J. Condensed Matter Nucl. Sci. 13 (2014) 516–527

Research Article

Demonstration of Energy Gain from a Preloaded ZrO_2–PdD Nanostructured CF/LANR Quantum Electronic Device at MIT

Mitchell R. Swartz*

JET Energy Inc., Wellesley Hills, MA 02481-0001, USA

Peter L. Hagelstein†

Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Abstract

A self-contained, preloaded CF/LANR quantum electronic component, a NANOR®-type LANR device containing active ZrO_2–PdD nanostructured material at its core, showed energy gain during, and after, the January, 2012 IAP MIT Course on CF/LANR. The Series VI two terminal device featured new composition, structure, and superior handling properties. Most importantly it was preloaded so that LANR activation is separated from loading. The calorimeter had parallel diagnostics, including heat flow measurement, and calibrations included an ohmic (thermal) control located next to the NANOR®-type device. The preloaded LANR device demonstrated energy gain which ranged generally from 5 to 16. It was 14.1 energy gain while the MIT IAP course was ongoing. During February and March, through a range of experiments, the NANOR® continued to produce excess energy, confirmed by daily calibrations. This open demonstration has confirmed the existence, reproducibility, and improved control of CF/LANR reactions, and as importantly, has shown a possibly superior preloaded nanostructured LANR material and driving device.

Keywords: Dry, NANOR, Preloading, Reproducibility

1. Introduction

Clean, high efficiency energy production is very important today, and in the foreseeable future, from whatever source. Lattice assisted nuclear reactions (LANR, also known as cold fusion and LENR) use hydrogen-loaded alloys to create heat and other products [1]. The "excess heat" is energy derived from what is believed to be deuteron fusion in aqueous, non-preloaded, earlier systems, and so the deuterons are the fuel and are extremely slowly consumed. LANR will

*E-mail: mica@theworld.com
†Email: plh@mit.edu

© 2014 ISCMNS. All rights reserved. ISSN 2227-3123

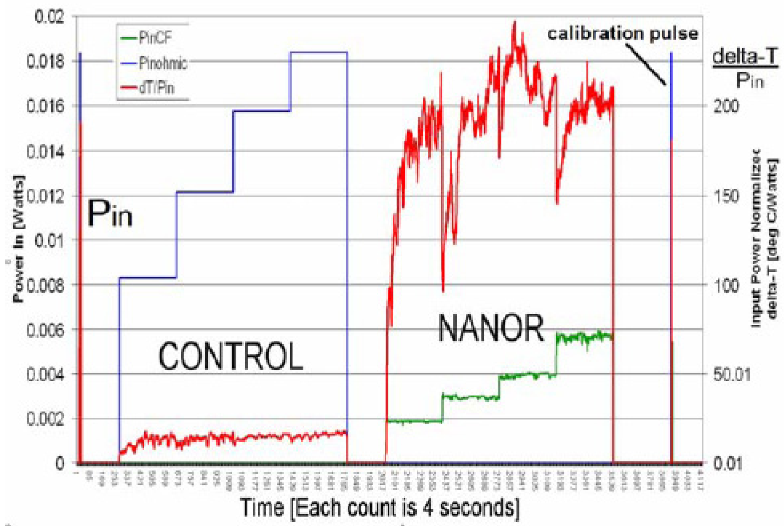

Figure 1. Input power and resulting output temperature rise (normalized to input electrical power) of a self-contained CF/LANR quantum electronic component Series 6–33; run EJan30B, a two terminal NANOR®-type device containing active preloaded ZrO_2–PdD nanostructured material at its core.

