FUSION Facts

A Monthly Newsletter Providing Factual Reports On Cold Fusion Developments

Fusion Facts Now Reports on Both Cold Fusion and Other Enhanced Energy Devices.

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HAPPY HOLIDAYS FROM OUR STAFF

NOTICE

All papers designated as being "presented at ICCF4" are from the pre-printed abstracts of papers from the 4th INTERNATIONAL COLD FUSION CONFERENCE held over December 6-9, in Maui, Hawaii. These papers will be more carefully reviewed and properly referenced when the full Proceedings are published or when we receive the full paper. Occasional **bold print** is *Fusion Facts'* emphasis. All references to Figures refer to those in the ICCF4 book of abstracts, which we did not have room to publish. *Fusion Facts* will publish the remainder of the abstracts in the January issue.

A. ICCF4 POSTMORTEM

FIRST THE GOOD SCENARIO: It is the consensus of many scientists, working in their areas of expertise, that "cold fusion" is new science that may have commercial potential. The efforts of these dedicated scientists and engineers has been commendable. They have exchanged information, listened to just criticism, have modified old or invented new measurements systems, have improved their data, have solved some· of the problems related to reproducibility, and have made important new discoveries. Some previously published anomalies are now more fully understood. New discoveries have been made in material science, nuclear chemistry, nuclear physics, solid-state physics, electro-chemistry, electronics, and many other sub-disciplines including instrumentation. **It has been conclusively shown that excess heat can be generated that is not explained by conventional chemistry.**

If scaling does not become a severe problem, then a scientific basis is being established for developing a solution to the problem of producing clean and (hopefully) inexpensive power. New discoveries are providing us with new insights into the structure and interaction of matter that could promote dramatic changes in nuclear chemistry. These changes may lead to improved methods of producing some scarce elements. New systems are being proposed that may improve the technology of cleaning up nuclear wastes. Under the best scenario, we may be able to provide new power sources for land, sea, air, and space transportation.

NOW THE LESS FAVORABLE SCENARIO: There are still dedicated skeptics (and we all need to be skeptical). In the worst case scenario, the hundreds of experimental results of observing nuclear ash (neutrons, tritium, helium, charged particles, gamma rays, and excess heat) are the result of bad experiments.

However, the following good has occurred: The technology and techniques of calorimetry have been improved. Our knowledge of hydrogen isotopes, especially deuterium, in metals has increased. Many new anomalies in condensed matter and in some types of gas plasmas have been explored. Our understanding of hydrogen diffusion, double layer, fugacity, over potential, recombiners, sonoluminescence, electrolysis, electric arcs and sparks, hydrogen loading, phase changes, etc. have all increased. These results are valuable.

Take one example -- Nuclear fission power plants were designed by the best scientists and engineers to last 40 years. Many of the operating plants are now being closed and dismantled after as little as 12 years **due to the unpredicted effect of hydrogen embrittlement of metals in the presence of radiation.** The cost to the U. S. taxpayers will run to over 100 billion dollars in the U.S. alone. It is difficult to predict the future value of the knowledge that has been and is being gained by the study of cold fusion anomalies.

Finally, if the more favorable scenarios are achieved, we will have demonstrated that the currently-administered peer-review system needs to be modified to provide for a more beneficial treatment of new discoveries. We will also have learned that stringent efforts to discourage new science is not a win-win game. In my judgement, the essence of new science is discovery. The essence of academic science is replication. The essence of engineering is application. The essence of commercialization is marketing. The last two of these four concepts remain to be accomplished for cold fusion.

B. MORRISON AND HUIZENGA ARE CORRECT.
By Hal Fox

Drs. Douglas R.O. Morrison and John R. Huizenga have been heavily criticized by many of us for their negative statements about "cold fusion". After spending some time during the ICCF4 conference with these intelligent, experienced, and articulate scientists, **I am now convinced that they are correct if you examine their facts and assumptions.**

Facts: It is well known that in gas-plasma nuclear reactions that d+d has three branching ratios that produce tritium (about 50%), neutrons (about 50%), or helium-4 (about one in a million fusion events.)

Assumption 1: The branching ratio found in gas-plasma physics is applicable to palladium metal lattices loaded with deuterium.

Assumption 2: The excess heat measured in a palladium/lithium/heavy-water electrolysis system **can only be the result of d+d fusion if the excess heat is caused by nuclear reactions.** Therefore, there must be neutrons to be measured if "cold fusion" exists as a phenomena.

Assumption 3: The d+d nuclear reaction is the only possible nuclear reaction in such an electrolysis system because it is the most likely nuclear reaction. Considerable experimental evidence in gas-plasma physics rules out all other nuclear reactions because the fusion probabilities are very low.

Assumption 4: The Coulomb barrier cannot be breached except by high velocity or high energy charged particles or by neutrons (or neutral particles). The evidence is very strong that there are no neutrons or few neutrons in the electrolysis system.

It is clear and correct that, based on these facts and assumptions (which many skeptics do not cite) d+d "cold fusion" in a metal lattice is impossible. I believe that all honest scientists will agree with Morrison's and Huizenga's conclusions if you accept their premises.

ARE THEIR ASSUMPTIONS CORRECT?

If you want to intelligently discuss "cold fusion" with Morrison and Huizenga, then you must start from their premises. The implications of their premises are the following:

1. There can be no new discoveries of nuclear reactions in a Pons-Fleischmann electrochemical cell. New science is denied.

2. If there are new discoveries, such as the excess heat anomaly, then it is not due to nuclear reactions.

3. The measurements of tritium, neutrons (if any), and excess heat (beyond that known to be possible by chemistry) are artifacts, fraud, contamination, or bad science.

SCIENCE ADVANCES BY NEW EXPERIMENTAL EVIDENCE

What is the probability that over 1,000 scientists from a variety of disciplines and including some of the world's foremost electrochemists are all involved in fraud, deceit, planned contamination of experiments, or inability to make accurate scientific measurements within their own field of expertise? **The answer is less than one in a million!**

These scientists involved in "cold fusion" research are finding and reporting new experimental evidence that should be and is being refined, revealed, and replicated. The essence of new science is discovery followed by shared information and replication.

SUMMARY OF THE EVIDENCE

Thousands of experiments have provided the following experimental evidence in a Pons-Fleischmann electro-chemical cell:

1. Under appropriate conditions (loading, electrolyte, electrode size, and shape, etc.) excess heat is observed on a continuous basis (after loading) and also in bursts lasting from minutes to days.

2. The amount of excess heat is much larger than can be attributed to known chemistry.

3. The amount of excess heat can be increased by modifying various experimental conditions such as:
   a. Changing the cell temperature.
   b. Adding various chemicals.
   c. Applying magnetic fields.
   d. Applying electromagnetic energy, especially about 89 MHz.
   e. Changing the electrical supply (both current and voltage).

Hundreds of other experiments have shown the following:

1. Excess heat can be produced in a molten-salts electrochemical cell.

2. Excess heat can be produced using nickel (& other anodes) in electrochemical cells wherein the electrolyte contains an appropriate alkali metal.

3. Excess heat and many nuclear byproducts can be produced using gas plasmas in the glow-discharge region with a palladium cathode.

4. Excess heat can be produced in capillaries filled with deuterium gas.

5. Excess heat can be produced using electrical sparking in appropriate gases and liquids.

6. A variety of isotopic and nuclear changes have been measured that are the result of modifications to the nuclei of elements used in the experiments. **Nuclear reaction byproducts have been measured.**

SUMMARY AND CONCLUSIONS

If you use the same premises used by Morrison and Huizenga, then you must agree that they are on firm scientific grounds and their denial of "cold fusion" is correct.

If you use accepted standards of scientific inquiry and include the replicated experimental results (such as excess heat) from hundreds of careful experiments, do the skeptics have grounds to declare that all "cold fusion" is bad science? **ABSOLUTELY NOT!** If any person makes such blanket condemnations of all "cold fusion" evidence, then they are operating as funding lobbyists and **not as true scientists.**

Drs. Morrison and Huizenga are distinguished, intelligent, and articulate scientists. Yes, they are confirmed skeptics but they are neither stupid nor blind. It is suggested that we continue to welcome them to our conferences and, especially, to our laboratories. As soon as they become convinced that there is new science in the many discoveries of "cold fusion", then they will be ardent supporters of advancing the use and understanding of this new science. **They could not be scientists and do otherwise.**

Note: Because the term "cold fusion" apparently means something different to different people the quotes are to be interpreted that "cold fusion" covers all of the anomalies of excess heat, isotopic shifts, tritium, and neutron (if any) measurements that have been made in thousands of experiments. The concept is that "cold fusion" is new science and the explanation of the

physical or chemical reactions producing the measured anomalies **is not as yet fully understood.**

C. NEWS FROM THE U.S.

CALIFORNIA - PROPOSED EXPERIMENT

Robert W. Bass (Scientific Advisory Board, ENECO, Inc., Salt Lake City, Utah), "Proposed Nuclear Physics Experiment to Conclusively Demonstrate and Explain Cold Fusion," presented at ICCF4.

AUTHOR'S ABSTRACT

The protocol of the proposed experiment makes only two plausible assumptions: (1) CONSERVATION OF BARYON NUMBER; and (2) that if three identically-prepared beams of deuterons of mean energy E_{crit} eV are directed toward three-identically prepared frozen samples of fully loaded $Pd.D$ lattices, for times of duration T, $2T$, $3T$, then the same *percentage* of deuterons will be wasted in each case (i.e. reflected or not entrant perpendicular to a plane of the embedded D lattice): more specifically, if a TOTAL of N_T, $2N_T$, $3N_T$ deuterons are injected in each case, then almost exactly N, $2N$, $3N$ deuterons will enter the lattice perpendicular to a lattice plane. where N is not predicted (but $N < N_T$). The *DESIDERATUM* is to demonstrate the *creation* of O, N, 2N, 3N **Alpha Particles** from **LOW ENERGY** fusion of O, 2N, 4N, 6N static-target (near zero-point) *bound* **Deuterons**, at a Kinetic Energy Cost of almost exactly O, $N \cdot E_{crit}$ eV, $2N \cdot E_{crit}$ eV, $3N \cdot E_{crit}$ eV plus unpredicted but *proportionate* wasted energy (which can be measured). If the experiment is performed and for **ANY** low-energy (say, less than 20 eV) value of E_{crit} eV attains the stipulated *desideratum*, that is, the number of Alpha Particles created is proportional to the beam *DOSE*, then the empirical reality of Cold Fusion will have been conclusively **DEMONSTRATED**. However, it will not have been conclusively **EXPLAINED**. The purpose of this paper, besides advocating this novel experiment, is to present a semi-classical quantized theory of "Lattice Induced Nuclear Transmutations" (LINT) including a new *Quantum Resonance Triggering (QRT) Principle* which predicts that an *optimal* value of E_{crit} exists (below or above which N is reduced), and that to a first approximation this value is about E_{opt} approx. = 6,3 eV.

CALIFORNIA - Ca FROM LIGHT WATER

R. Bush and R. Eagleton (Phys. Dept., Cal. Poly. Univ., Pomona, and ENECO, Inc., Salt Lake City, Utah), "Calorimetric Studies for Several Light Water Electrolytic Cells with Potassium Carbonate and Sodium Carbonate Electrolytes and Nickel Cathodes," presented at ICCF4.

AUTHORS' ABSTRACT

Results will be reported for calorimetric studies with several cells employing light water based potassium carbonate and sodium carbonate electrolyte and employing nickel fibrex (fine nickel mesh) electrodes. Highlights will include the following:

(1) Two otherwise "identical" potassium carbonate electrolytic cells have been run in series except that the electrolyte of one employed de-deuterated water with only 1 % of the heavy water contamination of the nanopure water of the other electrolyte. The fact that the excess powers at the same current density were identical within the limits of the experimental error supports the results of Bush's earlier mixing experiments, which employed cells constructed by Eagleton, indicating that there is a genuine light water excess heat effect that is not due, as some critics have claimed, to the known heavy water contamination of light water.

(2) Certain impurities such as aluminum and silicon appear to be important for achieving, and boosting, the heavy water excess heat effect. It would not be surprising that such co-factors may also exist for the light water excess heat effect. Experimental evidence is presented in support of a hypothesized co-factor for the light water excess heat effect achieved with a nickel cathode.

(3) Mills has claimed not to see an excess heat effect when sodium carbonate is employed as an electrolyte in place of potassium carbonate. (Indeed, according to the theoretical model of Mills and Farrell the light water excess heat effect should not be achievable with sodium carbonate.) Bush on the other hand attained even higher excess powers with sodium carbonate than with potassium carbonate for otherwise equal input parameters. This result supported his CAF Hypothesis ("Cold Alkali-Hydrogen Fusion" or, simply, "Cold Alkali Fusion") according to which all the alkali nuclides should be capable of undergoing a lattice-assisted cold nuclear [fusion] with a nucleus of hydrogen (proton, deuteron, and triton) partially manifesting itself as an excess heat reaction. In this experiment a light water cell with a nickel cathode and 60 ml of a 0.57 M potassium carbonate electrolyte is gradually converted to one with a 0.57 sodium carbonate electrolyte by 10 ml substitutions of the latter electrolyte. Excess power levels increase as the substitution progresses finally reaching a level compared to that for pure potassium carbonate comparable to the earlier results of Bush.

(4) An experiment to check the correlation of calcium production with excess heat production in a potassium carbonate cell appears to resolve the controversy between Mills and Bush in this regard. Thus, Mills asserted that the excess heat reaction is non-nuclear and claimed to detect no calcium production. Bush, on the other hand, hypothesized a cold nuclear reaction; viz. the transmutation of potassium to calcium via the addition to potassium of a proton, and detected a post-run calcium concentration in the electrolyte consistent with this. (Notoya subsequently provided an initial independent corroboration of this.) It is shown that the calcium concentration reaches a maximum of about 1 ppm, whereupon it stabilizes suggesting a dynamic equilibrium in which as much calcium is driven back into the cathode as is leaving the cathode. Thus, if Mills' threshold for calcium detection were much larger than 1 ppm, say 10 ppm, Mills would not detect calcium in the electrolytes of his cells.

CALIFORNIA - STRONTIUM PRODUCED

R. Bush and R. Eagleton (Phys. Dept., Cal. Poly, Pomona, California / ENECO Inc., Salt Lake City, Utah), "Strontium Production in Two Electrolytic Cells with Light Water Based Rubidium Carbonate Electrolytes and Nickel Mesh Cathodes," presented at ICCF4.

AUTHORS' ABSTRACT

Analyses of the pre-run electrode material and post-run electrodes from two light water based rubidium carbonate cells (cells #53 and #56) with nickel mesh cathodes by two independent laboratories provide strong initial evidence in support of Bush's CAF Hypothesis ("Cold Alkali Fusion") that strontium is being produced from rubidium via a cold nuclear reaction in which a proton is being added to Rb^{85} (Rb^{87}) to produce Sr^{86} (Sr^{88}). (In both cases no strontium was found in either the pre-run or post-run electrolytes above the 50 ppb level.) A SIMS analysis for the pre- and post-run cathode material of cell #53 showed strong lines at mass numbers 86 and 88 that were not present in the pre-run spectrum. An interesting finding from the standpoint of the CAF Hypothesis is the fact that, within experimental error, the ratio of the line height for mass number 86 to that for 88 was the same as that for the ratio of the rubidium signals at masses 85 and 87.

A disadvantage of these SIMS tests was that the mass spectrometer employed was unable to discriminate between rubidium hydride and strontium; i.e. $Rb^{85}H$ would be indistinguishable from Sr^{86}. So, even though there was strong evidence pointing to the noninvolvement of rubidium hydride, such as the instability of the latter and the fact that the rubidium oxide lines, which should have been higher than those for RbH because of the greater stability of RbO, were shorter than those for RbH. It was decided to pursue additional tests in which a chemical separation of the rubidium and strontium would first be performed prior to the mass spectrometric analysis. These analyses were carried out by West Coast Analytical Services, Inc., of Santa Fe Springs, CA. In addition to the cathode from cell #53, we also now had available that from cell #56, which had been run for much longer than cell #53, and had evidenced about five times as much excess heat.

The chemical separation was done by first etching the surface of the cathode sample and then performing the separation via chromatography by employing an ion-exchange column. (The divalent strontium tends to hold on to the column more strongly than the monovalent rubidium, so that the latter can be selectively "washed out".) Unfortunately, in the first attempt the etching was too deep so that both samples were put entirely into the solution. Since it was anticipated that there would be a surface bias to the strontium production, it was interesting that while the sample from #53 showed little enhancement of Sr^{86} relative to Sr^{88}, the sample from #56 already evidenced statistically-significant enhancement of Sr^{86} relative to Sr^{88} despite the noise contributed from the "deep" etching. (The virgin nickel fibrex contained a surprisingly large concentration, 100 ppm, of strontium with the ratio of Sr^{86} to Sr^{88} in the natural abundance ratio.)

In the second tests the etching time was significantly reduced limiting the echate to material much nearer the surface. Both samples now showed statistically-significant enhancements in the ratio of Sr^{86} to Sr^{88} relative to the natural abundance ratio. In the case of the sample from cell #56, which was associated with about five times as much excess heat as cell #53, the enhancement in the ratio of Sr^{86} to Sr^{88} relative to that for the prerun sample (essentially the natural abundance ratio) was by an amount equal to about <u>325 standard deviations.</u>

It seems, then, that there is rather strong initial evidence for the achievement of an isotopic abundance shift for strontium in these electrolytic experiments involving a light water based rubidium carbonate electrolyte. Moreover, the results could hardly be due to contamination, so that, in principle, they constitute much stronger evidence for cold nuclear reactions than does the evidence of an elemental shift to calcium in the case of a potassium carbonate cell. [This is an elegant experiment which should be replicated. Ed.]

CALIFORNIA - COMPLETE REPLICATION

M.C.H. McKubre, B. Bush, S. Crouch-Baker, A. Hauser, N. Jevtic, T. Passell[1], S. Smedley, F. Tanzella, M. Williams, and S. Wing (SRI International, Menlo Park, CA, [1]Electric Power Research Institute, Palo Alto, CA) "Calorimetry Studies of the D/Pd System," presented at ICCF4.

AUTHORS' ABSTRACT

An experimental program has been undertaken to determine the conditions under which reproducible power excess can be observed in electrochemical systems employing Pd cathodes in D_2O electrolytes. This program focusses on electrochemical kinetic and metallurgical issues that control D/Pd loading which appears to be a prerequisite for excess power production. Mass flow calorimeters have yielded most of our previously published results of power excess. Since ICCF3 these instruments have been refined, redesigned, rebuilt and operated in a new laboratory with new constant temperature baths and new electronic systems. Under these conditions we have reproduced, wholly, our previous observations of excess power, and are beginning to study the controlling parameters for the purpose of attempting scale-up. In addition to mass flow calorimetry of closed cells, we have also designed and/or developed a number of heat flow calorimeters, operating on several principles, and are studying these with both closed and open cells. A particular feature of the experimental program implemented in 1993 is the attempt to quantify the appearance, and set limits on the non-appearance, of potential products of nuclear reactions: neutrons, gamma and x-rays, ^3He and ^4He, and isotopic shifts of Pd lattice and electrolyte-derived species. A number of experiments have been designed, and are now at various stages of construction and testing, in order to measure simultaneously excess power and one or more of these possible products. These designs will be dissembled.

CALIFORNIA - MATERIALS EFFECTS

Robert A. Huggins (Dept. Mat. Sci. & Eng., Stanford Univ., California), "Some Materials Aspects of the Electrochemical Insertion of Hydrogen and Deuterium into Metals," presented at ICCF4.

AUTHOR'S ABSTRACT

A number of features of the presence of interstitial species in metals and alloys relevant to experiments related to "cold fusion" are

discussed. These include experimental evidence for very high virtual pressures of gases in solids under certain conditions as the result of the interplay between interfacial and bulk thermodynamic conditions. This can lead to the appearance of compositions and phases that are normally only observed under much more extreme external pressures. The influence of promoters and surface blockers on such phenomena under electrochemical conditions is well known.

Substantial dislocation generation and motion can result from the large stresses accompanying composition gradients and phase transformations that can be induced by the compositional effects of changes in the interfacial conditions. This can cause large changes in the bulk mechanical properties, including the initiation of internal fractures and surface cracks.

Because of the preferential segregation of interstitial species to dislocations, the solute distribution inside the solid is highly inhomogeneous, with much higher local concentrations and a different site occupation distribution in the very large stress field near the dislocation core. As a result, dislocation motion can be accompanied by the unusually rapid microscopic transport of interstitial solutes. Under conditions in which dislocations are caused to intersect the surface, this can lead to a high rate of solute entrance or emission at surfaces. This has been experimentally observed in the case of tritium, whose emission has been used as an indicator of plastic deformation.

Mechanical effects related to the presence of hydrogen and other interstitial species in solids can be very large, and quite often are sporadic. They also can have long incubation times before suddenly appearing. Examples are the phenomena of hydrogen embrittlement, stress corrosion cracking, and static fatigue.

CALIFORNIA - HELIUM MEASUREMENTS

M.H. Miles and B.F. Bush[1] (Chem. Div., Res. Dept. Naval Air Warfare Center Weapons Div., China Lake, CA, [1]SRI International, Menlo Park, CA), "Heat and Helium Measurements in Deuterated Palladium," presented at ICCF4.

AUTHORS' ABSTRACT

Our previous results present a correlation between the measured excess power and helium production in D_2O-LiOD electrolysis cells using palladium cathodes. The measured rate of ^4He production (10^{11}-10^{12} ^4He per sec per Watt) is the correct magnitude for typical deuteron fusion reactions that yield helium as a product. Because helium is present in the atmosphere (5.22 ppm), it is difficult to convince everyone that the ^4He measured in the electrolysis gas is a product of a fusion reaction within the cell. It is indeed a very challenging experimental problem to clearly establish the production of ^4He from Pd/D_2O electrolysis cells. This situation is compounded by difficulties in obtaining large excess power effects in these experiments. Table I presents the theoretical relationship between the excess power and helium production assuming ^2D + ^2D → ^4He + 23.8 MeV as the major fusion reaction with the energy being deposited within the calorimeter. At low levels of excess power, the uncertainties in measurements of the helium and the excess power are rather large. When the excess power exceeds 0.2 W, however, it could be possible to correlate the rate of ^4He production with

proposed fusion reactions. It should be noted that for any given excess power, the helium concentration in the electrolysis gas stream will be inversely proportional to the current. Helium measurements in D_2O and H_2O control experiments are presented in Table II. Metal flasks were used to collect the electrolysis gas samples in order to minimize atmospheric contamination due to helium diffusion through glass. The helium concentrations in Table II support a detection limit of approximately 10^{13} $^4He/500$ mL in these experiments as reported previously. Mean values for the measured helium concentrations in these control experiments are 4.4 ± 0.6 ppb or 5.1 ± 0.7 x 10^{13} $^4He/500$ mL. For experiments producing excess power, five helium measurements using these same metal flasks have been completed. These experiments yield a mean value of 2.0 ± 0.5 x 10^{11} $^3He/s·W$ after correcting for background levels of helium measured in control studies (Table II). This value is once again the correct magnitude for typical deuteron fusion reactions that yield ^4He as a product. However, the excess power levels measured during the collection of the gas samples in these new experiments were less than 0.1 W, hence experimental errors are rather large (Table I). Further experiments using metal flasks are needed that involve equal numbers of control cells and cells producing large excess power effects. This should provide additional statistical evidence regarding helium production in Pd/D_2O electrolysis cells.

