journal of Technology, PID, Hillside Road, New Delhi 7110012, India.

TECHNICAL NOTES IN *FUSION TECHNOLOGY*

Fusion Technology has initiated and is continuing a very successful section for "Technical Notes" on cold fusion. This section in intended for fast publication of important papers on new directions, innovative ideas, and new results. Over the past year over 48 papers on cold fusion have been published, making *Fusion Technology* one of the premier professional journals covering this area.

Technical Notes do not have a page limit but they typically run 2-4 journal pages (1 journal page approx. = 3 double-spaced typed pages). A brief abstract is required. ASCII format computer media can be accepted.

Technical Notes will be reviewed but the process stresses rapid response. **Reviewers are instructed to consider Technical Notes as speculative, sometimes incomplete work that should be judged on the basis of innovation, originality, and importance to fusion power development. Appropriate citations to prior work are also essential.**

Deadlines for future issues are as follows:
July 1991 issue: January 30, 1991
August 1991 issue: February 20, 1991

Send manuscripts to: George H. Miley, Editor, *Fusion Technology*, Fusion Studies Laboratory, University of Illinois, 103 S. Goodwin Avenue, Urbana, IL 61801. Fax (217) 333-2906. Phone (217) 333-3772.

CONFERENCE PROCEEDINGS AVAILABLE

Copies of the Proceedings of Anomalous Nuclear Effects in Deuterium/Solid Systems Conference, Oct 22-24, 1990 can now be ordered. The estimated publication date for the

conference proceedings is currently March 1991. Copies can be ordered by sending a check for $55, payable to S & J Scientific Co., to:
Prof. S.E. Jones, Physics Department
Brigham Young University
Provo, UT 84602

The First Annual Conference on Cold Fusion Conference Proceedings is now available. The proceedings include the papers presented March 28-31, 1990 at the conference. Send check for $55. Order from:

National Cold Fusion Institute
390 Wakara Way
Salt Lake City, Utah 84108

The Proceedings of the Cold Fusion Symposium of the World Hydrogen Energy Conference #8 can be ordered from:

Hawaii Natural Energy Institute
University of Hawaii
2540 Dole Street, Holmes Hall 246
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Make check payable to Research Corporation of the University of Hawaii. The prices is $15 for each copy of the Cold Fusion Proceedings. Price includes shipping and handling.

COLD FUSION INFORMATION

The following publications have been helpful in publishing articles on cold fusion:

FUSION TECHNOLOGY
Recently added new section on Cold Fusion
555 N. Kensington Ave.
LaGrange Park, Illinois 60525
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