be an important source of energy for this planet, for artificial internal organs, for interstellar probes, and robotics, transportation, and electricity production. With LANR we also get to transfer the use of petrochemicals and gasoline into making useful pharmaceuticals and plastics and perhaps even nanomaterials. In the case of LANR, there can rarely occur, in a lattice under special conditions, the fusion of two heavy hydrogen nuclei to form a helium nucleus at near room temperature. The product helium-4, or simply helium, is *de novo* meaning that this helium-4 is created new and fresh, generated directly from two, driven by more, deuterons physically located within the loaded palladium, nickel or one of their nanostructured materials. These reactions were first reported as CMNS, LANR, LENR or cold fusion, and it involves a palladium-alloyed lattice where the process occurred irregularly at low efficiency. Most importantly, the product with LANR, helium, is environmentally safe and does not produce global contamination or warming. One such cold fusion device (PHUSOR®) was openly shown at MIT during August 2003 [2]. This paper reports a second open demonstration; confer Figs 1,3–5; and, therefore, it is important to compare this to the previous LANR demonstration and technology. For example, we previously demonstrated success in LANR aqueous systems, linked to high solution resistance (impedance) and shaped-metamaterial LANR devices, with power gains more than 200–500%; and short term power gains using codepositional high impedance devices DAP (Dual anode Phusor®-Type LANR device; Pd/D_2O, $Pd(OD)_2$/Pt–Au have reached energy outputs of up to ∼8000% compared to input energy, where ohmic controls are defined as 100% [3–5].

The results of the previous open demonstrations of the PHUSOR®-type LANR devices including BOTH at MIT and later developed integrated larger systems involving paired Stirling engines driven by LANR to beyond 19 W of excess power [2]. These devices (cathode volume ∼0.47 cm^3, area ∼6.4 cm^2) yield significant excess heat after full loading, with a peak excess power production circa 1.5 W, and a peak power gain of ∼2.4 or higher. Their output depends upon loading rate, loading achieved, and confinement time. The palladium Pd/D_2O/Pt devices demonstrate a critical threshold input electrical current density circa $1.5^{\pm 0.3}$ mA/cm^2, and a possible activation energy of ∼60.7 kJ/mol. Open circuit voltage (V_{oc}) greater than 1.8–2.70 V is useful and heralds excess heat. The mean excess power gain (compared to an ohmic joule control) during the week was $2.30^{\pm 0.84}$ for electrical input powers of 120–750 mW. The system developed $338^{\pm 67}$ mW of excess power compared to a joule (thermal) control which is defined as 100%.

However, successful LANR requires engineering of multiple factors including loading, adequate confinement time (sometimes weeks within the component container because the materials can be potential toxic if inhaled), loading rate, and prehistory (with careful avoidance of contamination and materials and operational protocols which quench performance). Specifically, nanostructured materials [6], metamaterials [7], and their controlled operation [8,9] improve success. At LANR's nanostructured material "core" is an isotope of hydrogen, usually deuterons, which are tightly packed ("highly loaded") into binary metals, alloys, or nanostructured compounds, containing palladium or nickel, loaded by an applied electric field or elevated gas pressure which supply deuterons from heavy water or gaseous deuterium.

ZrO_2–(PdNi)–D LANR/CF nanostructured materials generate excess heat [10], including with acoustic and electric fields [11–13], with additional effects from orthogonal applied DC magnetic field intensities [12]. They have been made into LANR/CF transistors [3] which exhibit energy gain and simultaneous non-thermal near infrared emission. There are complicated polarization/transconduction phenomena including an "avalanche (transconduction electrical breakdown) effect" which has a critical role in excess heat. Nanostructured materials are important in LANR produced in codeposition structures [14], observed in non-thermal near infrared emissions [15,16], and exhibiting LANR excess heat correlated with the size of the Pd–D nanostructures [12,13]. Relevant to LANR and the future of LANR devices, nanostructured materials offer great opportunity. These nanostructured LANR materials include nanoparticles, nanocrystals, quantum dots, nanocatalysts. nanowires, nanocrystals, nanoclusters, nanodendrimers and higher polymer aggregates, and metallic-organic hybrids. They are made from metals, semiconductors, oxides, ceramics, polymers, composite materials, glasses, alloys and combinations of the above. As a result of the small size, nanotechnology built using these new nanostructured materials have two amazing properties. First, nanostructured materials have incredibly large surface area to volume ratios. Second, many also have new unexpected quantum mechanical properties. Nanostructured materials enable quantum confinements, surface plasmon resonances, and superparamagnetism. Examples of material properties which unexpectedly change by nanostructured utilization include significantly decreased melting temperatures (gold), significantly increased electrical conductivity (silicon), increased flammability (aluminum), improved catalytic properties (platinum), and unexpected transparency of metals (copper). Solvated gold nanoparticles have colors which range from red to black. Palladium nanoparticles often have a vacancy in their center. Similarly, LANR nanostructures include vacancies within them. In the alloys, they must drift into the bulk from the surface. This diffusion is slightly facilitated by the loading itself. *de novo* Pd-D vacancies have been made in loaded Pd (and Ni) with electron beam irradiation [17]. Codeposition has been used to make palladium, nickel and alloyed loaded materials on top of electrodes, and used dual anode LANR systems to produce very high levels of such LANR nanostructured materials locally [13,14]. In addition, nanostructured materials have been used in LANR using palladium black [10] in a double structure (DS)-cathode. They reported more than 200 MJ of excess energy was continuously produced for over 3000 h at an average rate of 50–100 kJ/h. The DS-cathode is a Pd cathode with "an internal vacuum zone filled with a deuterium storage type powder" and an outer cylindrical vessel of Pd metal (wall thickness of 3 mm). Such bulk cathodes rely on diffusion, making it difficult to reach 100 at% concentration solid solution of D in Pd or the other nanostructured material. The D ions are postulated to move over the surfaces of the Pd black by the "spillover-effect", without the need to becoming D_2 molecules. We have reported successful production of excess heat using nanomaterial palladium, nickel, and newer alloyed compounds, such as ZrO_2PdNi, and in a LANR transistor configuration, driven by two applied electric field intensities, which demonstrate LANR heat associated with low level near-infrared emission, controlled by two optimal operating point manifolds.