CALIFORNIA - OPPOSITION & SUPPORT

Mario Rabinowitz (EPRI, Palo Alto, California), Y.E. Kim (Dept. Phys., Purdue Univ., West Lafayette, Indiana), V.A. Chechin, and V.A. Tsarev (Lebedev Phys. Inst., Russ. Acad. Sci., Russian Federation), "Opposition and Support for Cold Fusion," presented at ICCF4.

AUTHORS' ABSTRACT

Modern science has never been so strongly and so long divided, as it has with respect to the phenomena of Cold Fusion (CF). Bifurcation persists because there is still only a sparse experimental meeting ground between the two camps. Conventional theory appears so diametrically opposed to the possibility of CF that little room is left for commonality in the theoretical realm. Experiment should and will be the final arbiter. Nevertheless, a theoretical existence proof, i.e. a proof of principle would go far in putting to rest reservations and doubts regarding the reality of CF.

Our emphasis will be on the theoretical issues in a search to see if a reasonable model of CF exists. For the last two years we have been working on a review of theoretical models for Cold Fusion. We were motivated to understand CF because at least certain of the phenomena appear undeniably real to us. The problem of an adequate theoretical model of CF has turned out to be no simpler than the problem of its unambiguous experimental proof. Many books and reviews have been written on the subject of CF by both its opponents and proponents. There is a serious need for a balanced account. It is our goal to present a perspective that is as balanced and objective as possible. Where feasible, we will point out shortcomings in the theory and experiments both by advocates and adversaries. We will only briefly cover the phenomenology, as previous CF review papers have extensively covered the experimental results. Our paper will primarily focus on a probing theoretical inquiry that is equitable to both sides of the issue.

CALIFORNIA - CAVITATION FUSION

Roger Stringham (E-Quest Sciences, Palo Alto, California), "Cavitation Induced Micro-Fusion," presented at ICCF4.

AUTHOR'S ABSTRACT

Bubbles produced by an acoustic field adiabatically collapse creating very high energy systems called jets. When the liquid for the bubble formation was heavy water (D_2O) and the surface on which the bubble collapse was palladium foil, three phenomena were measured originating in the palladium foil lattice. The first was excess heat, where there was production of enough pulse heat to melt the lattice and enough continuous heat to sustain excess output of 90 watts for periods of up to three days. The second was the production of a small amount of ^{4}He. The third was production of small transmutations in the exposed palladium lattice. The transient cavitation conditions produced violently collapsing bubbles in heavy or light water systems. The two water systems, heavy and light, circulating through the sealed reaction volume containing the palladium foil, were compared. The heat measurements are made at steady-state with heat input equal to heat output.

CALIFORNIA - SURFACE AFTER C.F.

David S. Silver (Phillips Lab., Edwards A.F.B., California), John Dash and Patrick S. Keefe (Portland St. Univ., Phys. Dept., Portland, Oregon), "Surface Topography of a Palladium Cathode after Electrolysis in Heavy Water," *Fusion Technology*, 1933, vol 24, no 4, pp 423-430, 9 refs, 9 figs.

AUTHORS' ABSTRACT

Electrolysis was performed with a palladium cathode and an electrolyte containing both hydrogen and deuterium ions. The cathode bends toward the anode during this process. Examination of both the concave and the convex surfaces with the scanning electron microscope, scanning tunneling microscope, and atomic force microscope shows unusual surface characteristics. Rimmed craters with faceted crystals inside and multitextured surfaces were observed on an electrolyzed palladium cathode but not on palladium that has not been electrolyzed.

AUTHORS' CONCLUSIONS

The following conclusion can be drawn from this study:

1. Electrolysis with a thin, cold-rolled palladium cathode in an electrolyte containing both hydrogen and deuterium ions produces macroscopic deformation of the palladium. This deformation begins at the start of electrolysis, and it is quite reproducible.

2. After electrolysis for 12 min., a palladium cathode contained microscopic craters. One of these craters has microscopic needles extending from the surface into the crater and others have rims

protruding above the surface. Faceted crystals occur inside some of the craters. The morphology of these features suggests that localized high internal temperature and pressure occurred during electrolysis and that this resulted in microscopic surface eruptions.

3. The reaction that produced localized high temperature and pressure sufficient to cause cratering is not known. Attempts to detect possible fusion by-products such as tritium and gamma and neutron radiation were not successful. However, we recently reported localized concentrations of elements that may have resulted from transmutations caused by neutrons from fusion reactions.

HAWAII - NICKEL WITH MOLTEN SALTS

Bor Yann Liaw, Bruce E. Liebert* and Yi Ding (Hawaii Nat. Energy Inst., School of Ocean and Earth Sci. and Tech., and Dept. of Mech. Eng.*, University of Hawaii, Honolulu, HI), "Charging Hydrogen into Ni in Hydride-containing Molten Salts," presented at ICCF4.

AUTHORS' ABSTRACT

Recent reports on excess heat production during charging hydrogen into Ni electrodes in carbonate aqueous solutions at near room temperature prompted our interest in studying this reaction at elevated temperatures. Ni is a reasonably inert electrode in hydride containing molten salts such as LiH in LiCl-KCl eutectic. Ni has a relatively low solubility toward hydrogen and lithium, although it has been reported that some Ni hydride formed under a high hydrogen partial pressure or electrochemically. We studied the electrochemical behavior of Ni electrodes in the LiH-containing LiCl-KCl eutectic solutions near 400°C. This paper will discuss the thermodynamic and electrochemical aspects of the Ni electrode in such an electrolyte system. Cyclic voltammetry is a useful tool to characterize this system. We found a surface poisoning changed the hydrogen reactions with the electrodes. Particularly, the hydrogen evolution reaction was suppressed to a higher overpotential and a limiting current situation was detected. We will discuss our cyclic voltammetry results and other complementary studies. We will also compare the results with those of the light water electrolysis in terms of thermodynamic considerations and calorimetry.

HAWAII - THERMODYNAMICS OF CHARGING

Bor Yann Liaw (Hawaii Nat. Energy Inst., Sch. of Ocean and Earth Science & Tech., Univ. Hawaii), "Some Thermodynamic Aspects Related to Charging Hydrogen Species into Metal Lattice," presented at ICCF4.
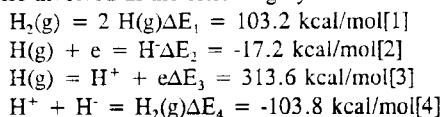
AUTHOR'S ABSTRACT

In relating excess heat to either chemical or nuclear origins, we should examine the detailed energy aspects involved in the process of charging hydrogen species into metal lattice such as Pd. We found that it is difficult to explain the recent intriguing results of
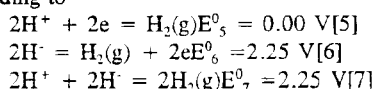
reproducible "excess heat" in the Ni-light water systems. In this paper, energy issues related to the charging process and the metal hydrogen systems will be discussed, aiming at a clear understanding of heat in "excess."

The thermodynamic properties of the H-Pd and H-Ni systems at high hydrogen pressures have been reported largely by Baranowski and his co-workers. They found the relative partial molar enthalpy of hydrogen in palladium is a strong function of hydrogen concentration as denoted by the H/Pd ratio (particularly in the range of above 0.88). Oriani recently argued that the enthalpy values are substantially negative. On the other hand, Levine and Weale reported that the isoteric heat of hydrogen sorption increases substantially with hydrogen concentration: from -11.0 to -2.8 kcal/mol H_2 for H/Pd=0.225 to 0.65. It is important that we look at the issue in terms of hydrogen partial pressure, concentration, temperature and external pressure. It is also important to discuss the issue under electrochemical conditions.

Another issue on the energy balance relates to the validity of the first law (energy conservation) of thermodynamics, which states that the energy change from one state to another is independent of the path or number of intermediate steps. In this context, we examined the energies involved in the following cycle:

$$H_2(g) = 2 H(g) \Delta E_1 = 103.2 \text{ kcal/mol}[1]$$
$$H(g) + e = H^- \Delta E_2 = -17.2 \text{ kcal/mol}[2]$$
$$H(g) = H^+ + e \Delta E_3 = 313.6 \text{ kcal/mol}[3]$$
$$H^+ + H^- = H_2(g) \Delta E_4 = -103.8 \text{ kcal/mol}[4]$$

Equation [1] is the dissociation of hydrogen molecule into atoms, where ΔE_1 is the dissociation energy per mole of hydrogen gas, which can be further defined as the bond energy. Equation [2] and ΔE_2 relate to the electron affinity (EA) of hydrogen. Equation [3] and ΔE_3 represent the ionization potential (IP) energy of hydrogen. Equation [4] was obtained from the standard reduction potentials according to

$$2H^+ + 2e = H_2(g)E^0_5 = 0.00 \text{ V}[5]$$
$$2H^- = H_2(g) + 2eE^0_6 = 2.25 \text{ V}[6]$$
$$2H^+ + 2H^- = 2H_2(g)E^0_7 = 2.25 \text{ V}[7]$$

Equation [7] is further converted to [4] through $\Delta E = -nFE^0$ where n is the number of electrons involved in the reaction and F is the Faraday constant. The striking result from this analysis is the same energy associated with [1], [4] and [7]; indicating the bond dissociation energy and redox reaction energy are the same. This conclusion leads to the implication that the charge separation pays no penalty, in contrast to the EA and IP specified in [2] and [3], respectively. The imbalance of EA and IP in [2] and [3] and E^0_5 and E^0_6 in [5] and [6] is also intriguing. It should be noted that [5] and [6] are irrelevant to hydration energy since the potential difference between [5] and [6] in molten salts or other electrolyte media are almost the same.

The energy involved in the cycle [1]-[4] is obviously unbalanced, implying that 295.8 kcal/mol is consumed in the cycle; mostly in the process of ionization. One would notice that steps [1]-[3] are usually referred to the vacuum state, while [4] or [5]-[7] are in the solution environments. The difference is the reference states these energies are referred to, which need to be addressed elaborately. On the other hand, the fact that the energies involved in [1] and [4] are the same magnitude deserves attention. Reactions [5]-[7] relate to the gas

evolution at the electrolyte/electrode interface, releasing 103.8 kcal/mol energy.

We attempt to address the confusing scenarios brought up above. Rationales will be proposed and we hope to stimulate further discussions of other thermodynamic properties related to this system.

ILLINOIS - MULTI-LAYER THIN FILMS

G.H. Miley (Fus. Studies Lab., Univ. Illinois), E.G. Batyrbekov (Nuc. Phys. Inst, Alma-Ata, Rep. Kazakhstan), J.U. Patel (NASA, Johnson Space Ctr., Houston), H. Hora (Dep. Theor. Phys., Univ. N.S.Wales, Australia), R.L. Zich (Microelectronics Lab., UIUC, Urbana, Ill.), and J.W. Tompkins (Rockford Tech. Corp., Vancouver, BC, Canada), "Heat Production with Multilayer Thin-film Electrodes," presented at ICCF4.

AUTHORS' ABSTRACT

Two types of experiments are needed to understand and verify the existence of chemically induced, or "cold," fusion: the measurement of nuclear reaction products and the measurement of excess heat phenomena. In the present research, we have concentrated on the latter, using a unique multilayer electrode design that is predicted to increase reaction rates by increasing the electrode interface area and by using select metals with large Fermi-energy-level differences. Initial experimental studies of heat production by electrolysis, using a multilayer thin-film cathode specially designed on the basis of the "swimming electron layers" theory, are described.

This theory, which is based on the existing knowledge of the electron theory of metals and the interaction of plasma with metal surfaces, suggests that multilayer electrodes comprised of thin films of titanium and palladium would exhibit enhanced cold fusion reactions. The application of this theory to the design of multilayer electrodes was discussed earlier, and the experiments described here are designed as a test of this theory. One major departure from earlier plans was the use of an electrolyte employing LiOH in light water. This was done in view of the consistent positive results from heat experiments reported by various groups using this electrolyte, typically with a nickel electrode. The multilayer cathode is made from a stainless steel plate, 25 mm x 25 mm x 3 mm-thick, coated with alternating layers of Ti and Pd, deposited by a unique e-beam evaporation method specifically developed for this purpose. The cathode has six layers of Ti, alternating with five layers of Pd per side (having a total thickness of 100 A), sandwiched around the stainless steel core, and finished off with a Cr top-coating (60 A thick) on both sides. This outermost Cr layer acts as a barrier layer to retain a high loading of hydrogen or deuterium in the electrode.

The experiment employed a calorimeter technique, which used paired, calibrated electrolytic cells. These cells were identical except that one utilized the multilayer cathode, while the second used a plain stainless steel plate of the same size. A wound Pt wire was used as the anode. Both cells were connected in parallel to the same power supply, in order to provide a matched power deposition. Midway during the experimental run, as an added control, the electrodes were interchanged between the cells.

The temperature of the multilayer-cathode cell was consistently 1.5 ± 0.5 °C higher than that of the reference cell. This corresponds to ~ 2 Kw/cm^3 energy production in the thin-film interface region, assuming reaction occurs, as predicted, over a region extending an electron-Debye length from the interface. The total volume average power, if applicable, would be several orders of magnitude lower than the interface value.

These results must be viewed as very preliminary, since the length of experimental runs has been limited by flaking of the thin layers, probably due to overheating. Also, this preliminary calorimeter technique involves some assumptions that need to be studied. The advantages and disadvantages of this calorimetric method have been considered in detail, and a new design is being constructed. Most of the disadvantages have been eliminated in this design, which provides a closed system and allows simultaneous measurement of both gas and heat production. Also, a new electrode design, with several improvements to increase film stability, has been developed. Experimental results with this newly designed setup will also be discussed.

MASSACHUSETTS - NEUTRON TRANSFERS

Peter L. Hagelstein (Res. Lab. Electr., MIT, Cambridge, MA), "Neutron Transfer Reactions and Lattice-Induced Nuclear Decay," presented at ICCF4.

AUTHOR'S ABSTRACT

Significant energy transfer between nuclei and a lattice can occur when highly excited impurity phonon modes are frequency-shifted in the course of a nuclear reaction. This basic result was reported last year in the case of neutron transfer reactions. This mechanism is now extended to include a larger class of reactions, such as lattice-induced alpha decay, proton decay, beta decay and even lattice-induced fission reactions in the case of high energy transfer.

We reported previously on the possibility that virtual neutrons may be delocalized in a lattice due to coherent resonant exchange scattering. We have developed a field theory to describe this effect, and have succeeded in applying infinite-order Brillouin-Wigner perturbation theory to exhibit explicitly the various coherence and lattice recoil effects. An approximation for the self-energy of the single neutron Green's function has been derived that shows explicitly the coherence factors in the presence of Dicke states relative to site occupation.

The basic theory now includes four classes of reactions: [1] fully coherent neutron transfer reactions that would account for heat and tritium; [2] semi-coherent neutron transfer reactions that result in alphas and gammas; [3] lattice-assisted neutron transfer reactions that result in higher energy incoherent products (gammas, alphas, neutrons, etc.); and [4] lattice-induced reactions that also result in higher energy incoherent products.

MASSACHUSETTS - ELECTRODE REACTIONS

Mitchell R. Swartz (JET Technology, Weston MA), "Isotopic Fuel Loading and Other Reactions Within an Electrode," presented at ICCF4.

AUTHOR'S ABSTRACT

Classical calculations of the activities of an ionic electrolyte next to a metal electrode have been applied to reactions involving loading of isotopic fuel into a metal, and have been used to derive the distributions of deuterium in palladium and solution. However the premise is that the systems are at equilibrium and that may not necessarily be true. Therefore, a quasi-one-dimensional model for an electrode filled by an isotopic fuel was formulated. This may clarify the processes because it indicates how competitive gas evolving reactions at the metal surface and the ratio of the applied electric field energy to thermal energy [k$_B$T] may be decisive in controlling the loading of the metal by the deuterium. We have modified that model and now derive the putative fusion equation which links the deuteron loading flux from the solution into the metal to the reactions within.

Lambda is defined as the ratio of the fluxes [loading flux (J$_c$) to the gas evolution (J$_g$)]. There is conservation of deuterons, with the exception of a small loss (f$_{fus}$) to any fusion reactions. Deuteron entry to the cathode is assumed to be electron limited [with all entry occurring only at the cathode-double layer interface]. [D$^+$]$_i$ is the initial concentration of deuterons in the solution. This equation assumes homogeneity, a simple distribution, and neglects contact potentials. The evolution of D$_2$ gas and loading to the palladium cathode are mutually exclusive. The desired reaction appears to be determined by five terms. The first term is the mutually exclusive loss of deuterons at the cathode through gas evolution. The second term is composed of geometric and material factors. The next two terms are dominated by the ratio of the organizing of the deuterons [by the applied electric field] to the random thermal disorganization. The final term is the fraction of deuterons (not accounted for by gas evolution, or reentry to the solution) which enter any putative fusion process(es).

$$J_f = \left(\frac{2\lambda}{2\lambda+1}\right) \times \left(\frac{B \times \langle D_r \rangle}{L_c}\right) \times \left[\frac{1}{1 - \exp\left(\frac{-qV}{k_B T}\right)}\right] \times \left(\frac{qV}{k_B T}\right)^2 \times f_{fus}$$

MASSACHUSETTS - CAM THEORY

Mitchell R. Swartz (JET Technology, Weston, MA), "Catastrophic Active Medium (CAM) Theory of Cold Fusion," presented at ICCF4.

AUTHOR'S ABSTRACT

The literature contains several models involving fractofusion where the cracks are postulated to create cold fusion phenomena. In contrast, and consistent with theories of adhesion and surface energy requirements, the catastrophic active medium (CAM) theory hypothesizes a two-stage system for cold fusion that ends with the production of the cracks which absorb, rather than create, the energy. The model begins following the loading of isotopic fuel. The cathode is described as being composed of three compartments. Following sufficient deuteron decortication of compartment 1, the reactions occur at select sites of the deuteron-loaded periodic palladium lattice (compartment 2) driven by sudden local catastrophic fractional desaturation of deuterons. As a result of inhomogeneity of heat distribution there begins an in-situ fractional desaturation of the palladium. A resultant deuteron flux out of that volume begins the process. The deuteron diffusion is coupled to the transitions between vibrational quantum states at the start of the process (at lower temperatures). Coupling of the mobile deuterons (via optical phonon modes) to the lattice occurs through polarons. This generates acoustic phonon modes which in turn provide most of the observed excess enthalpy. The polarons may also increase the effective mass of the deuterons improving the likelihood of the desired reactions. This net internal conversion may be augmented by corresponding plasmon flux through the lattice.

The material provides close contact, and synchrony of reactions, of the deuterons but in its fully saturated decompressing state also enables positive feedback. The temperature rises, augmented further as deuterons fuse, and especially as the acoustical and optical phonons become unable to carry off the momentum and excess energy of the reactions. The fusion reactions supply excess heat as the palladium catastrophically releases even more deuterons towards the defect sites - further driving further catastrophic local heating and desaturation. Synchronously through this feedback, astronomical pressures in compartment 2 develop. Electron screening (with the hydrogen overvoltage dominated by that of any alloy, rather than the base metal), high local temperatures, and confinement prior to the next phase, may all facilitate the process. These reactions continue until, by a second catastrophic process, the fusion-site becomes no longer confined. Ultimately, as the desaturation continues, the local diffusivity of the deuterons falls further increasing local temperatures and coupling of the deuteron flux to the lattice. Deformations and cracks appear which cease, rather than are the cause for, the desired reactions. The destruction of the metal/isotopic fuel order creates new lossy pathways (with respect to loading via this compartment 3) with the net degradation of sample functionality. Leakage now occurs and the sample becomes, at best, locoregionally inactive.

MINNESOTA - METALLURGICAL ASPECTS

R.A. Oriani (The Corrosion Research Ctr., U. of Minnesota), "Physical and Metallurgical Aspects of the Entry of Hydrogen into Metals," presented at ICCF4.

AUTHOR'S ABSTRACT

To attempt to optimize the anomalous phenomena that today go under the label "cold fusion" the experimentalist should be aware of the many aspects of the behavior of hydrogen in metals and of its entry into and egress from metals. This paper discusses the equilibrium characteristics of the isotopes of hydrogen in metals. This section discusses the thermodynamics of the terminal solutions of metal-hydrogen systems including the enthalpies of solutions, H-H interactions, effect of third elements, distribution of isotopes between phases, site occupation, and the partial molar volume of hydrogen in metallic solutions. Metal hydrides are briefly considered.

The mobility of hydrogen in a metal lattice is a very large subject. This paper is restricted to the kinetics of hydrogen diffusion, at and above room temperature, with respect to the variation with temperature, hydrogen concentration, isotopic mass and concentration of third elements. A distinction is made between the effects on the mobility and the effects associated with the non-ideality of the solution. The decrease of the diffusivity due to attractive interactions with lattice defects such as those generated by cold work are discussed in terms of trapping theory. Brief consideration is given to diffusion of hydrogen along grain boundaries and along dislocation cores as well as to diffusion motivated by gradients of electrical potential, of temperature and of mechanical stress.

When hydrogen is input from the molecular gas at fixed pressure and temperature, the overall driving force can be expressed in terms of thermodynamic parameters; the kinetic impediments to the ingress of hydrogen control the rate of entry and these are discussed. When hydrogen is presented to the metal by electrochemical means or by partially dissociated hydrogen gas, the driving force for entry into the metal cannot be expressed thermodynamically, although the concept of input fugacity is often used. This concept is discussed and incorrect inferences sometimes made from it are pointed out. The entry and the egress of hydrogen produces mechanical stresses in the metal which modify the thermodynamics of metal-hydrogen systems. They necessitate a distinction to be made between coherent and incoherent phase diagrams, and change the driving force for the exchange of hydrogen between the metal and the environing gas phase. More importantly, the generated stresses can relax by producing dislocations, subgrain rotation, cracks and microvoids. Examples of these phenomena are discussed. The generation of such lattice defects interacts in complicated ways with the intrinsic decohesioning effect of dissolved hydrogen to seriously affect the mechanical properties of metals.

