The 2011 Cold Fusion/Lattice-Assisted Nuclear Reactions Colloquium at the Massachusetts Institute of Technology—Part 1

(Report prepared by staff of JET Energy, Inc.)

The 2011 Lattice-Assisted Nuclear Reactions/Cold Fusion Colloquium at the Massachusetts Institute of Technology (Cambridge, Massachusetts) was held on Saturday, June 11 and Sunday, June 12, 2011. The meeting focused on the science and technology of cold fusion and lattice assisted nuclear reactions (LANR). This year, there were 23 presentations. LANR nanomaterials headlined the talks, only to be surpassed by patent issues, Rossi's contribution and recent high technologic developments in LANR. Plenary lectures in LANR were delivered by Dr. Mitchell Swartz (JET Energy), Professor Peter Hagelstein (MIT), Dr. Brian Ahern (Vibronics), Prof. Xing Zhong Li (Tsinghua University), Dr. Francis Tanzella (SRI International), Prof. George Miley (University of Illinois-UC) and Robert Smith (Oakton International Corporation). Another eight presentations were given by: Dr. Edward Tsyganov (UT Southwestern), Jeff Driscoll (Zhydrogen), Keith Owens (Cold Fusion Energy), Doug Yuill and David French (Second Counsel Services), Abd ul-Rahman Lomax (Lomax Design Associates), Ludwik Kowalski (Montclair State University) and Robert Weber (Strategy Kinetics). These were followed by two group discussions of the Rossi matter, the present LANR/CF business opportunities and Patent Office quagmire.

In addition, two cold fusion researchers who were diligent workers in the field, John "Alf" Thompson and Dr. Scott Chubb, had recently passed away and were memorialized.

Background

The organizers were Dr. Mitchell Swartz (Chief Technology Officer of JET Energy, Inc.), who hosted the event, and Gayle Verner, also of JET Energy (http://world.std.com/~mica/jet.html). Support was provided by the *Cold Fusion Times*, the Energy Production and Conversion Group in RLE at MIT, JET Energy, Inc. and the New Energy Foundation. Well deserved thanks and also attendees' gratitude go to Alan Weinberg, Jeff Tolleson, Kim Tolleson and Jeff Driscoll for all their help.

These annual cold fusion colloquia were initiated by Dr. Mitchell Swartz and the late Dr. Eugene Mallove beginning in 1991. They were originally designed for colleagues involved in the science and business of LANR, but later they evolved so that members of the student and other science communities were also welcome. The goals have been to increase cooperation among colleagues and public awareness of the development of the science and engineering of LANR/CF (lattice assisted nuclear reaction, aka, cold fusion) systems.

These cold fusion colloquia at MIT have become popular, not just because they are one of the few, if not the only, events of this nature, but because they allow everyone with a science or technology interest "a voice." And so this year, too, it did not disappoint. Not only did well known scientists of all stripes in the cold fusion arena come to speak from all over the world, eager to share their continuing research data, but they were augmented again by those voices who were previously unheard and who have worked quietly in the field for years. Also, some who usually are denied a platform at the larger conferences, and others who are systematically censored in other media forums, also are encouraged to openly present their work at the conferences.

Attendees from the 2011 LANR Colloquium at MIT, on the second afternoon. *(Photo by Edward Tsyganov.)*

Two Days of Excess Energy

This year's event proved again successful, so said the 70+ attendees who gathered for the two-day conference. The Research Laboratory of Electronics (RLE) conference rooms where the event took place were filled to capacity to hear the science and engineering of cold fusion (CF) through presentations about CF and related processes, technology and business, a science that has received a bad rap for its 22 year existence. The participants enjoyed the format, workshops and material.