2. Experimental

We report a new generation of LANR (CF) preloaded nanocomposite ZrO_2–PdNiD CF/LANR quantum electronic devices which are active, and capable of energy gain. These feature two terminals and self-contained superior handling properties enabling portability and transportability. NANOR-type lattice assisted nuclear reaction (LANR) devices use hydrogen alloys to create heat and other reactions. Most importantly, the activation of the desired cold fusion reactions is, for the first time, separated from the loading. These proprietary prepared preloaded ZrO_2–(PdNi) LANR/CF nanostructured materials are dry, and glued into electrically conductive, sealed configurations. The core is ZrO_2–(PdNiD) [Zr (∼66%), Ni (0–30%), and Pd (5–25%) by weight before additional D_2 and H_2 are added to achieve more than 130% D/Pd. These are potentially very useful. Their complex development has required control of their breakdown states and quenching tendencies. Series VI NANORs feature new composition, structure, and superior handling properties. Again, most importantly, they are preloaded so that LANR activation is separated from loading. The current driver system incorporates our proprietary third generation LANR (CF) Integrated Circuit which is microprocessor controlled and coupled to a Series V or VI preloaded CF/LANR nanocomposite ZrO_2–PdD and ZrO_2–PdNiD electronic devices to activate them. It is combined with a new type calorimeter and data processing which is used to evaluate and verify activity of the NANOR®, controls, and others materials. This system has already been demonstrated using the more reproducible nanostructured CF/LANR quantum electronic devices at MIT in 2012.

The LANR preloaded, stabilized NANOR®s were driven by a high voltage circuit up to 3000 V rail voltage. The duty cycle was split with half going to a control portion consisting of a carefully controlled electrical DC pulse into an ohmic resistor which was used to thermally calibrate the calorimeter. We also employed a new series of LANR-directed light indicator outputs to define states which has been a matter of incredible utility and assistance almost every time the system and device has been used. The new controlled driving system uses pulse wave modulated microcomputer control of specialized very high voltage semiconductors linked to a current source driving system driving system coupled to the NANOR®-type LANR system. It provides an improved method of current control, enabling new activation, a new method of driving, an improved and better paradigm system and the ability to evolve paradigms. Furthermore, the system is excellent for preliminary tests for usefulness to detect LANR activity, and by serially examining multiple samples of the same CF/LANR material to look for changes from doping, contaminants, and quenching materials. The new controlled driving system can be used for open demonstrations as discussed above, and to more closely examine LANR and other systems for their activity, linearity, time-invariance, and even the impact of additives. For example, a very successful investigation of silver doping was made. This system can easily detect the impact of impurities, dopants, contaminants, quenching agents, accelerants, and other factors. Basically, there are two levels of operation for NANOR® LANR systems, low and high power. High power is useful for applications requiring larger amounts of power such as transportation, heating, and artificial organs. In this case, however, low power is used for several reasons including to facilitate the rapid time constant, and because this is for demonstration and teaching purposes.