NEW HAMPSHIRE - C.F. IN SPACE

Eugene F. Mallove (Starbound Engineering, Bow, New Hampshire), "Cold Fusion: The High Frontier Implications for Space Technology," presented at ICCF4.

AUTHOR'S ABSTRACT

The confirmation of excess power production and nuclear product evolution in various hydrided metal systems has led many to speculate about technological applications. Here we present a preliminary assessment of how "cold fusion" (CF) reactions may affect the technologies that are critical to space exploration. In particular, the implications for space propulsion systems and for non-terrestrial electric power production are considered and found to be potentially very significant. We find that ion-engine thrusters, which are already a well developed technology, are likely to be the primary beneficiaries of compact cold fusion electric power systems

in space. These are highly efficient engines that are characterized by low thrust/weight, and which are suitable for many deep space missions. It is also possible that high thrust/weight engines that rely on higher-temperature CF reactors could be developed, enabling escape from the surface of celestial bodies, especially Earth. The specific technical parameters of the various engine systems, power modules, and space mission characteristics are compared to define the limits of applicability of cold fusion to space exploration.

NEW MEXICO - TRITIUM PRODUCTION

D.G. Tuggle, T.N. Claytor and S.F. Taylor (Los Alamos Nat. Lab., New Mexico), "Tritium Evolution from Various Morphologies of Palladium," presented at ICCF4.

AUTHORS' ABSTRACT

We have been able to extend our tritium production techniques to various novel morphologies of palladium. These include small solid wires of various diameters and a type of pressed powder wire. In the most successful experiments, the amount of palladium required, for an equivalent tritium output, has been reduced by a factor of 100 over our older powder methods. In addition, we have observed rates of tritium production (>5 nCi/h) that far exceed most of our previous results. Unfortunately, the methods that we currently use to obtain the tritium are poorly understood and consequently there are numerous variables that need to be investigated before the new methods are as reliable and repeatable as our previous techniques. For instance, it seems that surface and/or bulk impurities play a major role in the successful generation of any tritium. In those samples with total impurity concentrations of >400 ppm essentially no tritium has been generated by our gas loading and electrical simulation methods. We plan to discuss these new procedures, present typical results, and speculate concerning the implications for further work.

NEW MEXICO - HEAT PRODUCTION FACTORS

Edmund Storms (Los Alamos National Laboratory, retired), "Some Characteristics of Heat Production Using the "Cold Fusion" Effect," presented at ICCF4.

AUTHOR'S ABSTRACT

Evidence is presented to further show that heat production using the Pons-Fleischmann Effect has a positive temperature coefficient, has a critical onset current density, and originates at the palladium cathode. Numerous studies have shown that the amount of excess power production depends on the D/Pd ratio above a critical value and the area of the palladium having the necessary ratio. The D/Pd ratio is sensitive to chemical conditions that exist on the surface of the palladium. This work shows that these chemical conditions produce a temperature coefficient for the heat producing reaction that imply a barrier energy of ≈ 15 kcal/mole. The large magnitude of this value suggests diffusion in palladium is not the limitation to achieving an increased D/Pd ratio. Studies have shown that an increased cell current causes an increased D/Pd ratio. However, the current needed to achieve the critical D/Pd ratio depends on various factors that are difficult to quantify or control. This work shows that these factors are different between different studies and change with time during a study. These factors seem to be the major reasons for the difficulty in reproducing the effect.

NEW YORK - LONG WHISKERS

Lawrence P.G. Forsley (Dash, Find & Associates, Rochester NY), "Anomalous Surface Morphology and Composition of Electrolyzed PdD Cathodes," presented at ICCF4.

AUTHOR'S ABSTRACT

An experiment involving the electrolysis of LiOD with a Pt screen anode and a Pd cathode gave an apparent heat burst. SEM and x-ray fluorescence analysis of the cathode indicate large differences in surface morphology and elemental compositions between the original Pd and the used cathode. In particular, 1 micron wide and 10 micron long, whiskers dominate the surface of the heat producing cathode. There are also anomalous amounts of Ag at varying, and relatively high, concentrations across the surface, along with other elements. Additional analysis is under way to further characterize the source and concentration of these contaminants, which were not present in the original Pd. We are concerned that contamination may have resulted from either the Pt anode or the borosilicate cell wall.

In addition, Pd cathodes from 2 different batches were used experimentally. The non-heat producing cathode has none of the whisker structure associated with the heat producing cathode. These cells were run in the same cell with .3M LiOD electrolyte. We are awaiting elemental composition analysis of the non-heat producing cathode. Finally, the experimental design may shed some light on whether these are surface or bulk effects.

NEW YORK - TUNGSTEN OXIDES AND BRONZES

Jingdong Guo and M. Stanley Whittingham* (Chem. Dept. and Mat. Res. Cent., SUNY at Binghamton, New York), "Tungsten Oxides and Bronzes: Synthesis, Diffusion and Reactivity," *Int. J. Modern Physics B*, vol 7, nos 23-245, 1993, pp 4145-4164, 56 refs, 13 figs, 5 tables.

AUTHORS' ABSTRACT

The tungsten oxides and bronzes have been extensively studied since their discovery in the last century, because of their brilliant colors and high electrical conductivity. More recently the driving interest resulted from their potential use in electrochromic displays and other electrochemical systems. Their crystalline structures are generally based on the corner sharing of WO_6 octahedra giving tunnels of variable size and shape leading to exciting intercalation chemistry. These structures readily undergo redox reactions, and in

hydrothermal techniques have been used to prepare new sodium tungstates with the hexagonal tungsten bronze and the pyrochlore structures. The phase formed is a function of the pH of the reaction medium. The pyrochlore phase readily undergoes ion-exchange with a wide range of monovalent cations giving the compounds, $M_xW_2O_{6+x/2}$ · yH_2O; the value of y is strongly dependent on the identity of the cation, M. WO_3 with the pyrochlore structure could be formed from the hydronium and ammonium complexes. Lithium can be readily intercalated either chemically and electrochemically into both these phases, just as in the previously-known bronze phases. Surprisingly more lithium is incorporated in most cases in the hexagonal than in the pyrochlore phase. The ions in the pyrochlore structure show rapid ionic mobility, with the hydronium ion showing the greatest mobility.

AUTHORS' CONCLUSIONS

The reaction pathway of tungsten oxides and bronzes is strongly determined by the structure of the compound. Sodium tungstate phases with tunnel structures can be readily prepared by hydrothermal reactions, and the pyrochlore and hexagonal phases are probably the same as those initially reported by Freedman and co-workers. The sodium cations in the pyrochlore phase can be readily ion-exchanged for a variety of other monovalent cations. These cations show high ionic mobility with protonic species being the most mobile under ambient conditions. Lithium can be readily intercalated through a redox reaction. This high ionic mobility and ready redox behavior makes the pyrochlore phase an excellent candidate for the cathode of electrochromic devices. The hexagonal WO_3 phase exchanges less readily with cations, but has a higher capacity for lithium intercalation.

OREGON - TRANSMUTATION EVIDENCE

J. Dash and G. Noble (Portland St. Univ., Phys. Dept., Oregon), "Surface Morphology and Microcomposition of Palladium Cathodes after Electrolysis in Acidified Light and Heavy Water," presented at ICCF4.

AUTHORS' ABSTRACT

We recently reported on the electrolysis of D_2O acidified with H_2SO_4, using a Pd cathode made from a single crystal cold-rolled into a foil. Rimmed craters occurred on the surface of this cathode after electrolysis for 12 minutes, suggesting that localized melting had occurred. We also recently reported on comparative heat measurements during electrolysis from two cells in series, one containing H_2O and H_2SO_4, the other containing D_2O and H_2SO_4, and both containing cold-rolled polycrystalline Pd cathodes. A recombination catalyst was used in both. Excess heat was observed from the D_2O cell for the first 300 hours of operation, after which excess heat was observed from the light water cell for the final 100 hours of operation. Subsequent to our published report, we have begun to study the surface topography and composition of the Pd cathodes from both cells.

A low magnification scanning electron microscope (SEM) photograph of these electrodes is shown in [the ICCF4 abstract]. The appearance of both electrodes is similar. After about 400 hours of electrolysis, the original rectangular cross sections have become oval,

and the original rectangular longitudinal shapes have become tapered. The original smooth, shiny surfaces changed to dull, corrugated topography. Dark spots are present on the lower ends of both cathodes, where the shape changes were greatest. These dark spots most probably were caused by localized differences in topography, but localized differences in chemical composition also were observed by using an energy dispersive spectrometer (EDS) attached to the SEM. EDS gives surface analysis to a depth of about one μm.

For example, [see ICCF4 abstract] is a higher magnification photograph of a small portion of the bottom of the light water Pd cathode. The composition of a smooth area such as A is given by the spectrum in [see ICCF4 abstract]. This relatively smooth, flat area with little contrast appears to have no heavy elements other than Pd. On the other hand, region B, which appears darker and rougher with more contrast, gave the spectrum in [see ICCF4 abstract]. This spectrum shows an appreciable amount of Pt and Au in addition to Pd. Similar spectra were obtained from regions C and D. It is likely that Pt plated from the electrolyte where it occurs due to slow dissolution of the Pt anode. Au, however, is not expected to arise from a pure Pt anode. Nor is it expected to occur inhomogeneously as an impurity in Pd because Au and Pd are completely miscible in the solid state.

A possible mechanism for the occurrence of Au is transmutation caused by neutrons. For example, if the excess heat observed for the light water cell for the final 100 hours of electrolysis was caused by nuclear fusion, then neutrons may have been released. If a neutron is captured by Pt^{196}, it becomes Pt^{197}, which quickly decays to Au^{197}, a stable isotope.

OREGON - Ag TRANSMUTATION

J. Dash and D. Diman (Dept. of Phys., Portland State U., Portland, OR) "Localized Melting and Microcomposition of a Pd Cathode after Electrolysis in Acidified Heavy Water," presented at ICCF4.

AUTHORS' ABSTRACT

We recently reported on the electrolysis of D_2O acidified with H_2SO_4, using a Pd cathode made from a single crystal cold rolled into a foil. Rimmed craters occurred on the surface of this cathode after electrolysis for 12 minutes, suggesting that localized melting had occurred. We also recently reported on comparative heat measurements during electrolysis from two cells in series, one containing H_2O and H_2SO_4, the other containing D_2O and H_2SO_4, and both containing cold rolled polycrystalline Pd cathodes. A recombination catalyst was used in both. Excess heat was observed from the D_2O cell for the first 300 hours of operation, after which excess heat was observed from the light water cell for the final 100 hours of operation. In the work reported here, the same cells were used in series with the same electrolytes, but without the recombination catalyst. The power input to the heavy water (D) cell was maintained at least 0.1 watt less than to the light water (H cell). Although the mass of the D cell exceeded that of the H cell, the temperature of the D cell was the same or higher than that of the H cell throughout the experiment. The change in surface morphology of the heavy water Pd cathode caused electrolysis is shown in [see ICCF4 abstract]. The edges became rounded and spherical globules

protrude from the surface, suggesting that localized melting occurred during electrolysis. Using an energy dispersive spectrometer attached to a scanning electron microscope, chemical composition was determined in regions which had topography suggestive of localized melting. The spectrum is from such a region of about 50 μm diameter. This shows a strong Pd peak at 2.84 KeV, which means that Pd is the main constituent of this region. A spectrum was taken from a surface asperity about 1 μm diameter. This shows that the main Pd peak at 2.84 KeV is absent and the asperity is largely Ag. Other asperities in regions of apparent melting also gave strong Ag peaks and diminished Pd peaks. The strong Ag peaks did not appear, however, in spectra obtained adjacent to asperities. The possibility of electroplating silver from this cell is minimal. The anode was high purity Pt, the electrolyte was made from analytical reagents, and the container was glass. The possibility of Ag occurring as an inhomogeneous impurity in the Pd cathode also is minimal because the Ag-Pd system exhibits complete miscibility in all phases. A possible mechanism for the occurrence of Ag 4 is transmutation caused by neutrons. For example, if the excess heat observed for the heavy water cell was caused by nuclear fusion, then neutrons may have been released. If a neutron is captured by Pd^{108}, it becomes Pd^{109}, which rapidly decays to Ag^{109}, a stable isotope.

TEXAS - TWO TYPES OF TRIGGERING

J. O'M. Bockris, R. Sundaresan (on leave from Bhabha Atomic Research Centre, India), D. Letts and Z.S. Minevski (Dept. of Chemistry, Texas A&M Univ., Texas). "Triggering and Structural Changes in Cold Fusion Electrodes," presented at ICCF4.

ABSTRACT

Two types of triggering the Cold Fusion effects have been studied. The first type concerns electrochemical triggering, employing Low-High Current sequences of the type introduced by Bockris and Hodko and later by Takahashi. During this pulsing, the D/Pd ratio remained at about 0.83. The increase in the electrolyte temperature during the period of high current indicated an excess heat which was ~17% higher than that computed on the basis of classical electrolytic theory. The overpotential measurements on the Pd indicated a value of about 350 and 950 mV during low and high currents, respectively. The other kind of triggering involved Radio Frequency stimulation at MHz frequencies and at 20-100 mW intensity while maintaining the applied d.c. The temperature of the cell electrolyte increased within 30 minutes and the "excess heat" amounted to approximately 24% above that expected on classical grounds. The effect of potential, time and temperature of electrolysis on internal changes brought about within the palladium cathode have been studied in detail. Differential Polarization Interference Contrast Microscopy and Scanning Electron Microscopy were employed to examine the immediate sub-surface of the 50 μm thick Pd electrodes with respect to damage as function of overpotential, time and temperature. At $\hbar$ less than -0.25 V, the electrode appeared unaffected even after 6 weeks of electrolysis. When $\hbar$ was raised to -1.00 V, these cracks developed into localized dimple ruptures within a very short time. At low temperatures the cracks were more dense along the grain boundaries than at room temperature. As the temperature was raised to 50°C, however, the changes were similar to the ruptures seen at high overpotentials. Material changes did not extend beyond 2 μm in depth. The theory of cold fusion has been developed in the light of these results.

TEXAS - SUCCESS FACTORS

D. Cravens (Vernon, Texas and ENECO, Salt Lake City, Utah), "Factors Effecting the Success Rate of Heat Generation in CF Cells," presented at ICCF4.

AUTHOR'S ABSTRACT

Some factors have been empirically discovered to effect the success rate of heat generation in open CF cells. These include:

Preventing cracking of the host lattice by using special alloys (10% Ag in Pd, 5% Re in Pd, 10% Mg in Ni, 15% La in Ni, 5% V/Sn in Ti). Loading at low current densities (< 60 mA/cm^2) until well into the beta phase, delaying addition of poisons (Al, Si, B, Thiourea) until after the beta phase, pre-loading by gas at elevated temperatures, adding materials to increase diffusion rates of D (Li) and using thin films of Pd on Ag to decrease loading stresses.

Initiating reactions by dynamic conditions by rapidly changing the temperature (changes of 30 degrees or heating to 80 degrees C), suddenly increasing the current density (by about an order of magnitude), exposing the cathode to B field variations in the RF range, quickly changing the pressure, vibrating the cathode with ultra-sound.

Avoiding some kinds of contamination by electrolytically cleaning the anode material, placing anode connections well out of the cell, keeping hygroscopic uptake to a minimum, and preventing inclusion of diamagnetic materials at the surface of the cathode.

Selecting host lattice materials by avoidance of voids and fold formed Pd, uniform polishing of cathode surface, avoidance of sharp edges and convoluted forms, identifying good regions electrodes by bubble formation and surface coloration, and using casted and cold rolled materials.

Loading the cathode in a uniform manner by selecting geometry to avoid large variations in E fields over the surface of the cathode, assuring the uniform surface texture of the cathode, avoiding sharp corners on the cathode, proper construction of anode, and using current densities with high cell resistance (>5 ohms) during initial loading stages.

P.S. Load cold and slow, run hot and fast.

TEXAS - THE LETTS EFFECT

Dennis Letts (Energy Research Group LC, San Antonio, Texas), "Triggering Exothermic/Endothermic Effects in Deuterated Palladium," presented at ICCF4.
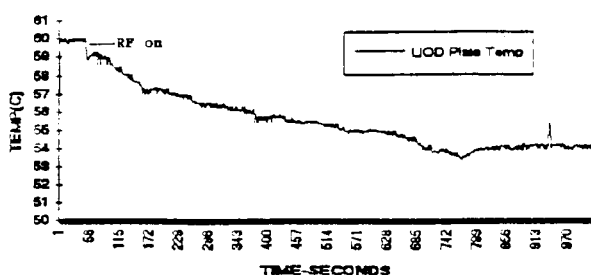
AUTHOR'S ABSTRACT

Investigator will provide detailed data on three experiments conducted during 1993 which measured large and sudden temperature changes of deuterated palladium in response to stimulation with RF energy or by the presence of a permanent magnet.

Experiment 25-5 (fig 1) demonstrates the response of D-Pd system when both cells were stimulated by RF energy at the same specific frequency. Experiment 16-16 (fig 2) is a single cell measurement attempting to repeat the exothermic effect observed in experiment 25-5. The response was endothermic when stimulated by RF energy of a particular frequency, ranging from 10 mW to 300 mW in power. The effect was observed and recorded 6 times during the experiment. The endothermic effect in response to RF stimulation has not been observed since experiment 26-16. Experiment 37-1 (fig 3) is a single cell measurement of temperature increase of deuterated palladium in response to the application of a 200 Gauss field (Arrow 1--2) and then an 800 Gauss field (Arrow 3). Cravens and others have reported similar observations.
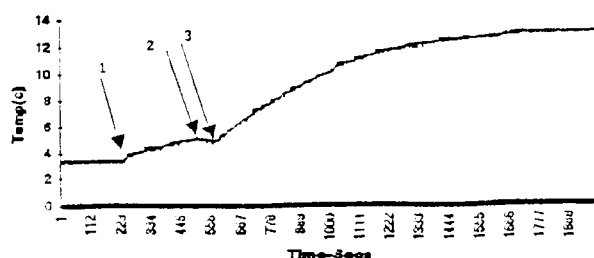
EXPERIMENT 25-FILE 5
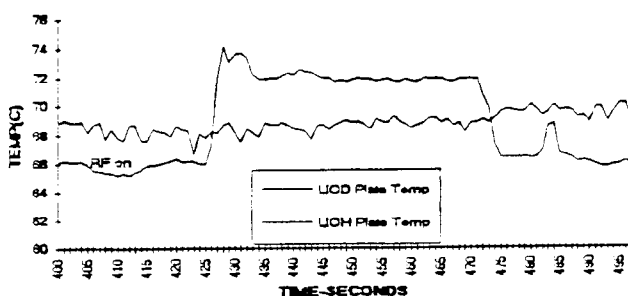
EXPERIMENT 26-FILE 16

EXPERIMENT 37-1

UTAH - COMMERCIALIZATION?

Hal Fox (Editor-in-Chief), "Cold Nuclear Fusion & Enhanced Energy Devices: a Progress Report," presented at ICCF4.

AUTHOR'S ABSTRACT

After four and one-half years of reporting on cold fusion and other enhanced energy devices, a bibliography of over 1500 entries has been compiled from papers gathered and reviewed from over 30 countries. This paper presents a summary progress report with an emphasis on demonstrated devices having commercial potential. An enhanced energy device that has the potential to produce 300% excess energy is defined as having commercial potential. Classes of cold fusion devices that qualify include (1) the Pons-Fleischmann palladium/lithium/heavy water system; (2) the Mills, Bush, Eagleton nickel/ alkali-metal carbonate systems; (3) the Karabut, Kucherov, Savvatimova palladium/deuterium gas plasma system; (4) the Liaw-Liebert molten-salt system; and probably (5) the Kaliev, Baraboshkin, Samgin bronze-crystal deuterium device; and (6) capillary fusion devices. Since March, 1989, the time of the Pons-Fleischmann first public announcement of cold fusion, there has been discovered a rich and diverse number of phenomena that produce nuclear reactions. Although these phenomena had been considered impossible but have been experimentally demonstrated and replicated by serious scientists, the result has been an increase in the serious study of other enhanced energy devices. Examples are DePalma-type N-machines such as (1) the Tewari Motor-generator and (2) the Inomata replication of the Tewari machine. There are claims, as yet not accepted in peer-reviewed literature, of substantial excess power produced by other magnetic and solid-state devices, for example (1) the J.J.Searle "Searle Effect Generator"; (2) the Methernitha TESTATIKA machine; (3) the Orlowski-Johnson Magnatron Motor; and (4) The QRM machine. Other excess energy devices include the Shoulders patented high-density charge cluster device which has been shown to produce more than 30 times excess power. There is evidence that some of these enhanced-energy phenomena have been a part of some of the experimental findings in cold fusion experiments. Some such evidence is presented and sources cited.

[Note: The sci.physics.fusion computer bulletin board on Dec 13, 1993 (Mark Hittinger) proclaimed that the Fox talk was the most damaging presentation (to the believers) given at the ICCF4. "Fox can accomplish in 5 minutes what takes years for Dr. Morrison", stated Hittinger.]

VIRGINIA - BAND-STATE THEORY

Scott R. Chubb and Talbot A. Chubb (Research Systems, Inc., Arlington), "Ion Band-State Fusion: Reactions, Power Density, and the Quantum Reality Question," *Fusion Technology*, 1993, no1 24, no 4, pp 403-416, 23 refs, 1 fig.

AUTHORS' ABSTRACT

The effects that limit deuterium-deuterium (D-D) fusion in bound systems, as opposed to those limiting D-D fusion in free space, are the result of quantum-mechanical particle-particle wave function

correlation, which may inhibit wave function overlap. Whether or not this at room temperature is determined by system energy minimization, not Gamow theory. A counter-intuitive example, known from atomic physics, that demonstrates how this alterative criterion may alter the relevant quantum mechanics is illustrated by the helium atom. At room temperature, near-complete overlap of the two helium electrons takes place when energy is minimized, while Gamow theory predicts negligible overlap. On the other hand, energy minimization does predict that no nucleus-nucleus overlap ever occurs in any normal molecule. In D^+ ion band-state matter, D^+-D^+ overlap occurs if the distributed charge view of quantum reality is correct, in which case D^+ band-state matter converts to $^4He^{++}$ band-state matter, releasing heat throughout a crystal lattice. This occurs in the limit $x \rightarrow 1$ in PdD_x (in agreement with experiments), provided adequate crystalline order is present. Further deuterium loading requires that additional injected deuterium occupy ionic band-like states in which only a small fraction of each additional deuterium atom occupies a lattice unit cell. Then, in each nuclear reaction gain to minimize energy of the entire system, the energy is distributed over many lattice sites, inhibiting production of energetic particles. Theory shows that steady-state power is proportional to the loading current. These points are discussed. An expression for P is derived, and possible cold fusion reactions are summarized.