At 7:30 a.m. on Saturday, June 11, the doors opened to the Hermann Haus conference room (in RLE) at MIT. This was fitting since the late Prof. Haus had been interested in cold (and other forms of) fusion. Eager participants arrived early, catching up with old friends, fellow researchers, new co-presenters, scientists, business execs, venture capitalists, enthusiastic students and colleagues from the DC-Virginia area, the West coast, and as far away as China. Four to five dozen early-rising cold fusioneers began sharing ideas and recent experiences before the two full days of lectures and workshops over beverages, such as Sumatra coffee, and a continental breakfast with other refreshments continuing through lunch. The jam-packed meeting actually began at 8:00 a.m. with the introduction and the first half dozen plenary LANR/CF papers.

In this and the next issue of *Infinite Energy* follow the scientific highlights from the event. The first group of LANR/CF presentations were on Aqueous and Gaseous LANR Systems. Dr. Mitchell Swartz welcomed the attendees and began the introduction to CF/LANR. He thanked the presenters for coming so early, the staff for preparing the food to support the group, and MIT, RLE and Prof. Peter Hagelstein for their help.

In the first lecture, Dr. Swartz (JET Energy, Inc.) summarized some of the more important facts about cold fusion and reasons that CF research is needed. He explained that although, in 1989, the physics community did not believe the initial LANR/CF experiments, many things have happened since. Then, fusion was not known to occur at low temperatures and was not known to occur in solids. Today, the facts show otherwise. The initial failures of CF resulted from bad experiments, bad paradigm, questionable materials, poor loadings and a poor appreciation of the requisite metallurgy and engineering. Today, those issues are resolved, and particle emission, excess energy, excess power gain, commensurate linked helium-4 production with excess heat, are undeniable, along with increasing power gains and total energies achieved since 1989. Together, these herald an important new, clean form of energy production, also called cold fusion, that is, fusion assisted by highly loaded metal hydrides in lattice assisted nuclear reactions [LANR].

In particular, Dr. Swartz noted that CF enables a much more efficient energy production, quite useful economically in an increasing energy demand. The incredible environmental importance is that LANR/CF reactions are "ultra-clean." He illustrated this using an energy flow diagram of the U.S. and then focused on a typical city, like Boston. He demonstrated that of a multigigawatt metropolitan city, each gigawatt per day today consumes 54,000 tons of coal burning into the air a new 180,000 tons of CO_2, 3600 tons of SO_2 and 480 tons of NO_2 each and every day. He emphasized that CF might be a potentially revolutionary, clean energy source capable of dramatically reducing pollution as well as the future expensive consumption of fossil fuel.

Dr. Swartz demonstrated that the utilization of successful cold fusion would change the hundred of thousands of *tons* of pollutants to a mere 24 garbage-size bags of an entirely pollution-free product: ordinary helium gas. And the material cost? Substituted for the 54,000 tons of coal is 6 pounds (three quarters of a gallon) of heavy water.

Cold fusion offers incredibly efficient energy production, clean and free of pollution, all toxic emissions, all carbon footprints, all greenhouse gases and radioactivity, while obviating fossil fuel. Dr. Swartz noted the medical and timely environmental matters which show exactly why cold fusion may just be the cleanest, and most efficient, energy source of the future.

The fuel substrate is deuterium, plentiful from the oceans, and the product is *de novo*, commensurate helium-4. The evanescent problem is that, although Benjamin Franklin first coined the term "cold fusion" for lightning-produced sand fulgurites, that phrase next appeared in 1989 involving metal hydrides (PdD and NiH) when the science was as widely, but not deeply, investigated. Since then, two decades of LANR R&D, sub rosa, have confirmed that excess heat production (far above the input) accompanied by very low level, but measurable, emissions can be driven by electric field and gas loading techniques.