D. NEWS FROM ABROAD

ALGERIA - COLD FISSION
Chemical Abstracts, 1 Nov. 1993

M. Asghar, N. Boucheneb, G. Medkour, P. Geltenbort, B. Leroux (Inst. de Phys., USTHB, Algiers), "Measurement of Cold Fission for $^{229}Th(n_{th},f)$, $^{232}U(n_{th},f)$ and $^{239}Pu(n_{th},f)$ with the Cosi fan tutte Spectrometer," *Nucl. Phys. A* 1993, vol 560, no 2, pp 664-676.

AUTHORS' ABSTRACT

The light-fragment-group mass-energy correlations for $^{229}Th(n_{th},f)$, $^{232}U(n_{th},f)$ and $^{239}Pu(n_{th},f)$ measured with the Cosi fan tutte, have been used to detect the cold fission probability for these fissioning systems. These are the first results on cold fission for $^{229}Th(n_{th},f)$ and $^{232}U(n_{th},f)$. For $^{229}Th(n_{th},f)$ cold fission is realized for the whole mass range $M_L \approx 80$-99 present in the mass spectrum, but the coldest fission shows up for $M_L \approx 85$. For $^{232}U(n_{th},f)$ cold fission is present for $M_L \approx 84$-107, with the coldest fission manifesting for $M_L \approx 100$-105. In the case of $^{239}Pu(n_{th},f)$, cold fission exists for $M_L \approx 95$-112 and here the coldest fission is produced for $M_L \approx 105$-110. The shells in the nascent fragments seem to play a decisive role in the realization of cold fission. These results are discussed in terms of the existing concepts and ideas on this phenomenon.

CANADA - C.F. AGGLOMERATION

Ernest E. Criddle (Electrochem. Sci. & Tech. Centre, Univ. Ottawa, Ontario), "Evidence of Agglomeration and Syneresis in Regular and Excess Heat Cells in H_2O," presented at ICCF4.

AUTHOR'S ABSTRACT

Dilute colloids of silica, trace metals and likely some bacteria exist as charged particles in aqueous solutions which combine in various shapes, sizes and with various charges. In an electrochemical cell, charged particles migrate and may agglomerate on electrodes unless Van Der Waals forces prohibit agglomeration. Thus, silica may coat a metal with a monolayer but will not agglomerate further unless metal ions are present.

Agglomerates of particles with various sizes and shapes form on an electrode like a house of cards, except the agglomerates are held by the charges. When the current changes, the agglomerate may undergo a dramatic crystalline change called syneresis. This may be a catastrophic change as if someone removed a bottom card from the house of cards. The resultant layer may be much less porous and even quite resistive to ion transport.

Evidence of agglomeration has been observed when the current density to electrochemical cells was changed. For example, the cell heat/watt of a soft Ni cathode ($28cm^2$) and Pt anode ($1.21cm^2$) in K_2CO_3 was being observed in a Pyrex cell by stepping the current every 12 hours and allowing the cell temperature to reach equilibrium. During the 12-hour wait, the cell voltage was averaged in 2-hour steps with readings logged every 30 seconds. The change in cell voltage vs. time is plotted for some of those steps. Voltage rose at lower currents (which was attributed to agglomeration) until the cell reached equilibrium temperature and the next step was initiated. At higher currents, gassing apparently dispersed the agglomeration and cell voltage declined during the 12-hour period.

Plot of cell volts and ΔT/watt vs time [see ICCF4 abstract] during a current step from 45 to 60mA in this cell is shown. Voltage barely changed as agglomerates hardly move at this input; heating per watt was also constant after the initial few hours at a new input. Notice that the cell voltage rises at the start of the 45 mA period. This fine structure is common on well agglomerated electrodes and is deemed to represent a period of syneresis. Here this fine structure is insignificant after the shift to 45 mA and absent during the shift to 60 mA.

[See ICCF4 abstract] shows the plot of similar data for a Plexiglass cell with an air oxidized Ni cathode ($36.4cm^2$) and two Ni anodes with a total area of ($55cm^2$). No glass components were present. The cell had run for two weeks before this cathode was installed and run at 60 mA; 8 hours later the anode bags were installed. This interruption dispersed some agglomerate so voltage fell. Syneresis is credited with the slight rise in voltage before the 60 mA current dispersed more of it. The anode bags visibly extracted colloidal impurities and gas bubbles were trapped in the gel on the cathode side of the bags. The fine structure repeated when the bags were

removed at 26 hours. Reduction of current 45 mA at 75 hours reduced cell voltage as expected but a slow agglomeration period followed until cell voltage at 45 mA exceeded that for 60 mA. In this situation the cell voltage was quite low and stable as described previously by Mills and Kneizys and Noninski. Calibration heat for this cell was 6.8°C/W so this cathode was more thermally active.

EGYPT - D RADIAL MOMENTS
Chemical Abstracts, 1 Nov. 1993

Mustafa M. Mustafa (Fac. Sci. Assiut Univ., Sohag, Egypt), "Radius and Radial Moments of the Deuteron," *Phys. Rev. C: Nucl. Phys.* 1993, vol 48, no 2, pp 929-932.

AUTHOR'S ABSTRACT

New values are extracted for the deuteron rms matter radius $r_D = 1.9547 \pm 0.0019$ fm and the matter radial deuteron moments $\langle r^4 \rangle = 54.2 \pm 0.1$ fm^4 and $\langle r^6 \rangle = 1828 \pm 1$ fm^6 by analyzing the experimental ratio of (e,d) to (e,p) scattering.

FRANCE - COLD FUSION BY SPARKING

J. Dufour (SHELL Research, Lab. Sci. Nucl. CNAM, Paris), Pr. J. Foos, and Pr. J.P Millot (Dep. Sci. Nucl. Appliquées CNAM, Paris), "Cold Fusion by Sparking in Hydrogen Isotopes Energy Balances and Search for Fusion By-products," presented at ICCF4.

AUTHORS' ABSTRACT

In a paper published in the September 93 issue of *Fusion Technology* ("Cold Fusion by Sparking in Hydrogen Isotopes), an experimental set-up was described, to carry out cold fusion reactions by passing sparks through hydrogen isotopes at atmospheric pressure, between electrodes made of palladium or stainless steel. New results have been obtained, using an ozonizer type of discharge, which allows comparative energy balances to be made under identical electrical discharge conditions. Excess energy production up to 100% have been obtained using this approach.

A scheme for possible nuclear fusion reactions, occurring at room temperature, had also been proposed, involving a 3-body collision between 2 hydrogen isotopes and an electron, the simplest of these reactions being:

$$^1_1H + \, ^1_1H + e \rightarrow \, ^2_1H + \text{neutrino} \quad (1)$$
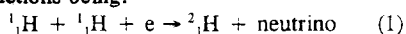
most of the fusion energy being carried away by the neutrino. It was also proposed that successive reactions of that type could take place in the metal, the final stable product being ^4_2He.

We have also analyzed the consequences of a more general type of these hypothetical 3-body reactions involving one hydrogen isotope, a metal nucleus and an electron:

$$^1_1H + \, ^A_zMe + e \rightarrow \, ^A_{z+1}Me + \text{neutrino} \quad (2)$$
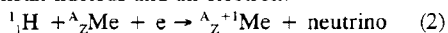
$^A_{z+1}Me$ can then undergo radioactive decay (beta-, X-ray emission ...), depending on the metal used, this decay explaining part of the excess energy produced and the X-ray emission observed. The strategy to find characteristic by-products resulting from reactions (1)

and (2) will be described and preliminary experimental results will be given.

FRANCE - SIMPLE CALORIMETRY

M. Fleischmann, S. Pons, M. Le Roux and J. Roulette (IMRA Europe, S.A. Science Centre, Valbonne, France), "Calorimetry of the Pd-D$_2$O System: the Search for Simplicity and Accuracy," presented at ICCF4.

AUTHORS' ABSTRACT

Our search for high levels of the rates of excess enthalpy generation in the Pd-D$_2$O and Pd-alloy-D$_2$O systems has been based inter alia on the following preconditions and suppositions: (i) that it is necessary to use materials which will withstand the high stresses induced by the experiments; (ii) given that (i) is assured, that it is necessary to adopt particular experimental protocols to achieve excess enthalpy generation at elevated temperatures; (iii) that the protocols (ii) should ensure a high D/Pd ratio under all conditions; (iv) that the protocols (ii) and (iii) should allow one to take advantage of "positive feedback" in the systems; (v) that the systems are sensitive to "hidden state variables" (vi) that the state variables need to be further generalized to take account of cross-terms and of gradients with position. The influence of factors (i)-(v) on the experiment design will be outlined (the factor (vi) will be touched on in a second communication at this meeting). The exploration of even a small part of the parameter space requires the execution of large numbers of experiments while (v) requires that the systems should not be subjected to constraints. Furthermore, the experiment durations are long (typically 10-90 days). It follows that the routine evaluation of these experiments should be based on simple on line procedures so as to cope with the large volume of data generated. At the same time, it is necessary to raise the precision and accuracy of the data treatments so as to ensure a high level of the statistical significance of the derived information. In this paper we will illustrate the ways in which we have sought to achieve the twin objectives of simplicity and accuracy while at the same time ensuring that the data treatments assess the validity of the modelling of the calorimeters.

FRANCE - Pd GAMMA PHASE

M. Fleischmann, G. Larramona, S. Pons, H. Sugiura (IMP-.A Europe, S.A. Science Centre), and G. Preparata (Univ. Milan, Italy), "Alfred Coehn and after: the Alpha-Beta-Gamma of the Pd-H System," presented at ICCF4.

AUTHORS' ABSTRACT

The Pd-H and Pd-alloy-H systems have been investigated for more than 100 years and, following the discovery of D, these studies have been extended to the Pd-D and Pd-alloy-D systems. The bulk of these investigations have dealt with:

    i) the behavior of H and D in the dilute a-phase

    ii) the thermodynamics of the transition to and the structure of the B-phase.

It is frequently asserted that these studies give no support for the notion that D dissolved at high activities in Pd and Pd-alloys can take part in novel nuclear reactions; these assertions are made notwithstanding the fact that there is no satisfactory model which can explain the properties of these strange materials.

The major illustration of the unsatisfactory nature of the currently accepted models is provided by the investigations of Alfred Coehn: a series of experiments carried out in the late 1920's and early 1930's showed that hydrogen in palladium is present as protons and experiences the full changes of the Galvani potential within the metal. We will trace the fate of this generic observation and indicate its importance to the development of the investigation of anomalous nuclear processes in host lattices.

We will illustrate also that these anomalous nuclear processes take place under conditions which have not been covered by the conventional studies of the "hydride phases", (i) and (ii). Recent measurements of the loading of the host lattices with H and D as well as of diffusion of H and D under the extreme conditions used in these studies indicate that a third, γ-phase is formed. The significance of this phase for the observation of anomalous nuclear processes will be discussed. It will be shown that the experiments of Alfred Coehn can be developed to give new insights into the behavior of the "hydride phases".

FRANCE - HEAT AFTER DEATH

S. Pons and M. Fleischmann (IMRA Europe, S.A., Valbonne), "Heat after Death," presented at ICCF4.

AUTHORS' ABSTRACT

We have described elsewhere that Pd and Pd-alloy electrodes cathodically polarized in D_2O solutions under extreme conditions can drive the calorimetric cells to the boiling point. We have then adopted the procedure of allowing the cells to boil to dryness. For these conditions the galvanostats are driven to the rail voltage (100V) but the cell current is reduced to zero. We have then found that cells which contained D_2O frequently remain at high temperatures (in the vicinity of 100°C) before cooling rapidly to the bath temperature. Cells containing H_2O can also be driven to the boiling point but such cells cool immediately on terminating the experiments. This phenomenon has become known as "Heat after Death" (the death referring to cessation of polarization). Calibrations of the cells for such conditions show the generation of high levels of enthalpy at zero enthalpy input. Methods of investigating such systems will be outlined and we will also refer to related observations by other research groups.

FRANCE - SCREENING & RESONANCE

Michel Rambaut (Bures-sur-Yvette, France), "One Can Account for Cold Fusion by Two Concepts: Screening by Electrons and Harmonic Oscillator Resonance," presented at ICCF4.

AUTHOR'S ABSTRACT

In a plasma, the role of electrons has been largely underestimated, in spite the "Screening Concept" was born early during the fifties. So if one considers two "fusible" nuclei, deuterons for example in a dense medium, and if one suppose that they are sufficiently close together, one has to take into account the specific nature of perturbation they impose to their environment. A potential well is created during a very short time, at the place of the two ions. Given the high velocity of electrons, in comparison with the one of the ions, a great number of environmental electrons can be trapped in this well. The creation of this well necessitates that two deuterons are approaching sufficiently close together. The trapped electrons are coming from the immediate proximity of the two approaching deuterons, causing an electron depopulation around the two deuterons. So the immediate environment becomes constituted by positive ions. This is conceivable since this trapping which causes the crossing of their mutual coulomb barrier by the two ions, lasts a very short time, typically between 10^{-14} and 10^{-12} second.

The unbalance of electron charge repartition, referred often to their polarizability, increases transitionally the Coulomb electrical potential at the place of the two colliding deuterons. In return this increase deepens the potential well, and could contribute to maintain the electron cloud around the two deuterons. So nuclear fusion reactions are possible for a two deuteron low relative velocity. This model appears to be common at the same time to various kinds of deuterated plasma: plasmas produced by collisions, plasmas made of deuterium absorbed by certain metals such as palladium, titanium, vanadium, or plasmas produced by high voltage capacitor discharges.

But given that the process is drastically different from the one occurring in a thermonuclear medium, the macroscopic fusion reaction production must be ruled by a specific production term T, different from the "usual" thermonuclear one. The results of calculations exhibit a linear relationship between Log T and Log E, with T = (σFL) / θ (σ the nuclear cross section, F the transmission barrier factor, L the effective barrier width, θ the barrier crossing duration, E the deuteron energy in the mass center system of reference). The slope p of the straight line representing the linear relationship corresponds to an electron accumulated constant number n around the two colliding deuterons. This slope p is bounded by two approximate limits,
$$1.3 < p < 1.8,$$
n being of the order of one to two thousands for p=1.3, and rather in the range of some hundreds for p=1.8. The corresponding linear relationship can be represented by:
$$\text{Log } (T/T') = p \text{ Log } (E/E') \tag{1}$$
But this model taking only into account the electron trapping by a potential well does not describe in what circumstances adequate deuteron collisions are occurring. One gets a view about a specific circumstance where adequate collisions followed by electron accumulation can occur, taking into account the results of high voltage capacitor discharge into deuterated media.

In some cases the fusion reaction production, which is most frequently detected by a neutron burst, is supposed to occur by sausage instability, after injection of a sufficient amount of energy into the deuterated medium. But the most interesting experiments are

the ones where there is no excess energy when the neutron burst occurs. In this case the onset of this burst coincide with the current apex. This occurrence suggests a resonance phenomenon, which could take place, just when the current begins to decrease. Given the short current wave pattern, no collective acceleration is possible, and this resonance cannot occur at an another level than at the particle level. The basic harmonic oscillator is constituted of one deuteron and of k electrons surrounding one deuteron. During the current increase, the harmonic oscillator is mildly submitted to electrodynamic forces, with a resonance frequency $\Omega = (2(kq)^2/mr^3)$ (r being the mean distance between deuterons, q the elementary charge, and m the deuteron mass). One can verify that this frequency is in the range of 10^{14} rad/s.

For simplifying, one can assume a sawtooth current pattern, with a leading edge duration θ_0, and a trailing edge θ, and a Lorentz force acting on the deuteron, whose velocity is supposed v_0, at the current apex. Assuming moreover that the deuterated medium has a cylindrical shape with a radius p, the maximum velocity attainable by the deuteron during the harmonic oscillator resonance, in the middle between the axis and the outer part of the cylinder has the following expression, I being the current at the apex:

$$f = \frac{\mu_0\, q\, v_0\, I}{m\Omega^2\, 4\pi\, \rho}\left(\frac{1}{\theta_0} + \frac{1}{\theta}\right)$$

(2)

The initial electron velocity is proportional to the integral of the current square $\int i^2\, dt$, between the onset and the apex. As this integral is proportional to current square at the apex I^2; and assuming that $\theta \ll \theta_0$, the deuteron energy is proportional to the sixth power of the apex current and inversely proportional to the square of the current decreasing duration:

$$E = I^6\, \theta^{-2}$$

(3)

Given that, for a specific medium density, the nuclear fusion rate is proportional to T, one gets:

$$\text{Log } R'/R = p\,[6\,\text{Log }(I'/I) + 2\,\text{Log }(\theta/\theta')]$$

(4)

The p value p=1.66 corresponds to the slope of Log R versus Log I, observed by J.D.Sethian et al.. This result is also in agreement with the pure stochastic point of view, which leads approximately to n such as $10^3 < n < 2\times10^3$ electrons around two colliding deuterons :

$$R'/R = (I'/I)^{10}(\theta/\theta')^{3.3}$$

(5)

In the case where there is an excess energy introduced into the deuterated medium, the deuteron energy is proportional to 14:

$$\text{Log } R'/R = p\,\text{Log }(I'/I)^4$$

(6)

One can recover the I^5 law observed in this case by J.D.Sethian et al. too, with a lower value than in the preceding case p, which would correspond to a greater number of electrons trapped by the potential well. the supplementary harmonic oscillator hypothesis gives a new confirmation to the trapped electron model (also called double screening model). As it has been shown in references, this model is also in agreement with the cluster fusion experiments performed by R.J. Euler et al.

INDIA - LIGHT WATER COLD FUSION

H. Ramamurthy, M. Srinivasan (Neutron Phys. Div., Bhabha Atomic Research Centre Bombay), U.K. Mukherjee, P. Adi Babu (Process Instr. Sys. Div., Bhabha Atomic Research Centre), "Further Studies on Excess Heat Generation in Ni-H₂O Electrolysis," presented at ICCF4.

AUTHORS' ABSTRACT

This paper presents the results of the further studies carried out at our Centre since the Nagoya conference, on excess heat generation during the electrolysis of alkali carbonate solutions in H_2O using nickel cathodes, confirming the findings of Randell Mills and his collaborators -- first reported in 1991. The corresponding measurements on tritium production are described in a companion paper to be presented in this conference. The basic experimental set up and calorimetric technique were essentially similar to that described in our Nagoya paper. All the electrolytic cells are of the open type and deployed double walled glass dewars (commercial thermos flasks). In the more recent experiments, the outer plastic container of the flasks was replaced by a 1000 ml glass beaker and the double walled dewars themselves were desilvered using dilute HNO_3 wash (after breaking the outer to obtain transparent see-through cells). With this the calibration constant which was earlier in the 20 to 35°C/W region diminished to values in the range of 7 to 10°C/W. Correspondingly the time duration to reach steady state also decreased from about 24 hours to about 10 hours. Each cell had two thermocouples (TCs) for temperature measurement, one located in the upper region and the other closer to the bottom of the cells. No stirrer was deployed. The temperature difference between the upper and lower thermocouples was less than 0.6°C at steady state in most of both during calibration as well as electrolysis. The difference in average temperature at steady state between the operating cell and that of an identical non- operational dummy was taken as a measure of the heat generation in the cells. The cells were calibrated using resistance heaters. A bank of 5 cells and one dummy were run at a time. The cathodes were mostly made of nickel. Different types of nickel were studied. The Pt wire anode was usually in the form of a coil wound around the flat nickel plate cathode mounted in a teflon frame. A few runs were however also made with the Pt anode in the form of a foil mounted parallel to the cathode. Although the majority of the runs used U frame design for holding the cathode, several experiments were also run with a sandwich type design wherein the Ni cathode was sandwiched between a pair of perforated teflon plates around which was coiled the Pt wire anode. The electrolytic solution was either 0.57 M K_2CO_3 or 0.1 M Li_2O_3 (natural or enriched in ^6Li) or 0.57 M Na_2CO_3.

As described in our Nagoya paper, cell voltage, current and temperature data were recorded continuously on a Yokogawa hybrid analog-digital multichannel paper chart recorder. In addition, the data was also simultaneously recorded on a Personal Computer for possible offline or online data processing.

In all 13 series of experiments were conducted, each with 5 cells (labelled XB to XQ series) during the three month period from Nov. 1992 to Aug. 1993. The steady state temperatures of the cells were recorded for various input Joule powers up to a maximum of 3W. In the XB, XD and XE series (Nov-Dec 1992) run immediately after

the Nagoya meeting, surprisingly none of the cells gave any excess heat. The only change effected in these experiments was the deployment of sturdy SS sheathed mineral insulated copper-constantan TCs instead of PVC sheathed and insulated copper-constantan TCs, to avoid frequent problems arising from the corrosion of the exposed hot junction by the electrolyte. In the XF series (7th Jan to Mar 1993) we therefore went back to use of PVC sheathed TCs. This resulted in all the 5 cells showing excess heat once again. **In a couple of cells which were showing excess heat, when an SS tube was dipped into the solution the excess heat vanished after a lapse of time (1 day) and was restored when the SS was removed.** The exact mechanism by which the excess heat phenomenon is suppressed by the presence in the solution of stainless steel is not yet clear. In all subsequent series of experiments, the SS sheathed TCs were therefore further encased in a glass tube to avoid contact between SS and electrolyte.

There was a second month frustrating phase (6th Mar to 9th May 1993) when the data points were very erratic. The calibration curve was periodically shifting. This was eventually traced to introduction of very low value (80 milliohm) shunts for measuring currents in place of the earlier 1 ohm manganin coils. This resulted in erroneous current measurements arising from contact resistance also contributing at times to the current measuring circuit. Once this problem was resolved and rectified, all (but one) of the subsequent series once again showed excess heat in at least a few of the five cells.

Excess heat has been observed both with U frame and sandwich design. As for electrolyte, K_2CO_3, Li_2CO_3, ^6Li enriched Li_2CO_3, and in a few cases even Na_2CO_3 solution has given excess heat. Also both solid Ni and porous Ni inclusive of fibrous Ni material similar to that used by R.T. Bush has indicated excess heat.

Excluding the experiments in which either SS sheathed TCs were used or 80 mΩ shunts were used, 28 cells were studied. Of these 14 have shown excess heat. One of the main observations arising from the post Nagoya series of experiments is that the excess-over-dummy-cell-temperature-points fall on a line which is more or less parallel to the calibration curve, indicating that the margin of excess power is approximately constant for a given cell, independent of input current or joule power, supporting the observation of Randell Mills, the originator of the concept of generating excess heat using electrolytic cells. In the present experiments the absolute magnitude of excess power was in the region of 0.2 to 0.7 W. This means that for Ni - H_2O cells, it is inappropriate to express excess heat as a percentage of input joule power. We now realize that it is futile to raise the range of power levels of operation of the cells to a maximum of 10 or 15 W, with a view to increasing the amount of nuclear transmutation products such as Ca from K, if any is produced. It appears that with a typical Ni cathode surface area of about 20 cm_2 (both sides) the maximum excess heat margin obtainable in our cells is less than 1 W. Efforts have been initiated to see if pulsed operation as recommended by Randell Mills will improve the overall energy gain.

As reported in our companion paper the electrolyte in several of these cells has shown low tritium concentrations of 3.5Bq/ml at the end of the runs.

INDIA - T IN LIGHT-WATER CELLS

T.K. Sankaranarayanan, M. Srinivasan, M.B. Bajpai and D.S. Gupta (Bhabha Atomic Res. Ctr.,Bombay), "Investigation of Low Level Tritium Generation in Ni-H_2O Electrolytic Cells," presented at ICCF4.

AUTHORS' ABSTRACT

At the Nagoya meeting, we had reported measurement of relatively large amounts of tritium in the electrolyte of several cells following electrolysis of aqueous (H_2O & D_2O) alkali carbonate (K_2CO and Li_2CO_3) solutions, using Ni as cathode and Pt as anode. Observation of tritium even when the electrolyte did not contain any D_2O (other than natural abundance) was a surprising new finding which has been met with considerable skepticism. We ourselves would have had less faith in the results were it not for the fact that at least one cell (cell# OM-3 with enriched Li_2CO_3 solution in H_2O) which was monitored every few days, showed a steadily increasing tritium level reaching a maximum value of ~225 Bq/ml at the end of about a month (See Fig.8 of our Nagoya paper). Thereafter the tritium data points oscillated in sawtooth fashion between a minimum of ~150 Bq/ml and a maximum of ~230 Bq/ml, over the next 45 days. This part of the behavior of cell # OM-3, obtained after the Nagoya paper was written up, was puzzling. While it could possibly be interpreted as attainment of an overall saturation level in the (190 ÷ 40) Bq/ml region, our confidence in the stability of the counting set up and accuracy of the sampling microdistillation techniques, suggests that perhaps the tritium concentration in the electrolyte did actually increase and decrease. Admittedly, this is a conclusion which is rather difficult to accept, as it implies existence of a strong mechanism for removal of tritium.

As mentioned in the Nagoya paper, the earlier tritium measurements were carried out at the Isotope Division which handles tritium samples of varying strengths received from other research groups in BARC Iso. To be on the conservative side only levels above 10 Bq/ml (twice background counts) were quoted. To ward off the criticism that the tritium observed in our samples could perhaps have altered as cross contamination, either during microdistillation or subsequent counting of the samples, a new low noise liquid scintillation counting set up was acquired, exclusively for our use. It was installed in a laboratory where no other tritium samples or any other type of radioactivity is handled. The stability and calibration of the new counting set up was checked by recording background counts and standard sample (2301 dpm/ml) counts almost daily over a three month period and found to be very satisfactory. Freshly procured "Triton X-100" based liquid scintillation cocktail was mixed with the distilled samples in the proportion of 10 to 1 for counting. The 0.57 M K_2CO_3 and 0.1 M Li_2CO_3 (Mat and enriched) solutions which were freshly prepared were checked for initial tritium content, if any, prior to charging into the electrolytic cells. In all ever a hundred samples have been distilled and counted so far using the new counting set up.

Six new cells labelled OM-4 to OM-10 were set up specifically to study continuous tritium build up. The outlet of cells were connected

to a trap containing Pt based recombination catalyst. The recombined water was also analyzed for tritium content. Some cells had a mixture of H_2O and D_2O in the electrolyte. The electrode assemblies were of flat plate type with Ni cathodes and Pt wire anodes. The cell currents were quite low ($\leq$ 60 mA). Some cells were driven by a pulsing unit (intermittent d.c. operation) as proposed by Randell Mills. Samples of electrolyte from all these cells were monitored at intervals of about 3-4 days for tritium content over a period of about 2 months. Of these cells, OM-7 (Li_2CO_3 in 25% D_2O) and OM-9 (Li_2CO_3 in H_2O) showed measurable tritium levels. Counts were several times background values. Both these cells have unambiguously indicated oscillatory type of variation of tritium levels between a maximum value of 3.5 Bq/ml and background counts. The fact that during the rising phase or falling phase several data points of counts fall on a straight line, clearly indicates that the oscillatory behavior is real and not attributable to any counting errors or artifacts. Similar oscillatory behavior has also been reported by several other workers such as Sánchez et al. and Chien et al.

Electrolyte samples from the cells used for calorimetric measurements conducted at the Process Instrumentation Systems Division (PISD) (see Abstract of companion paper by H. Ramamurthy et al.) were also analyzed for tritium. Only the analysis of samples from XO series (June 93) onwards are considered here as only these were counted using the new counting set up described above. Of the 15 PISD cells whose samples were counted, more than 50% have indicated low level tritium production (<3.5 Bq/ml).

In conclusion, while it may be stated that tritium production in Ni-H_2O cells at levels of a few (<3.5) Bq/ml stands confirmed, the quantum of tritium measured so far (during the period June - Aug '93) is far below that reported at Nagoya. It must be emphasized here that since cell currents were generally low, operating temperatures above ambient and make up water continuously being added, levels of tritium in the Bq/ml range cannot be accounted for by electrolytic enrichment process. Likewise the fact that many other samples have not given counts above background, clearly indicates that contamination from stray sources, atmosphere etc cannot be the source of the tritium reported in this paper.

ITALY - IMPROVED REPRODUCIBILITY

L. Bertalot, F. De Marco, A. De Ninno, A. La Barbera, F. Scaramuzzi, V. Violante (ENEA, Roma) "Deuterium Charging in Palladium by the Electrolysis of Heavy Water: Production of Heat Excess," presented at ICCF4.

AUTHORS' ABSTRACT

An experiment on the electrolysis of heavy water with palladium cathode and anode was performed in 1992, showing clear positive results, and its results were communicated to ICCF3. The particular geometry of the electrolytic cell permits to gather information about the permeation of deuterium in the palladium lattice. A set of second generation experiments has been started in 1993, in which the calorimetry has been refined, and the data acquisition system has been enriched. Positive results have already been obtained, with an encouraging feeling about the reproducibility of the phenomenon.

New runs are in program in the near future. The results of these experiments will be reported.

ITALY - PULSE LOADING OF Pd

F. Celani, A. Spallone, P. Tripodi, A. Nuvoli, A. Petrocchi, D. Di Gioacchino, M. Boutet (INFN-LNF, Frascati), and P. Marini, V. di Stefano (SKITECH-IRI, Pomezia), "High Power μs Pulsed Electrolysis for Large Deuterium Loading on Pd Plates," presented at ICCF4.

AUTHORS' ABSTRACT

After the interesting results (excess heat) obtained, during the 1992, by cycled low-high currents (6+6 h) In electrolysis using proper cold-worked Pd plates (Tanaka and IMRA, Japan), we have studied the pulse effect on the loading D/Pd ratio and an eventually related excess heat. In particular, we are looking for a stationary dynamic state in order to get a continuous excess heat production. It is a common opinion, and experimentally proved, that a very high D/Pd ratio is a necessary condition to initiate Cold Fusion processes. A very high current density produces high D absorption in the Pd plate, detectable by a related electric over-potential at the cathode; the Tafel equation gives the relationship between the current density and the over-potential.

Last year we confirmed the A. Takahashi results: the concentration of D in a pure Pd electrode (D/Pd) can be significantly increased by a 'sawtooth absorption-desorption procedure.' In that procedure the current is sharply switched off in order to allow a partial desorption of the Pd electrode. The required time for the absorption step is strictly related to the electrode thickness and current density. If a high, superficial, D/Pd value is required, the sawtooth process can be reduced to a high-power pulsed current, in which the dead time between two pulses should be related to the diffusion path of the deuterium along the actual electrode thickness.

According to this idea, and considering that the deuterium inlet into the electrode is essentially a surface-controlled process, we tried to apply pulsed current to a pure Pd cathode (Tanaka KK Japan) with an extremely large hardness value (300 Vickers under patent). Peak voltage, current density, width, and frequency have been the main control parameters of our experiments. We realized a specific pulsed electric current circuitry to supply the electrolytic cell. A very short time-width (1.5 μs), high current (up to 150 A) and very high power (up to 60 KW) pulse is generated with a repetition rate between 50 and 20.000 Hz; the current pulse rise time is about 0.3 A/ns. A proper circuitry was developed to measure the electric pulsed power absorbed by the cell and the mean current flowing through the electrodes. An electronic-controlled pressure gas system was arranged (operating with electro-valves) in order to measure the gas developed because electrolytic water dissociation, and then to compute the D absorbed by the Pd. A computer controlled system was used to get (in real time) all the physical parameters (temperatures, pressures, voltages etc.).

The Tafel law, known at low direct current, was found in accordance with our data even at high pulse current densities (up to 10 A/cm²), although depending by the peak pulse current amplitude instead of the mean one. Very high D/Pd values ($>$ 0.95) were reached and the

Pd plate was D-loaded and deloaded several times without bending effects. A measurement of D adsorption vs. time was performed and the deuterium diffusion coefficient in the palladium was studied, in particular during the D desorption. This study can provide the amount of D concentration in the deep of Pd plate. It seems that a very high D concentration occurs even into the thick layer of the plate. The over-potential has to be correlated with the D/Pd value and the study of this correlation is under progress.

A small but significant amount of excess heat occurred at the beginning (in a few hours) of the first D-loading of the Pd plate: It seems that a very high surface D/Pd was reached in short time (hours) and it is no possible to impute this to a bulk effect. We are deeply studying the parameters' optimization of the system (pulse amplitude. shape and repetition rate) in order to get a continuous excess heat relating to D-absorption and over-potential values. Some preliminary results obtained by the previous optimization are very promising.

ITALY - 1000 HOUR He MONITORING

Daniele Gozzi, Giovanni Balducci, Riccarda Caputo, P. Luigi Cignini, Guido Gigli, Massimo Tomellini (Dipartimento di Chimica, Università La Sapienza. Roma, Italy), Salvatore Frullani, Evaristo Cisbani, Franco Garibaldi, Mauro Jodice. G. Maria Urciuoli° (Laboratorio di Fisica, Istituto Superiore di Sanità, Roma, Italy), "Excess Heat and Nuclear Product Measurements in Cold Fusion Electrochemical Cells," presented at ICCF4.

AUTHORS' ABSTRACT

Recent results obtained in a new experiment by our multicell set-up will be presented. The experiment has been implemented with respect to the past mainly by:

a. Mass spectrometric quantitative measurements of ^{4}He in the gas stream escaping from the electrochemical cells (experimental details of the adopted method are presented by us in a separate contribution at this meeting). In the present contribution, it will be shown the ^{4}He time-pattern as measured on six cells for more than 1000 hours. Some tentatives to correlate the ^{4}He data with other independent findings will be presented as well as the effect of a possible air contamination as suggested by the ^{20}Ne tests made simultaneously to the ^{4}He measurement;

b. Modification of the Pd cathode design both to test our theoretical ideas on the role of current on D charging and to show as the electrochemical confinement of D depends on the current. In fact, one of the cells has been prepared with a Pd cathode containing a Au core acting as blocking interface for migrating deuterons. A secondary d.c. circuit has been connected between the Au core and a surface spot-welded platinum thin sheet. Preliminary results obtained indicate that it is possible to control the D confinement by both the primary (electrolysis current) and secondary current. Due to external catalytic recombination, deuterium release in the gas phase by the Pd cathode has been measured by mass spectrometry

only when the D_2/O_2 ratio exceeds that in D_2O. Well-defined increases or decreases of the D_2 signal have been detected decreasing or increasing one of the two currents. Other results concerning excess heat and low values of excess of tritium will be reported together with neutron measurements carried out by the Jomar-Camberra high efficiency 60-^{3}He tubes neutron detector.

ITALY - HELIUM 4 DATA

Daniele Gozzi, Giovanni Balducci, Riccarda Caputo, P. Luigi Cignini, Guido Gigli (CNR-Centro Termodinamica Chim. alle Alte Temp., Dip. Chim., Univ. "La Sapienza," Roma), Massimo Tomellini (Dip. Sci. e Tec. Chim., Univ. "Tor Vergara," Roma), Salvatore Frullani, Evaristo Cisbani, Franco Garibaldi, Mauro Jodice (Lab. Fis., Ist. Sup. di Sanità, Roma), G. Mana Urciuoli (Nat. Inst. Nuc. Phys., INFN sez. Sanità, Roma), "Helium-4 Quantitative Measurements in the Gas Phase of Cold Fusion Electrochemical Cells," presented at ICCF4.

AUTHORS' ABSTRACT

A single focusing magnetic mass spectrometer (12", 60°) has been used in order to quantitatively evaluate the ^{4}He content in the gases produced by a multicell electrochemical cold fusion experiment. Boiling off liquid nitrogen was used as a carrier gas in order to flush the cells; the overall gaseous mixture, after passing through a D_2 removing system and Pd powder, has been collected into stainless steel cylinders 500 cm^3 in volume. These samples, transferred to the mass spectrometer. have been made to be absorbed in active charcoal at liquid nitrogen temperature prior to the admission into the mass spectrometer ion source. The overall sensitivity obtained tenths of pA per He ppb, led to an estimated minimum detection limit of 0.03 He ppb.

The mass spectrometer has been operated with a resolution power set at values over 700 in order to ensure a complete separation of ^{4}He and D_2 peaks irrespectively of the relative amounts. Although the mass spectrometer could not be operated in a fully static way, the emission of the collected sample into the valved off ion source produced ^{4}He signals lasting some minutes which allowed to measure, at the ppb concentration level, both the maximum intensity of the ion and the intensity vs. time integral. Calibrations performed with nitrogen-air mixtures to cover the He concentration range from ppm to ppb showed the linearity in the measurements. The ^{4}He background, originating from the collecting lines, D_2 removing system, and transferring procedure, was shown to be at the units of ppb level with measures taken before the beginning and during the cells charging period. Approximately 250 measurements have been performed during the electrolysis experiment itself and ^{4}He concentrations exceeding the background have been found in several cases (see other contribution of the same group presented at this meeting).

Nevertheless, during the experiment. in order to fully confirm that the ^{4}He measured was generated in the cell, we were led to look for a marker which could indicate a contamination with air. To this end

Neon was used. It was possible to perform nearly simultaneous measurements of Neon and Helium ion intensities. The contribution to the ion intensity measured at the nominal mass 20 attributable to the ^{20}Ne isotope had to be disentangled from those provided by deuterated water isotopes and doubly ionized Argon. While the ^{20}Ne peak and the adjoining mass 20 peak due to the deuterated water were almost resolved in the spectra discrimination between the Ne$^+$ and Ar^{++} ion signals has been accomplished by operating at different ionizing electron energy.

ITALY - THEORETICAL IDEAS

G. Preparata (Dip. Fis., Univ. Milano and INFN, Sezione di Milano), "Cold Fusion '93: Some Theoretical Ideas," presented at ICCF4.

AUTHOR'S ABSTRACT

The main problems of the most studied Cold Fusion system - the Pd/D system - are of two types:
(i)   the structure of the Pd/D phase.
(ii) the Cold Fusion mechanism in the Pd/D system

The general theory of QED coherence in condensed matter will be applied to these problems in search of a deep understanding of the vast and reproducible Cold Fusion phenomenology. The very encouraging results of this analysis will be illustrated and discussed.

ITALY - SHADOW MODEL

A. Scalia (Dip. Fisica dell'Università, Catania INFN, Catania, Italy), "'Door' Energies in Sub-Barrier Fusion at Very Low Energy," *Il Nuovo Cimento*, vol 106A, no 6, 1993, pp 855-858, 6 refs, 1 table.

AUTHOR'S SUMMARY

"Door" energies are found in the framework of the "shadow" model for sub-barrier at very low energy. It is suggested to solve the solar-neutrino problem by using these "door" energies.

ITALY - TRITIUM vs. TEMPERATURE

F. Lanza, E. Parnisari, C. Ronsecco (Inst. Adv. Mat., JRC Ispra, Italy), "Influence of Temperature on the Production of Tritium Due to Deuteration of Ti-Zr Shavings and Pd Based Catalysts," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 42-49, 3 refs, 3 figs, 2 tables, in Italian.

AUTHORS' ABSTRACT

The investigated materials were deuterated with deuterium gas at low temperatures. The tritium produced was obtained as a balance between the tritium present in the incoming gas and the tritium obtained from the materials after high temperature degassing. Ti-Zr

shavings have been deuterated at temperatures ranging from 350°C to 550°C, while palladium catalysts have been treated between -35°C and 0°C.

In both cases a clear decrease in tritium production has been detected with the increase of temperature. The dependence is more clear in the case of palladium catalysts. At the temperature of -27°C a tritium concentration has been obtained which is 70% higher than the initial value in deuterium gas.

ITALY - COLD FUSION AT CISE

P.G. Sona (CISE Spa, Segrate, Italy) with A. Battaglia, L. Buzzanca, N. Radatti, F. Barberis, A. Capelli, R. Berti, D. Capra, A. Tosi, I. Ciaccolini, L. Dentri and G.A. Costa (Chem.-Phys. Inst., Genova Univ., Genova), "Experimental Activity on Cold Fusion in CISE," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 50-59, 7 figs, in Italian.

AUTHORS' ABSTRACT

A short description is given of three types of experiments: 1) search for heat production in D$_2$ dry charging of Zr-V-Ni alloys, with precise calorimetry; 2) Mills-type electrolytic experiments (nickel cathode in H$_2$O + K$_2$CO$_3$ or Na$_2$CO$_3$) and 3) tritium measurements in electrolytic cells with nickel cathode and D$_2$O + K$_2$CO$_3$. Mass balance method has been used, with a separate analysis of solution and recombined D$_2$O. The first and third experiments did not produce positive results. In the second experiments strong recombination effects were found, causing apparent heat excess, if ignored. [Post meeting analysis of new running experiments gave positive results: Tritium production ($\sim 10^{10}$ atoms per cell in about 2 weeks) has been found in 5 cells of a total of 6, with palladium cathode in D$_2$SO$_4$ and with separation between anodic and cathodic compartments.]

ITALY - Pd - Rh ALLOYS IN COLD FUSION

G. Mengoli, M. Fabrizio (IPELP CNR, Padova), C. Manduchi, E. Milli, and G. Zannoni (Dip. Fisica "G. Galilei," Padova), "Anomalous Effects During the Electrochemical Insertion of Deuterium into Pd-Rh 5% Alloy," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 60-67, 6 figs, 1 table, in Italian.

AUTHORS' ABSTRACT

Pd-Rh alloy constitute a useful host material for deuterium to achieve cold fusion for the following reasons:
    -More deuterium may be loaded in these alloys than in pure palladium;
    -The resulting deuterides have high decomposition pressures so that significant changes of ration deuterium-to-metal is induced by temperature variations in the range 25-100°C;

-The mechanical properties of the alloys are maintained during repeated loading/unloading runs.

After the electrochemical insertion of deuterium into PdRh 5% alloy it was found that:

-A neutron emission (<1 n s^{-1}) is always paralleling the initial conversion of the alloy into deuteride;

-Afterwards, although neutron emission may start again, it is hard to say whether neutrons are really emitted or whether we are dealing with background fluctuations;

-There is however, a way to distinguish a real emission from the background: a temperature increase from 25° to 90°C quenches any neutron emission.

The latter phenomenon is likely accounted for by deuterium loss from the metal host paralleling the temperature increase. The described results are quite reproducible; in addition, although the investigation was not specifically designed to assess anomalous thermal effects, during an experiment it was estimated that the enthalpy excess output was around 10 W against a power input of around 0.5 W.

ITALY - TRITIUM PRODUCTION

G. Mengoli, M. Fabrizio (IPELP CNR, Padova), C. Manduchi. E. Milli, and G. Zannoni (Dip. Fisica "G. Galilei," Padova), "Systematic Determination of ^{3}H During the Electrolysis of D$_2$O/ 0.1 M LiOD at Pd Sheet Cathodes," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 68-73, 1 ref, 3 figs, in Italian.

AUTHORS' ABSTRACT

Three experiments, utilizing similar Pd sheet cathodes but different cell geometry, were performed: the electrolyses were lasting 1-3 months. Evolution with electrolysis time of ^{3}H content both in the electrolyte and in gas was systematically followed. ^{3}H was determined by a scintillation spectrometer: uncertainty of the measurements was minimized by carrying out a set of at least 9 determinations of 2000 s each for any sample and averaging from different samples. In the first experiment, ^{3}H in excess of isotopic enrichment provisions was observed since the first days of electrolysis: ^{3}H production later ceased and eventually restarted (after 1 month). In the second experiment ^{3}H excess (mainly in the gas) was measured after more than 1 month of electrolysis. In the third experiment, a steady ^{3}H production was going on "ab initio" and was deliberately stopped by reverting the current. The overall ^{3}H excess tested in each run ranged from 1.1011 to 1.5 [sic, probably 1-1.5 x 10^{11}] atoms with about 15% uncertainty.

Obstacles are the things you see when you take you eyes off the goal. —Ray Blignant

ITALY - NEUTRON EMISSION

G. Mengoli, M. Fabrizio (IPELP CNR, Padova), C. Manduchi, E. Milli, and G. Zannoni (Dip. Fisica "G. Galilei," Padova), "Neutron Emission from the Interaction of D$_2$ with either Ti or Pd Based Alloys," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 68-73, 1 ref, 3 figs, in Italian.

AUTHORS' ABSTRACT

A possible neutron emission from Ti / D$_2$ system was investigated by the method originally devised by the group of Frascati. After repeated loading/unloading of the same Ti sample and several thermal cycles between room temperature and -197°C carried out for about 1 week, the first significant neutron emission took place from the sample maintained at room temperature under vacuum. Neutron emission (>10 standard deviations) went on periodically for about 2 weeks. The reaction between D$_2$ and Pd-Rh and Pd-Ag alloys was investigated by an isochoric method where the temperature, slowly decreasing from 900 to 25°C was the driving force of absorption. Indeed, fluctuating absorption/desorption processes occurred since the higher temperatures, and were paralleled by neutron emission: however, the maximum emission was recorded towards room temperature when maximum loading was approached. Conversely, no neutron emission generally occurred from quiescent fully loaded samples.

ITALY - HEAT & TRITIUM

Francesco Celani, Antonio Spallone. Paolo Tripodi, Anna Nuvoli (INFN Nat. Lab., Frascati), and Basilio Polichetti (Dip. Fis., Univ. Salerno), "Measurements of Excess Heat and Tritium During Self-biased Pulsed Electrolysis of Pd-D$_2$O," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, p 139, previously submitted at ICCF-3 in Nagoya, 1992.