Today, there are several types of LANR: conventional, two types of codeposition, as well as dual cathode, dual anode and a variety of other loading systems. On one hand, high electrical resistance LANR systems have yielded metamaterials and control of deuteron flux. On the other hand, codeposition, where fresh Pd and D plate out together on the cathode, point the way to speedy onset for some of the reactions. The excess heat has been monitored by up to five corroboratory diagnostics, including heat flow measurements, electricity production and LANR-coupled Stirling motors. Success requires control of vacancies, adequate incubation time, high loading, concomitant flux, the absence of quenching conditions and critical control of input power. He also emphasized that to create excess heat it is necessary to have sufficiently high loading (the value of x in PdD_x) and that this has to occur before additional flux of deuterium through the loaded material is introduced. In particular, he cited work by SRI (Drs. McKubre and Tanzella) that shows that to achieve excess heat, values of x must be greater than 0.85.

Newer diagnostics include near- and far-IR imaging which reveal hot spots. Calibrated imaging has revealed non-thermal near-IR emissions correlated with excess heat. Dr. Swartz showed various electrodes loaded with hydrogen, which is necessary for successful CF/LANR. He then demonstrated CF/LANR near-IR emission appears in successful runs. These images were made from calibrated electrodes in high Z and codeposition LANR experiments. He said they have observed near-IR radiation emissions when excess heat is present. This near-IR emission is "non-thermal" in origin because it is correlated with excess heat production and not with the physical temperature. None of the control experiments (in which heat is introduced in the electrodes resistively) produce a comparable effect even at higher temperature. Dr. Swartz pointed out that these emissions may confirm the hypothesis that Bremsstrahlung emission, under increasingly lower temperatures, shifts from penetrating ionizing radiation toward skin-depth-locked infra-red radiation.

Given the prevalence of the fuel, and the incredible efficiency, LANR could play a critical role in all future technologies with potential revolutionary applications to transportation, electricity production, medicine and space travel. Dr. Swartz explained that besides creating heat, LANR/CF processes can possibly be used to develop new materials, and have been used in a range of LANR devices. America now has these resources and LANR is an energy multiplier. But, the question remains, do we (America and the world) have the resourcefulness to get to the light at the end of the tunnel?

Following an overview of the field, and survey of the positive results, Dr. Swartz explained why the term "low energy nuclear reactions" (LENR) is a misnomer, since they are not "low energy," based on emissions of high-energy MeV states.

The field of cold fusion (LANR) is so extensive that readers should see the peer-reviewed published survey of the field [Swartz, M.R. 2009. "Survey of the Observed Excess Energy and Emissions in Lattice Assisted Nuclear Reactions," *Journal of Scientific Exploration*, 23, 4, 419-436, http://world.std.com/~mica/Swartz-SurveyJSE2009.pdf].

MIT Prof. Peter Hagelstein gave three presentations. His first presentation analyzed in detail the Piantelli experiments using nickel hydrides in the 1990s, and discussed the relationships between the PdD experiments of the Fleischmann-Pons type done at SRI with the NiH experiments described by Piantelli's group. In the SRI experiments, high D/Pd loading has been found to be a requirement, and deuterium flux inside the PdD has been found to be correlated with excess power production. He has postulated a new conjecture that we need molecular D_2 to form inside the PdD, which does not normally occur in bulk metal since the electron density and the spatial density are too high. Hagelstein's calculations examined how the electron density is lower near a vacancy and how it may enable D_2 to form.

Vacancies can be present at a low concentration in bulk Pd, and they appear after loading because they are stabilized as more H or D go into the metal. In fact, once the concentration reaches 0.95 in PdD near room temperature, the vacancies become thermodynamically favored. The problem is that thermodynamics does not indicate rate; and unfortunately the vacancies diffuse very slowly (less than 1 Angstrom in a month). So one suggestion for successful CF/LANR is to arrange for vacancies to appear in the bulk.

As a second suggestion, Dr. Swartz and Prof. Hagelstein began investigating vacancies in Ni and Pd in the late 1990s made *de novo* by electron beam irradiation and examined their creation and disappearance with time. This demonstrated that they can both form and "heal," and thus disappear.