AUTHORS' ABSTRACT

Following the Takahashi results about large excess heat by pulsed electrolysis, we built a gas-closed flow calorimeter to perform pulsed current electrolysis. Some blank tests, using Au plate cathode, were carried out to characterize the system. Four cold-worked Pd sheets were tested and two of them produced 7.5% and 6% of mean excess heat for many weeks. The other Pd sheets did not produce excess heat through one of them. after a deuterium reloading. gave up to +25% of excess heat but only for few hours. Tritium analysis was carried out and some coincidence between tritium production and excess heat was found.

ITALY - EXCESS HEAT FACTORS

L. Bertalot, F. De Marco, A. De Ninno, A. La Barbera, F. Scaramuzzi, V. Violante, P. Zeppa (ENEA, Frascati), F. Cilloco, R. Felici (CNR ISM, Frascati), "Electrolysis in LiOD with Pd Electrodes. Considerations on D-Pd Loading and Excess Heat Generation," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 140-160, 10 figs, in Italian.

AUTHORS' ABSTRACT

Last year (1992) experiments performed in Frascati by the ENEA team were aimed to relate excess heat measurements with other critical parameters. The experimental set-up is the same already described in the Proceedings of ICCF3 in Nagoya. A membrane electrode was used having one face in electrolyte and the other in D gas. Particular care was devoted to calorimetrical aspects. In several runs we studied the effect of pulsed current period, current density, voltage variations, deuterium flux through membrane. Excess heat evidence (several times the input power) is related to an anomaly in Pd membrane behavior. Anomalies in the behavior of Pd when loaded with hydrogen isotopes in concentration of about 0.8 H(D) per Pd atom are reported. The emerging picture seems to point out that a phase transition should be responsible of most of the anomalies and closely connected to heat excess generation. D on Pd loading has been studied measuring the lattice parameter with an X-ray spectrometer during electrolysis. A first experiment performed shows that after about 300 hours of electrolysis, the D/Pd ratio is around 0.8. Further runs are planned to state the influence of loading ratio on the raising of the excess heat phenomenon.

ITALY - COLD FUSION THEORY

P.G. Sona (CISE spa, Segrate), "Phenomenological and Theoretical Aspects of Cold Fusion," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 161-178, 9 figs, in Italian.

AUTHOR'S ABSTRACT

After a brief discussion of the known phenomenology, a model is presented (in course of formalization) based on localized heavy fermions and on a strong bosonic correlation in deuterons wave function. The electrons-deuterons system is treated in Born-Oppenheimer approximation. The deuteron correlations may lead to a coherent tunneling of Coulomb barrier, reducing the Gamow factor to its square root, and inducing as dominant channel the reaction D + D → ^{4}He + energy of deuteron fluid. The energy is released in an delocalized way to the whole coherence domain of ~0.1 microns. The model predicts the formation of special correlated phase of the deuteron fluid with high thermal stability. The importance of studying the kinetics of formation of this phase is stressed. Also phenomenological consequences are discussed related to the (not dominant) radiative channels T + p, ^{3}He + n, X-ray production.

ITALY - COMPUTER MODELING

Simone Melchionna (Chem. Dept., "La Sapienza" Univ., Roma) and Alexander Tenenbaum (Phys. Dept., "La Sapienza" Univ., Roma), "Atomistic Simulation of Thermodynamic Instability in Pd-D," Proceedings of the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, pp 205-218, 29 refs, 1 fig, 2 tables, in Italian.

AUTHORS' ABSTRACT

We have started a microscopic study of the Pd-D system, with the aim of testing the scenario foreseen in the Collapsing Lattice Model (CLM) of cold fusion (Tabet and Tenenbaum), namely that a thermodynamic instability could lead to a sudden and coherent collapse of some regions in the metal lattice and to a deuteron's drag toward the spots where the energy released during this collapse is concentrated. This study will be based on a combination of Molecular Dynamics and Monte Carlo techniques, in order to simulate the very slow (on a microscopic scale) D diffusion process which produces the nucleation of the high- and low-concentration regions. If a collapse begins, a full dynamical simulation would then give a detailed description of the mechanism of energy and deuterons concentration. So far, we have developed a Molecular Dynamics program which simulates the Pd-D system at equilibrium, reproducing its more relevant physical characteristics. In particular, the model exhibits the strong dilation due to the D concentration, which plays a fundamental role in the CLM.

ITALY - PALLADIUM HARDENING

Francesco Celani, Antonio Spallone, Paolo Tripodi, Anna Nuvoli (INFN Lab. Nat., di Frascati), and Basilio Polichetti (Dip. Fis., Univ. Salerno), "Metallurgical Properties of Palladium Plates in Cold Fusion Experiments and Geometrical Aspects of Sample-Holder," presented at Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, in Italian.

AUTHORS' ABSTRACT

We found a sort of correlation between working process of palladium plates and their physical properties: hardness and density. In cold fusion experiments specific procedures are adopted for the preparation of the palladium plates: "special" atmosphere during melting (and subsequent cooling-down) and cold working. Then two kinds of cold working are adopted: forging and rolling. In respect to the melting and cooling-down process, two separate ways are used: controlled atmosphere (nitrogen or vacuum) and free air. Up to now, the plates that give anomalous excess heat come from free air process, although at low repeatability.

The cold-working process increases the hardness of plates in [comparison to its natural hardness], due to the "normal" melting process. Moreover, the increase of hardness takes place after a quite long time (some months) by constant current electrolysis and after a shorter time (some weeks) by pulsed electrolysis (low-high current density periods of some hours, like Takahashi procedure). Annealing

(700°C. nitrogen atmosphere), even for a short time (10 min.), causes the reduction of hardness to values close to the "normal" melting process.

We observed that the D/Pd ratio achieves the largest values increasing hardness and decreasing density. Up to now, the best results in pulsed electrolysis are obtained using palladium plates provided of hardness as large as 170 Vickers and density as low as 11.8 g/cm³ (instead of standard value of 12.0 g/cm³ for pure palladium). Finally, we observed a dishomogeneous hardness distribution in the surface of palladium plates after pulsed electrolysis: maximum at central area and minimum at the border lines. therefore, we built an improved sample-holder that, by proper electrical field geometry, reduced greatly the highly deleterious effect of deuterium degassing at the border lines.

ITALY - NEUTRON RADIATION OF Pd

B. Stella[1,2], F. Celani[3], M. Corradi[1], F. Ferrarotto[1], N. Iucci[2], V. Milone[1], A. Spallone[3], and G. Villoresi[2,4] ([1]INFN Sezione di Roma at: Dip. Fis., Univ. "La Sapienza", [2] Dip. Fis., Univ. Roma III, [3] Lab. Nazionali INFN di Frascati, [4] Ist. Fis. Spazio Interplanetario - CNR Frascati), "Excess of Neutrons Coming Out of Deuterated Palladium Samples Irradiated by Prevalently Thermal Neutrons," presented at the Rome Workshop on the Status of Cold Fusion in Italy, Università di Roma III, 14-16 Feb. 1993, in Italian.

AUTHORS' ABSTRACT

In order to study the effect of palladium lattice in cold fusion, metallic deuterated Pd specimens have been irradiated with neutrons from partly moderated Am/Be source and the resulting neutron intensity has been measured by the FERMI apparatus, an advanced detector for moderated neutrons. After subtracting the vessel + (empty) Pd contribution, measured in "blank" runs, in excess of 14.7 ± 0.6 neutrons s^{-1} ($\approx$ 4% of the total measured rate) has been detected, corresponding to several outgoing neutrons for each neutron impinging on the Pd-D samples. We find < 1 MeV average energy of the excess. Similar measurements with fast neutrons gave lower effects. The repetition of this experiment with the same Pd samples in somewhat different conditions gave a much lower excess. The distribution of the time interval between two subsequent neutron pulses was also independently studied.

Systematic errors in the first experiment, due to the slightly movable position of the source, cannot be excluded, but it doesn't seem to be a likely explanation for the whole of our results. The process can be interpreted as enhanced d-d fusion in a Pd-D_x lattice perturbed by slow neutrons. This effect would demonstrate that the palladium lattice strongly increases the probability for d-d fusion even almost at rest, addressing a key issue of solid state fusion.

JAPAN - NEW TYPE Pd CATHODE

Yoshiaki Arata and Yue-Chang Zhang (Osaka University, Japan), "A Remarkable Excess Heat Generated Using a New Type Pd Cathode," presented at ICCF4.

AUTHORS' ABSTRACT

A new type cathode, a double structure cathode which contained another Pd inside a Pd-rod was developed, the inside cathode having many advantages. Such double structure cathode (DS cathode) was electrolyzed to be deuterized for a long period. Using this cathode, remarkable excess heat larger than the input energy was observed consistently after a certain incubation period.

Experiment and discussion: A closed cell system as a experimental apparatus was used, and the cell was set in a commercial vacuum bottle and the water cooling coil was built inside the cell (internal cooling method). Fig. 1 shows the characteristic of the temperature change of the inside cathode, the electrolyte and the cooling water during electrolysis: Tc and Tl indicate the inside cathode temperature and the electrolyte temperature of the neighborhood of the cathode surface, and To and Tl indicate the inlet and outlet temperature of the cooling water respectively. Here, Tc-To, Tl-To and ΔT[:Tc-Tl] can be noticed as important parameters, and Fig. 1 shows that Tc is higher than Tl and the maximum value of ΔT is 3.5°C. Fig. 2(a) shows the relation of input energy(Qin) and output energy(Qout) at every six hours, and a unit of these energy is [KJ], Fig. 2(b) shows the relation of out power [Watt] and input power [Watt]. In these data, it seems that the output is two times the input for about one month. Fig. 3 shows the change in the excess heat rate ϵ^*(= (Qout-Qin)/Qin[%]) at every six hours, in which its incubation period was about a half month, and it can be seen that the excess heat rate restores quickly compared with its incubation period, after the input energy put into zero, electric source switch off, during 20 minutes. Using the new developed DS-cathode as mentioned, the excess heat rate ϵ^*[%] have been recorded to ϵ^* approx > 100% for a long period. Authors want pay attention to the characteristic of the ϵ^*[%] be extended over a long period without deciding the cause of the heat generation hastily at time. With regard to DS-cathode, it will be described with details in next report.

JAPAN - H/D LOADING OF ALLOYS

H. Akita, Y. Tsuchida, T. Nakata, Akihiko Kubota, Akiko Kubota, M. Kobayashi, Y. Yamamoto, N. Hasegawa, N. Hayakawa and K. Kunimatsu (IMRA Japan Co. Ltd., Sapporo, Japan), "Electrolytic Hydrogen/Deuterium Absorption into Pd, Rh and Pd-Ag Alloys in Fuel Cell Type Closed Cell," presented at ICCF4.

AUTHORS' ABSTRACT

Significance of high loading by deuterium in palladium cathodes for excess heat generation has been well recognized since the recent works to correlate quantitatively excess heat and deuterium loading

ratio D/Pd. However, the experimental conditions for the high loading is not fully understood yet because the loading can be influenced by many experimental parameters. The aim of the present report is to review important parameters controlling electrolytic loading of hydrogen and deuterium into Pd and Pd-based alloy cathodes based on data obtained in our laboratory. Possible factors controlling cathode loading are: (1) cathode materials. (2) cathode pretreatment, (3) surface modification, (4) electrolyte (5) electrolyte current density or cathode overvoltage, (6) temperature.

Experimental details of electrolysis method utilizing a fuel cell anode in a pressurized closed cell for *in-situ* determination of hydrogen/deuterium loading in cathodes have been described elsewhere.   The electrolysis was conducted mostly under galvanostatic conditions. The loading ratio H(D)/M, where M stands for the cathode metal, has been determined mostly from the pressure decrease of hydrogen or deuterium gas in the cell after the electrolyte was started. In some cases the loading ratio was determined also from cathode resistance measurements in order to check consistency between the loading data obtained by the two methods. The effect of cathode materials on the loading was studied by comparing the loading on Pd, Pd-Rh alloys and Pd-Ag alloys. A composite of palladium and silver made by diffusion joint of those plates using a plasma sintering method was also studied and its loading characteristics was compared with other materials.

Cathode pretreatment was standardized to polishing, degassing in vacuo at 200°C for three hours and electrochemical surface cleaning by scanning electrode potential between 0.4 V and 1.5 V(vs. RHE) at 50 mV/sec. for ten minutes under hydrogen or deuterium gas before pressurizing the cell. Effect of surface modification was studied in two ways: firstly by adding catalytic poison such as thiourea which is adsorbed on the cathode surface and inhibits the hydrogen desorption process, 2H (adsorbed) → H_2. The organic substance like thiourea can be used only in the fuel cell type cell in which potential of the fuel cell anode during electrolysis is not high enough to evolve oxygen and consequently thiourea is not oxidized at anode. Secondly, the Pd surface was modified geometrically by a sputtered gold film leaving a minor portion of the Pd surface exposed to the electrolyte. The electrolysis current is focused to the exposed Pd surface at which the actual current density could be much higher than the nominal (average) current density over the cathode surface. The loading of hydrogen into such a Pd cathode would be higher because of the higher cathode overvoltage.

The effect of electrolyte was studied focusing on the difference between acids and bases and in particular on the role of alkali metal cations in the hydrogen loading into Pd cathode. The study has led eventually to loading experiments in alkaline solutions without alkali metals, i.e. tetramethyl ammonium hydroxide. The effect of electrolysis current density was investigated by measuring dependence of H(D)/Pd on current density up to 1 A/cm². The dependence was converted to the dependence on cathode overvoltage for hydrogen evolution which was measured with respect to the reversible hydrogen electrode, (Pt/Pt), in the same solution, and was corrected for the IR drop between the cathode and RHE.

The effect of temperature was studied by observing change of cathode loading by hydrogen/deuterium when temperature was changed from 10°C to 60°C. The temperature change was executed in two ways: firstly, cathode loading was determined at each

temperature in different cells, and secondly the temperature change was given after the cathode loading of hydrogen in 1M LiOH and of deuterium in 1M LiOD has reached 0.94 and 0.85 respectively at 10°C. The temperature dependence at the high loading conditions both for hydrogen and deuterium were studied in this way.

The results are summarized briefly as follows:
1.   All the factors studied have significant influence on cathode loading
2.   The cathode loading is strongly reduced by the presence of alkali metal cations, in particular potassium ions, in the electrolyte.
3.   High current density is of primary importance for higher loading.
4.   D/Pd on Pd higher than 0.9 can be achieved by surface modification.
5.   D/M = 1.0 can be achieved for Pd-Rh alloys, where M= Pd + Rh
6.   Cathode loading determined by resistance measurement is consistent with data obtained by pressure measurement.

Experimental data to support these conclusions and their significance in the excess heat measurements will be discussed.

JAPAN - He & T WITH EXCESS HEAT

T. Aoki, Y. Kurata, H. Ebihara (Isotope Center, Univ. of Tsukuba, Japan) and N. Yoshikawa (Inst. of Nuc. Study, Univ. of Tokyo, Japan), "Study of Concentrations of Helium and Tritium in Electrolytic Cells with Excess Heat Generations," presented at ICCF4.

AUTHORS' ABSTRACT

Concentrations of He and T in electrolytic cells were studied by several methods. The cells used were composed of heavy water (LiOD) and light water (LiOH) baths, Pd cathodes and Pt anodes, Pd black recombiners and gas bags. The cells were softly sealed for gas cyclic calorimetric systems. The Pd cathodes with dimensions of 30x25x lt (sic) were sandwiched between 50x50x0.lt (sic) Pt anodes. Concentration of He gas was measured by a gas chromato-graphic method during electrolysis. Production rates (He atoms/sec) were (4.5 ± 1.5)x10¹⁰ for the D_2O cell with the excess heat, and (4.1 ± 1.5)x10¹⁰ and (3.9 ± 1.5)x10¹⁰ for the two H_2O cells without the excess heat generation. Therefore net He production rate for the excess heat was (0.5 ± 2.1)x10¹⁰ He atoms/sec, which corresponded to (2 ± 8)x10⁻² W, assuming that the origin of the excess heat was the reaction of d + d = α + 23.8 MeV. Since the excess heat production rate measured by the calorimetric method was 4.8 ± 1.0 W, disagreement between these was the order of (4 ± 1.6)x10⁻³. Concentration of DT gas in the same cell was measured by a homemade proportional gas chamber. Gaseous samples of 20 cc were taken from the electrolytic bath and were put into the chamber. The energy spectra from 0.1 keV to 12 keV were always measured. The difference of counting rate before and during the excess heat generations was 0.03 ± 0.04 cps. Therefore, we had no meaningful T increase in the gas phase. Concentration of DTO in the heavy water bath of the cell with the excess heat of 3.4 ± 1.0 W during 16 days were measured by a liquid scintillation counter. Net increased disintegration counting rate before and after the excess heat

generation was 1.0 ± 0.03 dpm/cc, which corresponded to $(5.6 \pm 0.2) \times 10^9$ T atoms in the bath. If this total T atom was produced by the reaction; $d + d = t + p + 4.03$ MeV, the expected excess heat was $(3.6 \pm 0.1) \times 10^{-3}$ J. However the observed amount of the excess heat was 4.7×10^6 J. The difference was the order of 10^{-9}. It might be concluded that the extremely small increases of He and T atoms in gas and liquid phases in the cells could not explain the amounts of excess heat.

JAPAN - MAX. TEMP. IN SONOFUSION

Kenji Fukushima and Tadahiro Yamamoto (Dept. Phys., Tokyo Metro. Univ.), "Sonofusion: Maximum temperature of hot spots," presented at ICCF4.

AUTHORS' ABSTRACT

Recently sonoluminescence attracted a great attention of researchers in a variety of fields of science and technology. The brief introduction of the phenomenon is as follows: As well known, a supersonic field applied to a liquid induces the cavitation in it and cavities thus created oscillate radially more or less in phase with the applied supersonic pressure field. In their contraction phase the gas contained in a cavity is greatly, adiabatically compressed and as a result a hot spot of high temperature and high density is instantly created in the liquid. The facts are indeed probed through luminescence from the hot spot.

Flint and Suslick succeeded in directly measuring the temperature of hot spots in a silicon oil through the analysis of the spectra of luminescence from C_2 molecule and obtained the value $T = 5075 \pm 156$K. Recently Hiller, Putterman and Barber obtained the value of $\sim 6eV$ for hotspot temperature fitting the spectra of luminescence from air bubble in water to those of black-body radiation. Consequently there arises a scientific problem of how high the maximum temperature of hot spots induced by a supersonic field is and the purpose of this work lies just in solving it.

Since its discovery about fifty years ago the sonoluminescence has intensely been studied and now constitutes a well-established branch of science. Particularly bubble dynamics has been developed and successfully applied to the problem by many authors, starting with fundamental hydro- and thermodynamic principles. We at first ignore the compressibility and viscosity of the liquid, and assume the spatial uniformity for the gas content. Furthermore we introduce the polytropic index κ to approximately describe intermediate processes between isothermal process and adiabatic one, i.e., $PV^\kappa = constant$, where κ takes on values between unity (isothermal limit) and the specific heat ratio γ (adiabatic one).

The equation of motion for the radius of a cavity takes the form of

$$\ddot{R} = -\frac{3}{2R}\dot{R}^2 - \frac{1}{\rho R}\left[\left(P_0 + \frac{2\sigma}{R_0}\right)\left(\frac{R_0}{R}\right)^{3\kappa} - \frac{2\sigma}{R} - \frac{4\mu\dot{R}}{R} - P_0 - P_A(t)\right]$$

where R_0 is the initial radius of the cavity. The cavity is assumed to be initially static in equilibrium with hydrostatic pressure P_0 and $P_A(t)$ is the applied supersonic field such as $P_A(t) = -p_A \sin \omega_A t$. ρ, σ and μ are the density, surface tension and viscosity coefficient, respectively. For definiteness the equation of state of ideal gas is assumed.

The figure depicts the maximum temperature T_{max} reached by a hot spot against initial radius R_0. Here we assumed the adiabatic process with specific heat ratio $\gamma = 1.4$ for the contraction phase and used such parameter values for supersonic field that $P_A = 4$ bar and $\omega_A = 15$ kHz. The differences in the maximum temperature and pressure between ideal gas content and van der Waals one are less than one percent. Of ^R course the minimum radii of collapsed cavity are quite different. On the other hand it turned out that different values of polytropic index κ cause only small change less than ten percent in the maximum temperature and pressure.

It is remarkable that T_{max} reaches temperatures of order of 10^8 Kelvin when R_0 is less than 10 micron, which is high enough to cause high-temperature fusion if the gas content is deuterium. Not to say we have made a lot of simplifications in the calculation. Particularly we found that the velocity of the wall of cavity exceeds the sound speed of the liquid when R_0 is less-than 5 micron, which means the inadequateness of the assumption of the incompressibility for it. We shall show what happens for a compressible liquid.

JAPAN - C.F. IN FUEL-CELL TYPE CELL

Norifumi Hasegawa, Nana Hayakawa, Yukimi Yamamoto, Keiji Kunimatsu (IMRA Japan Co.,Ltd., Sapporo, Japan), "Observation of Excess Heat During Electrolysis of 1M LiOD in a Fuel Cell Type Closed Cell," presented at ICCF4.

AUTHORS' INTRODUCTION

In our previous paper, we reported correlation between excess heat generation and deuterium loading ratio during electrolysis of 1M LiOD in a fuel cell type closed cell up to D/Pd=0.89. The aim of the present study is (1) Confirmation of reproducibility of the previous result using different kinds of palladium from different sources. (2) Measurement of excess heat for D/M higher than 0.9 by increasing D/M according to the following two methods. 1) Surface modification of the Pd cathode by addition of thiourea (THU) in electrolyte. 2) Using Pd-Rh alloys as cathodes. (3) Clarifying the role of D/M in the excess heat generation.

AUTHORS' ABSTRACT

Measurement of excess heat and D/M during electrolysis was conducted in a hermetically sealed cell containing 1 M LiOD pressurized by deuterium gas in which a gas diffusion electrode was employed as an anode. Palladium cathode materials obtained from IMRA MATERIALS (I/M), Tanaka Kikinzoku (TNK), Johnson Matthey (J/M) were used for the excess heat measurements in order to examine the performance of different Pd materials from various

sources. The surface of the palladium rods were polished with 1 μm alumina with or without subsequent etching in conc. HNO_3. They were then degassed in vacuum at 200°C for three hours. Extending the excess heat measurements to the region where D/M > 0.9 was realized either by surface modification of Pd by THU or by employing Pd-Rh alloys as cathodes.

AUTHORS' RESULTS AND DISCUSSION

Reproduction of excess heat generation on various Pd cathodes. Figure 1 and 2 show the dependence of excess heat on current density and on loading ratio respectively on various Pd cathodes. The results show that all Pd except one made by TNK gave rise to excess heat generation. Excess heat appears to be almost proportional to current density, the critical current density to give rise to excess heat being close to $200mA/cm^2$. The data is in agreement with those reported by Pons and Fleischmann and by our lab. Figure 2 shows that the excess heat generation becomes prominent around D/Pd = 0.84. The data is in agreement with those reported by McKubre et al., and with our previous data. Excess heat generation was not observed on Pd made by TNK even for current density higher than $200mA/cm^2$ because D/Pd didn't reach 0.84 in that particular experiment. The excess heat was not observed either in the electrolysis of 1M $LiOH/H_2O$. We can summarize that excess heat is observed on different kinds of palladium above $200mA/cm^2$ and for D/Pd > 0.84. Measurement of excess heat for D/M > 0.9. D/M > 0.9 was achieved either by addition of THU in electrolyte or by using Pd-Rh alloys as a cathode. The results will be discussed in terms of the role of D/M in the excess heat generation.

JAPAN - Pd-Rh ALLOY CATHODES

Nana Hayakawa, Norifumi Hasegawa, Yukimi Yamamoto, Keiji Kunimatsu (IMRA Japan Co., Ltd., Sapporo), "Electrolytic Deuterium Absorption by Pd-Rh Alloy Cathodes in Fuel-cell Type Closed Cell", presented at ICCF4.

AUTHORS' INTRODUCTION

It has been shown recently that the excess heat generation during electrolysis of LiOD depends on the deuterium loading ratio in the cathode; critical loading ratio for excess heat generation is ca. 0.84, above which the excess heat increases with increasing loading ratio. However, for Pd cathodes it is not easy to increase and maintain the loading ratio higher than 0.9 under ordinary electrolysis conditions. Therefore, in order to enhance deuterium loading, we tried to modify Pd surface by addition of thiourea (THU) into 1 M LiOD, which resulted in the maximum deuterium loading ratio of 0.94. On the other hand, there have been many studies in the hydrogen absorption characteristics by Pd-based alloys, and it has been reported that hydrogen loading ratio of PdRh alloys are higher than that of Pd. The purpose of the present study is to investigate the hydrogen/deuterium loading into Pd-Rh alloys of various compositions as a function of electrolysis current density and hydrogen overvoltage.

AUTHORS' ABSTRACT

The electrolysis was conducted in a fuel-cell type closed cell containing 1M LiOD/LiOH and pressurized by D_2/H_2 gas in which

a gas diffusion electrode served as an anode. Pd-based alloys with various Rh contents, Pd-5at%Rh, Pd-10at%Rh, Pd-15at%Rh, were used as cathodes. The deuterium/hydrogen loading ratio was determined from the D_2 or H_2 gas pressure decrease after initiation of electrolysis.

AUTHORS' RESULTS AND DISCUSSION

Figure 1 shows the dependence of the deuterium loading ratio on the overvoltage on Pd, Pd-5at%Rh and Pd-10at%Rh, respectively. The loading ratio on Pd-Rh alloys increases with Rh content as well as overvoltage. Maximum deuterium loading ratio on each cathode is as follows: D/Pd = 0.89 on Pd, D/M = 0.95 on Pd-5at%Rh, and D/M = 1.0 on Pd-10at%Rh. Figure 2 shows the initial stage of the electrolytic deuterium loading at $50mA/cm^2$. We can see that the deuterium loading process on Pd-Rh alloys slows down while the steady value of D/Pd becomes higher with increasing Rh content. It is clear from Figure 1 that deuterium loading ratio close to 1.0 can be easily achieved on Pd-Rh alloy cathodes. The measurement of the excess heat during electrolysis of LiOD by Pd-Rh alloy cathodes would play an important role in the investigation of the relation between excess heat generation and deuterium loading ratio in D/M > 0.9 region.

JAPAN - NEUTRON EMISSION

Shigeru Isagawa, Yukio Kanda and Takenori Suzuki (Nat. Lab. for High Energy Phys., Tsukuba-shi, Ibaraki -ken, Japan), "Search for Excess Heat and Trial to Reproduce the Anomalous Neutron Emission from Palladium-Deuterium Electrolysis Cells," presented at ICCF4.

AUTHORS' ABSTRACT

In order to determine whether the claimed excess heat has its origin in nuclear reaction or not, the power imbalance as well as neutron and γ emissions have been continuously pursued on several sets of open type cells. Each cell consists of Pd cathode, Pt anode and $D_2O/0.1$ M LiOD electrolyte. Main efforts have been concentrated this time on the experiment in which thermally insulated dewar type cells immersed in a constant temperature water bath were used.

Until now neither burst-like nor steady state excess heat as reported in the reference could be observed, although new ghost phenomena which were caused by change of bubble formation in the cells were found. Due to a long period of electrolysis, the concentration of Li as well as Si that dissolved in the electrolyte changed, which induced changes in viscosity and bubble coalescence of the electrolyte. Bubbles grew up larger owing to their longer life time, stuck to the inner perforated teflon flange and thermally separated the total cell volume, which produced plausible heat burst phenomena. The cell design and the way of sample preparation are being improved now. Countermeasures were taken already to protect the cell against unwanted hydrogen entering. Such a contamination could be suppressed negligibly small by taking careful cell design and its handling.

As already reported before, we observed increase of neutron emission, about 3.5σ above the background level, which lasted for 9 hours on the 20th day after starting the electrolysis. One of four cells

installed in a bath just showed a spontaneous increase in current coincidentally. Aiming to reproduce these abnormal phenomena, measurements have been continued with more neutron counters. Pd samples were replaced, but the same samples were also reused partly, after renewing the electrolytes, after degreasing their surfaces or after polishing their surfaces mechanically. In some cases charging currents were artificially modulated with a similar pattern that simulates the spontaneous increase found before. Neither increase of neutron emission as observed before nor γ emission has been detected to date. Irreproducibility proves, however, the stability and the reliability of our neutron counting system to be very sufficient and even paradoxically shows the more credibility of the anomalous increase of neutrons reported before.

For some of the palladium samples used for electrolysis, surface profile observation as well as surface element analysis was done by the use of SEM and EDX techniques. It was found that after prolonged electrolysis Pd surface was covered with various unexpected contaminants such as Si, Ca, O, AL, Zn, Ba, Mg, etc. The further studies may be necessary to specify the origin of these **contaminants.**

JAPAN - CATALYZED COLD FUSION

Hideo Kozima (Dept. Phys., Fac. Sci., Shizuoka Univ., Shizuoka, Japan), "Trapped Neutron Catalyzed Fusion of Deuterons in Inhomogeneous Solids," presented at the Fourth International Conference on Cold Fusion, held in Maui, Hawaii, 6-9 December 1993, 8 refs.

AUTHOR'S ABSTRACT

We now want to discuss fundamental features of the cold fusion phenomenologically on a basis of existing experimental data. One of the most remarkable features of the [cold fusion] phenomena is the stochastic character of the occurrence of the neutron burst and the sudden heat production. These features of the phenomena brings the catalytic nature of chemical reactions to our remembrance. **Something might be working as catalyst in the cold fusion.** It is also remarkable that the cold fusion occurs scarcely when the ambient radioactivity is reduced markedly as in Kamiokande experiment. Not saying other features of the Cold Fusion such as done by Yamaguchi et al., **the characteristics mentioned above suggest a catalytic nature of the phenomena originating probably in the ambient radioactive substances.**

Assuming the catalytic nature of cold fusion essential, we take up a mechanism of the cold fusion induced by the background neutrons in the palladium (titanium) metal occluded with deuterium and calculated probability of the induced fusion. The result taking into account of a solid state effects shows it is possible that the cold fusion reported hitherto could be induced by this mechanism. Other causes of the induced cold fusion might be relevant with ambient gammas and cosmic rays.

JAPAN - GOLD PLATED Pd CATHODES

Akiko Kubota, Koji Kato, Keiji Kunimatsu (IMRA Japan Co. Ltd., Sapporo, Japan), "Electrolytic Deuterium Absorption by Pd Cathode with Sputtered Gold Film," presented at ICCF4.

AUTHORS' INTRODUCTION

"Cold Fusion" in Pd Cathode has been said to occur when the deuterium loading ratio, D/Pd, is higher than 0.84. It is not easy, however, to attain high D/Pd by an ordinary electrolysis method. Therefore, surface modification of the Pd cathode has been employed by adding inorganic or organic substances such as Al and thiourea into LiOD solution in order to attain and maintain the higher deuterium loading in the cathode. However, the effect of these surface modifiers is not well understood at molecular level. Recently we have developed a Pd cathode partially covered by a sputtered metal film which is electrochemically less active than Pd in the hope that the current density on the exposed Pd surface could be raised substantially on such cathodes and this could lead to higher deuterium loading. The purpose of the present study is to investigate the performance of such Pd cathode with sputtered gold film on its surface.

AUTHORS' ABSTRACT

The electrolysis was conducted in a fuel-cell type closed cell under galvanostatic conditions between 0 and 500 mA/cm^2 at 10°C. Three types of Pd cathodes with a 7000Å gold sputtered film have been prepared by the RF magnetron sputtering controlling the surface coverage by Au film to 80%, 97% and 100% respectively. Then, they were degassed and annealed in vacuum at 200°C-3 hrs. →250°C-1 hr. A gas diffusion electrode was used as the anode. A platinized platinum electrode in the same solution acted as a reference electrode (RHE) to measure hydrogen overvoltage at the Pd cathode. Electrolyte was 1M LiOD. The initial pressure of D$_2$ before the electrolysis was 8 ~9 kgf/cm^2. D/Pd and hydrogen overvoltage were determined at each current density.

AUTHORS' RESULTS & DISCUSSION

Fig.1 shows the change of the D/Pd with time on Pd with different surface coverages by sputtered Au film. Line 1 shows a hypothetical loading curve for 100% current efficiency. At the initial stage of the loading at 30mA/cm^2, loading curve of Pd without Au coating fits with line 1 up to D/Pd=0.5. On the other hand, loading rate of Pd with Au film becomes lower with increase of surface area of the Au film. It should be noted that the Pd cathode totally covered by Au film has been loaded by deuterium, too. Therefore, it appears that deuterium permeates through Au film and is absorbed into Pd, though hydrogen solubility in Au is very low, 1x10^{-8} ~ 10^{-7}m^2/sec. The time required for diffusion of hydrogen through 7000Å Au film is calculated as 0.1 sec at 10°C. Accordingly, it suggests that loading is controlled by deuterium solution in the Au film. When Pd cathode was subjected to current interruption (Fig.2), D/Pd decreased to its value at equilibrium potential, for which existence of Au film has little effect. This suggests that absorbed hydrogen in Pd can permeate through Au film easily. We conclude from these data that

electrolytic deuterium absorption into Pd cathodes covered by Au film to various degrees proceeds not only on the exposed Pd surface but on the surface covered by Au film. D/Pd of Pd cathodes covered with Au film is higher than that on Pd without Au coating by 7% at 50mA/cm². The palladium cathode 97% covered with Au film gave D/Pd=0.92, while D/Pd=0.85 on Pd without Au film. Dependence of D/Pd on current density on these Pd cathodes with Au film suggests that they could be used as cathodes for excess heat measurements for D/Pd>0.9.

JAPAN - NEGATIVE NUCLEAR BYPRODUCTS

Hiroyuki Miyamaru, Yasuhiro Chimi, Toshihiro Inokuchi and Akito Takahashi (Dept. of Nuclear Engineering, Osaka University, Japan), "Search for Nuclear Products of Cold Fusion," presented at ICCF4.

AUTHORS' ABSTRACT

In search of nuclear products of cold fusion, some electrolyses experiments were carried out, using two types of electrolysis cells. A measurement system with a closed type stainless steel cell was constructed in order to accomplish on-line detection of nuclear products (helium, tritium and neutron). Electrolysis gas is completely collected and stored in the cell for the helium analysis with a high resolution mass spectrometer. The fast neutron detector (NE213, 10 inch diam.) is placed in front of the cell and on-line neutron measurement is performed. Electrolyte samples for tritium analysis are taken at the end of experiments. The loading Deuterium/Palladium ratio is monitored by the cell pressure. The electrolysis with Pd electrode was carried out for one month as a preliminary experiment. The result is that the D/Pd ratio was gradually decreased from 0.87 to 0.70 and no significant excess heat and helium generation were observed. The amount of helium was less than detection limit (approximately 10^{13} atoms). Various methods for causing cold fusion phenomena, such as, surface modification of Pd electrode, variation of the electrolysis current, is to be attempted. An open type cell was designed as a flow type calorimeter to study the correlation between excess heat and neutron emission. Some experimental studies using various palladium samples with different treatments (cold worked, annealed, surface modified) are being continued. These results will be reported at the conference. [Note: One of the few negative papers. -Ed.]

JAPAN - PROTON CONDUCTOR EXCESS HEAT

Tadahiko Mizuno, Michio Enyo, Tadashi Akimoto and Kazuhisa Azumi (Hokkaido Univ., Sapporo, Japan), "Anomalous Heat Evolution from SrCeO₃-Type Proton Conductors during Absorption/Desorption of Deuterium in Alternate Electric Field," presented at ICCF4.

AUTHORS' ABSTRACT

The cold fusion phenomena were tested with use of proton conductor solid electrolyte plates maintained at 300 ~400°C. An anomalous level of excess heat evolution of the order of 100 watt cm⁻² was

observed during absorption/desorption cycles of deuterium-containing hydrogen gas under application of an alternate electric field.

Introduction: The alleged cold fusion reaction observed is accompanied by a very low and weak level of neutron emission, by occasionally rather a high level of tritium production and by a limited number of cases of low or high level of heat evolution. Nevertheless, reproducibility is generally still poor, as no adequate control of the reaction is possible due to lack of knowledge of its mechanism. It is hopeful that some theoretical attempts have been reported, such as the one by Chubb et al., who discussed a high possibility of D-D nuclear fusion in solid state, which may yield ⁴He.

A common system widely employed is the electrolysis of heavy water using Pd electrodes, in which one reason for experimental difficulties is that deuterium charging into the sample requires an extremely long time. Takahashi observed a large amount of heat generation by employing cyclic changes of current on Pd in heavy water electrolysis. This suggests that a kind of perturbation in electric current may be advantageous. Yamaguchi reported a clear evidence of ⁴He production from a Pd plate each of whose faces were covered with MnO₂ and Au film, respectively. In this work, the sample was believed to contain comparatively low concentration of deuterium, and it was heated up to several hundred degree centigrade by an electric heater. This may mean that quick raise of temperature is advantageous, in spite of the view that solubility of deuterium is lower at elevated temperatures. However, the condition of heat and other reaction products showed very low reproducibility and no controllability. Common to these cases, a kind of triggering might be helpful in this reaction. With the consideration that the reaction may occur with a chaotic state caused by the movement of proton in an array of the atoms of the specimen, we have tried to use proton conductor ceramics at suitable temperatures and to apply an alternate electric field.

Samples: Samples were made from a mixture of SrCO₃, CeO₃, Y₂O₃ and ONb₂O₃ powders. Mixed oxide powder was once sintered in a furnace at 1440°C in air for 24 hrs, and was pulverized, again mixed and filtered to 400 mesh . The powder was pressed to form a plate of 0.8 cm diameter and 0.1 cm thick in a pressing machine and was again sintered in a furnace at 1460°C in air for 24 hrs. Both sides of the sample plate were then coated with porous Pt film, 0.05 ~0.15μm, by applying Pt paste and calcination at 700°C for 24 hrs.

Measurement: Sample was held with Pt plates of 1 mm thick pressed to both sides and fixed on a copper holder (5 x 4 x 2 era) with a thin (0.1 ram) mica film in between Pt and a Ni plate which is connected with a stainless steel-coated thermocouple. A heater wire passes through several holes drilled in the copper holder. The holder is fixed with use of stainless steel bolts which were connected to bottom of the metal fitting of a glass jar. The glass jar has a cover flange which has several electric connectors: These connectors were used to introduce thermocouples, electric power lines for temperature control, electric field signals supplied to the sample, etc. Reaction cell is made of a 5 mm thick stainless steel cylinder with 8 cm diameter and 30 cm long. Sample temperature was kept constant by means of a stabilized power supply. The electric field was supplied from a function generator vie, a power amplifier. The electric power was recorded continuously by means of a recorder and two digital voltmeters for current and voltage. Temperature was also recorded

by a digital voltmeter at 0.1°C of precision. The pressure of the system was measured by a pressure-to-voltage transducer. Temperature vs. input heater power relationship was calibrated for various gas mixtures.

Experimental Results: $SrCe_{0.9}Y_{0.08}Nb_{0.02}O_{2.97}$ and $Al_2Si_{0.5}O_4$ dummy sample, which are placed in the atmosphere of deuterium-containing hydrogen gas. The samples were heated by the heater, and the temperature rose up to a constant level of e.g. 383°C within one hour. The deuterium gas was then introduced into the reaction vessel: Temperature once fell down to 360°C, but it again started to rise, attaining 410°C after 5 hrs. and this temperature was maintained at least for 20 hrs. at which the experiment was terminated. In the other cases of hydrogen gas with the same type of sample or dummy sample in deuterium-containing hydrogen the temperature fell down to about 270°C within one hr. and stayed there afterwards. This type of temperature fall should well be accounted for as due to increase of heat loss caused by thermal conduction of hydrogen. A small difference recognized between [the sample] and hydrogen is probably caused by a small difference in their thermal conductivity.

The heat generation from the proton conductor in the experiment of deuterium-containing hydrogen gas was estimated to be approximately 50 watt (~ 100 watt cm^{-3}) over 20 hours, or ~ 3.6 MJ in total. The input power given to the sample was $+ 18V$, $\pm 40\,\mu A$ (sic), or 7.2×10^{-4} watt. **Accordingly, the output-to-input power ratio was estimated to be as large as 7×10^4.**

JAPAN - NEUTRONS & OVER VOLTAGE

Makoto Okamoto, Yuri Yoshinaga and Takehiro Kusunoki (Research Laboratory for Nuclear Reactors, Tokyo Institute of Technology, Japan), "Excess Heat Generation, the Over Voltage Deviation and the Neutron Emission in D_2O-LiOD-Pd Systems," presented at ICCF4.

AUTHORS' ABSTRACT

A series of the electrolysis of D_2O-LiOD solution with Pd-Pt electrodes has been carried out by means of Low-high pulse mode operation to elucidate the mechanism of the solid-state nuclear phenomena. In the present work, a simple heat measurement system has been equipped to the electrolysis cell to monitor the excess heat generation as was used by Takahashi et al. Five thermocouples were used for the temperature measurement, two were placed in the outlet and inlet point of the cooling water from a constant temperature water bath of the room temperature and the other three were placed around the electrodes in different positions. Before the foreground experiment, a calibration curve was obtained between the input power and the temperatures measured by the above three thermocouples by use of the same electrolysis cell. The neutron emission was detected by a NE-213 liquid scintillation neutron spectrometer as described in a previous paper. Throughout the electrolysis run, the temperatures, the neutron count and overvoltage have been measured automatically by use of a computer system.

Three foreground runs and a background run were performed on the same system. The background run was performed in H_2O-LiOH-Pd system, and did not give the positive neutron emission and excess heat. All of the three foreground runs gave the positive neutron emissions and one of them gave an appreciable excess heat. In this case, three thermocouples placed around the electrodes gave almost same temperature deviation from the calibration curve. The temperature deviations from the calibration curve increased as increasing of the input power up to 36W in the high current mode. The excess power was evaluated from the average value of the temperatures of the three thermocouples to be up to 6W in and up to 18%. The correlation between the excess heat generation and the neutron emissions has been checked as a function of operation periods and the neutron energies. There was no clear correlation. The profiles of the overvoltage change are significantly different in the cell with the excess heat generation and with no excess heat. In the former, the overvoltage increased linearly in the first half of the operation time and then exponentially with increase of operation time, while that in the latter increased linearly. The point from linear to exponential was found to be very important point. From this point, the excess heat became satisfactorily clear beyond the statistical error. And one more important finding lies in the difference of overvoltage between the cell with excess heat and without excess heat. The overvoltage of the former was about 1.5 times higher than that of the latter even at the start of the foreground run, and to reach to 1.7 times higher. The growth rate of the overvoltage in this period is 0.22 V/h and 0.11 V/h in the former and the latter, respectively. As has been discussed, the higher overvoltage is a very important factor for the excess heat generation but also the anomalous increase of the overvoltage might be essential phenomenon for the excess heat generation. The process of the anomalous increase of the overvoltage will be discussed in elsewhere in the present conference ICCF-4 by the present authors.

## JAPAN - MOLTEN SALT LOADING RATIO

Hikaru Okamoto and Shinji Nezu (IMRA Mat. R&D Co., Ltd., Kariya, Aichi, Japan), "Measurements of Hydrogen Loading Ratio of Pd Anodes Polarized in LiH-LiCl-KCl Molten Salt systems," presented at ICCF4.

AUTHORS' ABSTRACT

Cold fusion reaction in a molten salt system has been reported by Liaw et al. For heavy water electrolysis, correlations between excess heat and deuterium loading ratio have been reported by several laboratories. The H/Pt phase diagram shows that Pd absorbs very little hydrogen (H / Pd < 0.02) at a hydrogen partial pressure of 1 atm at 400°C where molten salt experiments might be carried out. It is generally accepted that the loading ratio attained by electrolysis is higher than that of a gas loading method. This stimulated our investigation to measure hydrogen loading ratio of Pd anodes polarized in LiH-LiCl-KCl molten salt systems.

Prior to measuring the loading ratio, we studied the behavior of Pd electrodes in LiCl-KCl molten salt systems using cyclic voltammetry. Fig. 1 shows cyclic voltammograms obtained for a Pd and Ni

electrode in a LiCl-Kcl molten salt at 430°C. When the Pd electrode is used, ambiguous cathodic waves appear at potentials positive with respect to the potential for Li deposition onto the Ni electrode. The electrochemical reactions corresponding to these waves have been found to be the formation of Li - Pd alloys with various compositions. When LiH was added to LiCl-KCl molten salt, the potential of the Pd electrode changed from +2400 mV to +580 Mv (vs. Li/Li+). This means that the Pd electrode is chemically reduced to form Pd - Li alloys by the addition of LiH. Fig. 2 shows an anodic voltammogram obtained by scanning from the rest potential anodically. It can be seen that several waves overlap. The electrochemical reactions corresponding to the waves should be as follows:

$$Pd_xLi_yH_z \rightarrow Pd_xLi_{y-a}H_z + aLi^+ + a\,e^-$$
$$Pd + xH \rightarrow PdH_x + xe^-$$
$$H \rightarrow 1/2\ H_2 + e^-$$
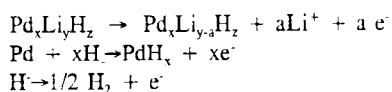
The hydrogen loading ratio was evaluated by measuring the amount of the evolved gas during electrolysis using a mass flow meter or a gas burette. Fig. 3 shows the typical response of the mass flow meter for a Pd and Ni electrode upon switching on and off the electrolysis. As can be seen in this figure, for the Ni electrode, the gas evolution began and stopped immediately on switching on and off, respectively. For the Pd electrode, on the other hand, delays in the response were observed, indicating the hydrogen absorption. The exact value of the loading ratio was determined by using a system with a gas burette shown in Fig. 4. The hydrogen loading ratio (H / Pd) of 0.05 ± 0.02 was obtained. It was confirmed that the current efficiency was close to 100% using the Ni electrode.