Hagelstein proposed that much of the old SRI experiments can be understood if one thinks of the problem of vacancy formation. Since vacancies don't diffuse, the only way to form them is through codeposition at a D/Pd loading greater than 0.95, where the vacancies become thermodynamically favored. The conjecture is that if one waits long enough, some of the Pd will dissolve (during anodic cycling, for example), and then subsequently be codeposited. If the codeposition occurs at sufficiently high loading, then the codeposited layer will have massive vacancies. Analysis of the surface in some experiments indicates that the outer 1000-3000 Angstroms of the cathode contains elements that could only have become part of the surface layer through codeposition. As he noted, this conjecture is consistent with the observation of He-4 in the gas phase associated with excess heat. The helium would not be able to diffuse if made further inside the cathode. If the NiH experiments "work like" the PdD experiments, then we need to understand if (and how) vacancies are made in the NiH experiments.

The first issue he noted was the question of how much hydrogen can load into nickel. The pressure isotherms of Ni/H are known, and the H/Ni loading ratio should be only on the order of 0.02% in bulk even near the 1 atmosphere of pressure used to load in the Piantelli experiment. Yet, the amount of H in the Ni is observed to load much more. Prof. Hagelstein's first question is: "Why?" He said he suspects that the higher loading could be caused by impurities and/or defects. As he noted, in the Cammarota replication, the impurity concentration seems too low to have produced the observed Ni/H loading ratio of 0.2 which was measured. So the question is whether this high loading might be due to vacancies.

Prof. Hagelstein's analysis demonstrated that vacancies form much more easily in NiH than in PdD, and that in NiH a loading of only 0.7 is needed near room temperature to stabilize the vacancies. He presented p-T isotherms measured by Baranowski at much higher H pressures than in the Piantelli experiment. At about 6000 atm, NiH can form near room temperature. He then discussed interesting electrochemical experiments in NiH where X-ray diffraction measurements were done, and revealed that in the miscibility gap alloyed islands of 0.7 NiH loading appear, increasing with the loading (a behavior very different than in PdD). In essence, this means that even when NiH has a modest loading, there can be great inhomogeneities with the local loading able to reach NiH ~0.7.

Hagelstein's hypothesis intuits that this results from local vacancies which are generated. He suggests this because in the early Piantelli group papers, a protocol is described in which the temperature is lowered and then raised, following which excess heat is observed. This protocol must necessarily be accompanied by an influx and outflux of H, which seems very similar to the stimulation of excess power in PdD experiments associated with influx or outflux of D in aqueous systems that also appear to produce such vacancies.

Prof. Xing Zhong Li gave the third talk and discussed "Nuclear Physics and Green Nuclear Energy," including background to his extensive work in both hot and cold fusion (see Part 2, which will appear in the next issue).

Dr. Mitchell Swartz gave the fourth plenary talk on "Excess Heat in LANR/CF Systems" and summarized updates to two decades of LANR R&D. He began by demonstrating excess power in LANR through paired runs (one with an ohmic joule control) of both simple thermometry and calibrated thermal power spectroscopy.

Dr. Swartz demonstrated that present CF/LANR systems get megajoules of excess energy over days. As he (and later Prof. Hagelstein) noted, even if the entire cathode was replaced with TNT, an explosion would release on ignition only 1.2 Kilojoules. This clearly, absolutely demonstrates that chemistry is not the source of LANR's energy. He showed several types of JET Energy high electrical impedance and codepositional LANR devices. Several of these were shown with data as they were used for electricity production, and paired with LANR-coupled Stirling motors. He showed data demonstrating excess powers between 0.5 W to 19 W in carefully calibrated systems and higher in less well calibrated systems. These correspond to excess power gains from 200% to 800%. One dual anode PHUSOR® (DAP) had a peak of 8,000% power gain for a short time using the DAP [Pd/D_2O,Pd$(OD)_2$/Pt,Au] arrangement.

He showed data from several runs of LANR devices using paired LANR-powered Stirling motors, with electrical inputs in the 1-19+ watt level. One run clearly demonstrated that removal of the energy to the Stirling motor leads to under-unity performance at the core, which is consistent with the Second Law of Thermodynamics and further indicates that this is not an error.

Swartz uses different materials, coatings and a different approach than most of the other experimenters in the LANR field. Dr. Swartz explained some "tips" for understanding and controlling LANR in these PHUSOR®-type and high impedance systems. Swartz has maximized the excess heat effect by using ultra-pure D_2O, low-paramagnetic D_2O, which has high purity, and anodes that have 99.99% purity, along with cathodes that are constructed systematically using low-contamination materials. He pointed out that other experimenters in the field rely on lower purity materials and electrolytes; while by adopting an approach, in which purer materials are used, they have made discoveries that have had significant consequences. In particular, by using a pure electrolysis solution, empirically, they have found that an extremely high electrical impedance of the solution in LANR is good for producing excess heat. An explanation for this is that solutions that have higher conductivity induce significantly higher rates of gas evolution, and this results in low (usually zero) excess power.

At JET Energy, Inc., he said they have emphasized the need for *in situ* calibration controls, during experimental runs, and have found conclusive evidence for substantial excess power. Impedance matching and high electrolyte impedance are needed to avoid deuterium loss from bubble formation. Bubble formation severely reduces excess power. There is an optimal operating point (OOP) in applied power that maximizes excess power that can be identified from plots of output power as a function of input power. He also pointed out the importance of coatings of Au or B, which can change the hydrogen/deuterium admittance, leading to enhancements (increases) in loading and excess heat production and reproducibility. The activation energy of the LANR Pd Phusor® system is ~60.7 kilojoules/mole. Importantly, Dr. Swartz pointed out that during ICCF10, he demonstrated to an audience that it is possible to produce reproducible excess heat if the open circuit voltage exceeds 0.7 volts at the end of a particular run.

He also reported results from some of his extensive "light" water nickel experiments. Swartz has investigated the effect of adding small amounts of D_2O to ordinary H_2O in Ni LANR experiments. He has found that these additions increase the excess power. He reported this fact during ICCF9. He also demonstrated that when excess deuterium is added to light water experiments involving Ni, when sufficiently high current densities are applied or excessively high D_2O concentrations are used, changes in the metal's color and in its electrical properties take place, and the associated changes "flatten" the OOP manifold, irreversibly destroying the excess heat process. These destructive effects do not occur in Pd, where LANR involve more reversible processes.

Drs. Fleischmann and Pons observed a strange phenomenon in the early 1990s, which they referred to as "Heat After Death" (HAD). This occurs when excess energy is observed after the CF/LANR cell is turned off—or in the case of Fleischmann and Pons when the cell had run out of electrolyte solution. Dr. Swartz has analyzed experiments that produce this effect closely. He refers to the excess power that is generated in this kind of situation as Tardive Thermal Power (TTP). TTP is a more precise term than HAD and the integral of the TTP with respect to time, over an interval of time, is the HAD associated with that time interval. He has reported that this quantity decays initially with a shorter time constant, then, it decays with a longer time constant. Swartz suggests that this may be the result of the presence of shallow traps in the electrodes (where he speculates that excess heat is produced) which gradually turn into deeper traps.

TTP occurs when the open circuit voltage at the end of a run is above a threshold value. Dr. Swartz has also reported that the TTP is proportional to the square of the voltage that initiates the effect, followed by a decay in its value until the open circuit voltage drops to 0.7 volts. This produced in the early LANR systems power gains of 170-220% (with energy gains of 152%). He said that JET Energy, Inc. has used TTP to run Stirling engines and that they have also run Stirling engines using excess power from high-Z PHUSOR®-type LANR systems. [PHUSOR® is a registered trademark of JET Energy, Inc.; protected by US Patents, including D596,724; D413,659. All rights reserved.]

Part 2, which will continue with more science and engineering from the 2011 LANR/CF Colloquium, will appear in Issue 99 but will be posted on Infinite Energy's website sooner (www.infinite-energy.com).