JAPAN - EXCESS HEAT - NO ASH
Chemical Abstracts, 1 Nov. 1993

Noboru Oyama, Takeo Ohsaka, Osamu Hatozaki, Yuko Kurasawa, Nobushige Yamamoto, Seiji Kasahara, Naoki Ohta, Yukio Oyama (Dep. Appl. Chem., Tokyo Univ. Agric. Technol., Koganei, Japan), "Electrochemical Calorimetry of Heavy Water Electrolysis Using a Palladium Cathode - an Undivided, Open Cell System," *Bull. Chem. Soc. Jpn.*, 1990, vol 63, no 9, pp 2659-2654.

AUTHORS' ABSTRACT

Electrochemical calorimetry of the electrolysis of D_2O was carried out using a Pd cathode in an undivided, open cell fashion, together with measuring the total volume of the evolved gases. The excess heat production, observed using a Pd cathode pretreated by a special procedure, cannot be explained as a result of the D_2-O_2 recombination alone. However, the present data certainly do not confirm cold fusion, because no evidence has yet been obtained for neutron, gamma-ray, tritium or helium production during the authors' electrolysis of D_2O with Pd cathodes.

JAPAN - EFFECT OF THIOUREA

Yumiko Tsuchida, Hidemi Akita, Toshihide Nakata and Keiji Kunimatsu (IMRA Japan Co., Ltd, Sapporo), "Absorption of

Hydrogen into Palladium-Hydrogen Electrode: Effect of Thiourea," presented at ICCF4.

AUTHORS' ABSTRACT

Excess heat during electrolysis of heavy water with a Pd cathode has been found to be a function of deuterium loading ratio D/Pd. Enyo et al. reported that thiourea poisoned Tafel step for hydrogen electrode reaction giving rise to higher H/Pd in acidic solution. The aim of this report is to study the effect of thiourea (THU) on H, D absorption into Pd cathode in alkaline solutions in order to find experimental conditions to realize D/Pd > 0.9. which is not achieved in 1 M LiOD without such catalytic poison in our previous studies.

Experimental details have been given in our previous work. Electrolysis was conducted galvanostatically in a fuel cell type closed cell using Pd rod ($\phi 5$ x 16mm or $\phi 4$ x 25 mm) as cathode and gas-diffusion electrode as anode. Electrolyte was 1 M LiOH(LiOD) containing 0, 0.1, 0.6mM THU. The current density was changed up to 1000 mA/cm^2, and loading ratio, H(D)/Pd, and Pd hydrogen overvoltage with respect to RHE in the same solution were measured at each current density.

Results and Discussion: Relation between H/Pd and Pd hydrogen overvoltage is shown in Fig.1. Addition of 0.1 mM THU had little effect on loading ratio, but when the concentration of THU was 0.6 mM, the loading ratio has increased as much as by 13%, the maximum value of H/Pd being 1.05. Addition of 0.6 mM THU to LiOD electrolyte also increased D/Pd by 10% to give rise to the maximum value of the loading ratio of 0.94 as shown in Fig. 2. These data show clearly that THU adsorbed on Pd acts as a good promoter to increase the electrolytic hydrogen as well as deuterium absorption into the Pd cathode presumably by poisoning the desorption step of absorbed hydrogen(deuterium) atoms as $H_2(D_2)$ molecules. The poisoning effect can be observed more directly by monitoring change of H(D)/Pd with time after electrolysis is terminated. The change of H/Pd with time when the electrolysis current was stopped after loading hydrogen into Pd is shown in Fig. 3. Desorption rate of hydrogen from Pd electrode in the system containing THU is much lower than the rate without THU. These results suggest clearly that hydrogen recombination step was poisoned by THU and desorption of hydrogen from Pd electrode was inhibited, which led to increased loading ratio of hydrogen as well as deuterium in Pd cathode.

NETHERLANDS - QUARK MODEL
Chemical Abstracts, 1 Nov. 1993

Peter C. Tiemeijer, and J.A. Tjon (Inst. Theor. Phys., Univ. Utrecht), "Effects of Negative Energy Components in the Constituent Quark Model," *Phys. Rev. C: Nucl. Phys.* 1993, vol 42, no 2, pp 896-901.

AUTHORS' ABSTRACT

Relativistic covariance requires that in the constituent quark model for mesons the positive energy states as well as the negative energy states are included. Using relativistic quasipotential equations the

contribution of the negative energy states is studied for the light and charmonium mesons. These states change the meson mass spectrum significantly but leave its global structure untouched.

RUSSIA - GLOW DISCHARGE

Yan Kucherov, Alexander Karabut and Irina Savvatimova (Sci. Indust. Assoc. "Luch, Podolsk, Moscow / ENECO, Salt Lake City, Utah), "Calorimetric and Nuclear Products Measurements at Glow Discharge in Deuterium," presented at ICCF4.

AUTHORS' ABSTRACT

The results of four years of experimental work on glow discharge in deuterium with cathodes made of palladium and other materials are presented. About 500 experiments were made. The typical cathode area was ~ 1 cm^2, with about 0.1mm thickness. Deuterium pressure was in 1-20 Torr range. Discharge current varied in 10-100 mA and voltage in 100-500 V range.

The measuring instruments included slow and fast neutron detectors, neutron spectrometer, NaI and Ge-Li gamma-spectrometers, two-channel charged particle spectrometer with various SSB detectors, X-ray film, activation foil and track detectors, heat loss-type calorimeter. All of the instruments could work simultaneously, except calorimeter-SSB combination. As a result, maximal measured excessive heat was about 30W and about 10KJ, about ten times the heat that could be produced in chemical reactions with existing deuterium and up to five times the electric input. Excessive heat was observed in about 50% out of 78 experiments in which calorimeter was used. In different experiments heat production was not correlated with neutron or gamma fluxes, but in a separate experiment it was. Maximal Pd-cathode temperature at which nuclear products could be observed was $\sim 500\,°C$.

Neutron fluxes with intensity up to 10^7 n/s were observed by activation of silver foil, ^{3}He-filled detectors and scintillation detectors. Neutron spectra showed neutron energies up to 17 MeV with anomalous shift to high energies (five orders) relative to d-d reaction. Gamma-spectrometry showed low level radioactive isotopes formation. Together with half-life time measurements it allowed to identify some of the isotopes, such as Rh and Sr isotopes. Most of the lines (~ 100) are still unidentified. Non-background gamma-lines sometimes can be seen for few days. Most of the gamma-lines appear in lower than 300KeV region. X-ray films outside the chamber with lead screens show some beam-like spots with energy 100-200 KeV.

Charged particles registration with SSB and CR-39 detectors showed good correlation of the results obtained by these methods. Maximal observed fluxes of charged particles were $\sim 10^6$ s^{-1}. SSB detectors which could see the cathode from inside the vacuum chamber and from outside through Be-window showed charged particles with energies up to 18MeV with average energy 2-4 MeV. Degrading foil method showed existence of heavy particles in the spectra (A > 4). X-ray film with lead screens showed X-ray fluxes up to 10^9s^{-1} with soft (< 1KeV) and hard (10-30KeV) components. Sometimes

characteristic X-rays of palladium can be seen with Ge-Li detector. The sum of all measured products carries energy 4-5 orders less than heat release and may be part of registered products that are not related to heat effect.

RUSSIA - PROTON CONDUCTORS & NEUTRONS

A.L. Samgin, A.N. Baraboshkin, I.V. Murigin, S.A. Tsvetkov, V.S. Andreev, G. Vakarin (Inst. High-Temp. Electrochem., Rus. Acad. Sci., Ekaterinburg), "The Influence of Conductivity on the Neutron Generation Process in Proton Conducting Solid Electrolytes," presented at ICCF4.

AUTHORS' ABSTRACT

The cold fusion process accompanying a generated nuclear emission (neutron, for example) was observed in solids with different conductivity types: in metals, tungsten bronzes, segnetoelectric, and proton conducting solid electrolytes. In this case the investigation of the phase transition influence resulting in a change of conductivity in the neutron generation process is of great importance. The proton conducting solid electrolyte, possessing only protonic conductivity in the high temperature region, was selected as an object of our research. The method of this investigation is described in this paper. **The sample's thermocycling after filling the cell with deuterium and electrolysis revealed a neutron emission exceeding the background on the level 4σ during definite temperature intervals.** When a high deuterium pressure was produced in a cell (up to 3 atm), the sample's partial reduction was observed, accompanied by the sample turning black. The sample reduction resulted in a sustained electronic conductivity with air atmosphere at room temperature. The fact that the neutron generation process stopped after the sample reduction may relate particularly to mixed electronic-cationic to electronic conductivity passage.

The investigation of this deuterium-solid state system's property permits a new interpretation of anomalous nuclear-electron effects. The same behavior is in agreement with one of the main conditions of cold fusion - the formation during deuterium saturation in strongly nonequilibrium conditions of the local inhomogeneous zones with an abnormally increased deuterium atom concentration relative to the lattice atoms, with a hypothesis of formatting the regions with dielectrical properties in Pd.

Here we may mention that the discovered effect is in agreement with the neutron emission observed in monocrystals of tungsten bronzes during the changing of the alkali metal concentration (for example, by replacing with hydrogen isotopes), which produces semiconductor and dielectrical layers. Current observations also correlate well with the investigations of deuteron emission from solids with segnetoelectric-dielectric or segnetoelectric-ion conduction. This presents peculiarities of the nature of conductivity that may also be useful in understanding both mechanisms which have a common origin in electromagnetic current behavior in dense media, and capillary fusion in special structures with channels.

Obviously the nature and the mechanism of conductivity and the existence of multilayered structures with different conductivity types in solids appear to be the additional critical conditions of an abnormally increased rate of nuclear-electron reactions in a solid state deuterium system.

RUSSIA - PROTON CONDUCTORS & NEUTRONS 2

A.L. Samgin, A.N. Baraboshkin, V.S. Andreev, I.V. Murigin, V.P. Gorelov, S.V. Vakarin, S.L. Tsvetkov, A.L. Shalyapin, A.G. Golikov, L.N. Fomina (Inst. High-Temp. Electrochem.. Rus. Acad. Sci., Ekaterinburg), "Neutron Generation in the Solid Protonic Conductors with Perovskite-type Structure," presented at ICCF4.

AUTHORS' ABSTRACT

Cold fusion processes proceed in solids in which hydrogen dissolves well. We have conducted systematic investigations of neutron generation processes in solid ionic conductors (strontium cerate and barium carate) with high protonic conductivity, and local zones of high concentration of protons and with a high proton mobility.

Deuteron conducting samples were prepared of ceramic disks 20 mm in diameter and with different thicknesses, with the opposing surfaces of these disks covered with capillary Pt or Pd electrodes. The measurement of thermal neutron emission from this protonic conductor was taken by means of two independent blocks of detectors with a paraffin retardant. During the process of deuterium saturation by electrochemical methods we registered a neutron flow above background on the level 4σ. This neutron flow appeared as a pulse which lasted not more than a few tens of seconds.

It is found that neutron flow generated in the heterostructures based on solid protonic conductors depend on the sample preparation technology and its electrochemical treatment. On the other hand, the conditions and the regimes of thermocycling and electrolyzing also influenced the neutron emission. The reproducibility of neutron emission with temperatures determined to be connected with phase transitions was discovered. The same effects were registered when raising and decreasing the temperature of the sample.

RUSSIA - GLOW DISCHARGE IMPURITIES

Irina Savvatimova, Yan Kucherov, and Alexander Karabut (Sci. Indust. Assoc. "Luch", Podolsk, /ENECO Inc., Salt Lake City, Utah), "Impurities in Cathode Material Before and after Deuterium Glow Discharge Experiments," presented at ICCF4.

AUTHORS' ABSTRACT

The new data obtained in the development of our results on impurity concentration measurements in palladium cathodes by different analytical methods before and after deuterium ion bombardment in the glow discharge in deuterium is presented. X-ray microprobe, high resolution mass-spectrometry, secondary ion mass-spectrometry etc. were used to study impurities concentration in the Pd cathodes before and after the experiments with glow discharge in deuterium.

Concentration of individual elements (Na, S, In, Ag, Zr, Nb, Sn. K, Cl, Br, Se, Ni, Mg, Zn, Ge, Sr and some other) which were not present in the discharge environment increased up to 1 to 4 times. Change was observed by spark mass-spectrometry in the Testing Analytical Center (A.G. Lototsky's group). The impurities distribution on the surface was measured using microprobe. The comparison of microprobe - SEM pictures ("Hitachi S-800" with "Link Analytical" detector) showed that most of the impurities are localized on the palladium crystalline subboundaries.

The impurities segregation points density was about 10^9 mm^{-2} for individual elements. This quantity for Zn was about 10^9 mm^{-2} and for Br $\sim 4 \times 10^9$ mm^{-2}. For example, integral density of the impurities in some of the segregation for Zn, Br, Mg, Co was about 10^{10} mm^{-2} with probe resolution about 2.5×10^{-11} mm^{-2}. With TRM method voids with the size 100-1000 angstroms can be seen in the surface layer with the thickness ~ 1000-10000 angstroms with the density about 10^{20}mm^{-3}, significant part of which sits around grains subboundaries of the Pd-cathode after ion bombardment.

Autoradiography of the palladium cathodes after experiments showed that two components of radiation are emitted. Application of various screens showed that low energy component had energy about 20 KeV and high energy - about 0.5 MeV. The blackening of the X-ray film depended on the position on the cathode sample. Radiation was emitted either from the front or from the backside of the sample. The results of element and isotopic analyses before and after the experiments suggest that some kind of fission reaction takes place. This assumption was made in an attempt to understand these reactions in the Pd-D system is presented in another paper, submitted to this conference.

SPAIN - ANOMALIES AFTER ELECTROLYSIS

M. Algueró, J.F. Fernández, F. Cuevas and C. Sánchez (Dpto. Fisica de Materiales, Facultad de Ciencias, Univ. Autónoma de Madrid), "On the Subsistence of Anomalous Nuclear Effects After Interrupting the Electrolysis in F-P Type Experiments with Deuterated Ti Cathodes," presented at ICCF4.

AUTHORS' ABSTRACT

Nuclear effects related to cold fusion experiments are characterized by several peculiarities that form a complicated frame. One of these peculiarities appears on electrochemical loading of Ti cathodes with D: during neutron emission the electrolytic current is interrupted and the cell left in open circuit conditions, the neutron emission decays smoothly below the detector sensitivity. Figure 1 shows neutron data corresponding to ETi6, an experiment carried out in 1989 by our group in which the neutron decay transient lasted 100 minutes.

It is well accepted now that a high loading ratio (D/Ti=2) is needed to favor the appearance of C.F. related phenomena either being the high D concentration in the bulk or in a thin layer near the sample surface. To get such a high loading ratio using electrochemical techniques presents several difficulties as it has been emphasized by

different authors. It has been shown on Ti cathodes that only a narrow layer close to the surface is deuterated. The thickness of this layer is mainly a function of the electrolysis time and may range from a few to tenths of μm as the electrolysis time varies from one week to two months. D concentration profiles inside the metal during and after electrolysis are described by the Wagner model as it has been shown by Mizuno et al. and Fernández et al. on analyzing Zr and Ti. This model involves the diffusion mechanism of one species in another with more than one phase present.

An explanation is proposed of the neutron emission decay transients observed in F-P type experiments with Ti cathodes after interrupting the electrolysis. The neutron transient is related to the reduction of deuterated bulk of loading ratio over a threshold due to diffusion phenomena. The hypothesis is tested by contrasting neutron detection data to numerical calculations of the active bulk through the Wagner model.

SPAIN - PHASE TRANSITIONS IN TiD

J.F. Fernandez, F. Cuevas, M. Alguero and C. Sanchez (Dpto. Fis. Materiales, Facultad de Ciencias, Univ. Autonoma de Madrid), "The Cubic-Tetragonal Phase Transition in Titanium Deuteride and its Possible Relation to Cold Fusion Reactions," presented at ICCF4.

AUTHORS' ABSTRACT

It is now well recognized that in order to get "Cold Fusion reactions" the system (Ti-D, Pd-D...) should be far from equilibrium. A lot of work has been done to investigate the behavior of the system in different non-equilibrium conditions: Fractofusion and crack generation, phase transitions or electrical current effects. Following this approach we have focused our attention in phase transitions as possible triggering mechanisms of the so called "Cold Fusion reactions". This possibility is supported by some theoretical works.

The Titanium-Hydrogen (Deuterium) system at large $x = H(D)/Ti$ ratios ($x \cong 2$) shows a cubic to tetragonal second order phase transition in the neighborhood of R.T.. In spite of the fact that the phase transition has been studied by several authors, no clear boundary between the cubic and tetragonal phases has yet been drawn. The drastic influence on the phase diagram boundary of different factors like stress or atomic impurities have been repeatedly shown. This kind of factors could be related to the irreproducible behavior of "Cold Fusion reactions". Therefore, in order to check if any possible relation exits between that phase transition and cold fusion phenomena it is necessary to make sure that samples are completely reproducible in their phase transition properties.
To this aim we have studied the influence of the hydride (deuteride) preparation procedure variables (Pressure, Temperature, Titanium type) in the phase transition characteristics. Optimization of the sample preparation parameters will be presented and the reproducibility of the phase transition properties at the optimum conditions will be shown. In Fig. 1 specific heat of Titanium Deuteride as a function of temperature is shown. A clear increase in the specific heat near R.T. can be observed as is expected for a

second order phase transition. The higher the specific heat peak, the better the sample quality and the stronger the collective phenomena are when the phase transition takes place.

Once phase transition properties were controlled we tried to confirm if there is any relation between it and "Cold Fusion reactions". This study is now in course and results will be presented at the meeting. The nuclear detection is accomplished by two liquid scintillator spectrometer (NE213 3.8 x 3.8 cm and BC501 12.7 x 12.7 cm) and two proportional counters (BF_3). Discrimination against γ radiation for both spectrometer is achieved by pulse shape discrimination technique. Time spectrum obtained with an Am-Be source for the small NE213 is shown. Taken into account the geometry of the experiment the detector efficiency and the neutron background at our laboratory a minimum neutron flux from the sample about 1 n/s can be detected.

SWITZERLAND - MORRISON'S REVIEW

Douglas R.O. Morrison (CERN, Geneva, Switzerland), "Summary of Cold Fusion Review," manuscript handed out at ICCF4, 3 manuscript pages.

AUTHOR'S ABSTRACT

Progress will be reviewed on work on Cold Fusion since the previous annual Cold Fusion conference, ICCF3, held in October 1993. Recent results on calorimetry will be compared with earlier work. Similarly measurements of possible nuclear products, X-rays, neutrons, protons, gammas, 3He, 4He, and tritium that have been reported in the last year, will be described and compared with previous results reported. Progress on making practical heaters using Cold Fusion techniques will be presented. Recent theoretical understanding will be discussed. The conclusions of the previous three annual Cold Fusion conferences will be recalled.

AUTHOR'S CONCLUSION

On the basis of contemporary experiments, Cold Fusion is a mistake. On the basis of thousands of previous experiments giving a unifying theory, Cold Fusion is impossible by at least 50 orders of magnitude.

EDITOR'S COMMENTS

To be precise, Morrison does not attack "cold fusion" in all the meanings that may have been ascribed to the words. In their first paper, Fleischmann & Pons only suggested that it might be d+d nuclear reactions which **"are only a small part of the overall reaction scheme and that the bulk of the energy release is due to an hitherto unknown nuclear process or processes..."** Were Morrison to be more precise he would state, "If the nuclear reaction is d+d reaction **and if we assume that the reactions in a palladium-lithium-heavy water electrochemical system are the same as in gas plasma experiments, then ..."** When stating his conclusions in a more precise fashion, we must agree with Dr. Morrison's conclusions. Although many of us include other

anomalies under the terms "cold fusion" Morrison limits his strongest criticism to d+d nuclear events.

Morrison states that "The laws of Physics are Universal." Were he more careful he would state that the generally accepted laws of Physics are assumed to be Universal, and in most cases have been shown to be such, at least in that par: of the universe subject to our exploration. He does, of course, realize, that the laws of Science are not immutable. The history of science is one of modeling, testing, discovery, and rebuilding. Under this more precise definition of the structure that Morrison is criticizing, we should listen carefully. Morrison is bright, knowledgeable, articulate, and entertaining. This editor believes that Morrison (and Huizenga) would admit that new **science has been discovered,** as soon as we can demonstrate complete replication of any **strong** measure of nuclear reactions. We do welcome them at cold fusion conferences and we should listen to their comments when made with precision and made as fellow Searchers for Truth. They both have a wealth of knowledge to draw upon to help us to advance the new science of "cold fusion."

E. LETTERS TO THE EDITOR

LETTER FROM DR. PETER GRANEAU

Dear Hal,

Neal and I would like to thank you for your inspiring review of Newton versus Einstein in *Fusion Facts*. It is proving quite difficult to get reviews from the average type of physics professor. They would rather throw a blanket of silence over the book.

The capacitor bank with which I did all my experiments at MIT has been shipped to Canada and is being set up for capillary fusion experiments. If all goes well, we should begin shooting early next year in Toronto. Amongst other things, we hope to look for excess heat and X-rays.

/s/ Peter Graneau

F. MEETINGS AND MISCELLANEOUS

MINSK COLD FUSION CONFERENCE - MAY 1994 AMENDED CALL FOR PAPERS

The Fourth Annual International Conference on Cold Fusion produced some exciting papers. We will be sending special invitations to selected authors to present a paper at the Minsk Conference. Therefore, the English language paper deadline has been extended to January 10, 1994. Please send abstracts immediately to either Hal Fox or to V.A. Filimonov at the addresses below.

A bilingual, international conference on cold nuclear fusion and affiliated energy systems will be held in Minsk, Republic of Belarus during the last week of May, 1994. Papers accepted will be published in English and Russian editions of proceedings that will be provided to attendees at the start of the conference. Presentations of the papers can then concentrate on the latest developments and the answering of questions. The proceedings are expected to provide a tutorial overview of the new science of cold nuclear fusion for a multidisciplinary audience and provide the latest experimental and theoretical findings.

Russian language papers should be sent to:
>   Dr. Filimonov V.A.
>   14 Leningrad St., Research Inst. of
>   Physical and Chemical Problems
>   Minsk - 80, 220080
>   Belarus.

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