Data is taken from voltage, current, temperatures at multiple sites, and even as a 4-terminal measurement of the NANOR's internal electrical conductivity. Data acquisition has all temperature and electric measurements sampled at data rates of 0.20–1 Hz, with 24+ bit resolution (e.g. Measurement Computing (MA) USB-2416, or a Omega OMB-DaqTemp or equivalent; voltage accuracy $0.015^{\pm 0.005}$ V, temperature accuracy <0.6°C). All connections are isolated when possible, including where possible with Keithley electrometers, or their equivalent, for computer isolation. All leads are covered with dry, electrically insulating tubes, such as medical grade silicone, Teflon, and similar materials, used to electrically isolate wires. To minimize quantization noise, if necessary, 1 minute moving averages may be used for some signals. The noise power of the calorimeter is in the range of ∼1–30 mW. The noise power of the Keithley current sources is generally ∼10 nW. Input power is defined as $V * I$. There is no thermo-neutral correction in denominator. Therefore, the observed power is a lower limit. The instantaneous power gain (power amplification factor (non-dimensional)) is defined as P_{out}/P_{in}. The energy is calibrated by at least one electrical joule control (ohmic

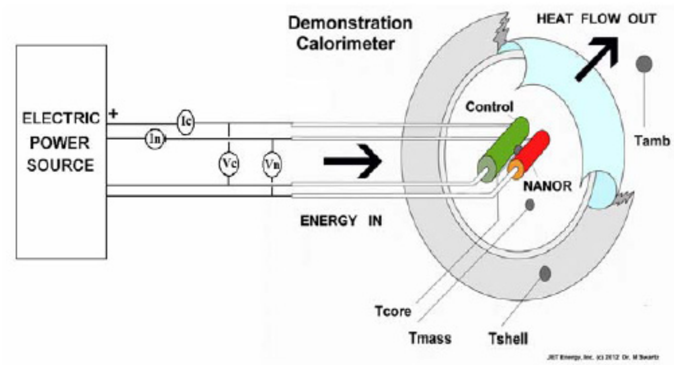

Figure 2. Electric driver and calorimeter showing parallel diagnostics consisting of heat flow measurement and temperature, and the ohmic (thermal) control. The electric power supply provided a high voltage DC rail voltage with the electronics controlling the applied voltage across the component.

resistor) used frequently, and with time integration for additional validation. The excess energy, when present, is defined as (P_{out}–P_{in}) * time. The amount of output energy is determined from the heat released producing a temperature rise, which is then compared to the input energy.

3. Experimental – Methods

Figure 2 is a three-dimensional (3D) schematic perspective view of the NANOR® and control and sensors located inside, and monitored by, several systems and a calorimeter. The distances shown, and relative sizes of objects, in the figure are not actual, simply schematic to help demonstrate what is occurring. At the center are the NANOR® and the ohmic thermal control. Additional temperature measurements are used for further accuracy and verification. Physically located between them, is one of the Calorimeter's three central core temperature probes. To ensure thermal contact, a thermally conductive, electrically resistive material can be used. Thermal compounds can include Wakefield Thermal compound (Pelham, NH). Some of the heat flow was measured by an Omega HFS Thin Film Heat flux sensor. In all cases, a thin layer of electrically insulating, but thermally conductive material is place above and below these three elements of the system. Very thin insulating ceramics can be used, such as Wesgo AL-500 and Molecular Dielectrics, Inc (Clifton, NJ) MYKROY J11. There are also specialized additional thermal masses which are for the most part completely and adiabatically isolated from the ambient environment by a series of five insulating barriers. One of these barriers enable the leads from the NANOR®, ohmic control, and temperature sensors (and other diagnostics such as heat flow sensors) to leave the calorimeter through specially modified firebricks.

Using a low power type system for open demonstrations, the output of this system was presented at MIT from January 30, 2012 through mid May 2012. The input powers were below 100 mW [19], because the set-up was designed to run at low power input levels to increase the safety at the educational institution for its multi month-long stay at MIT. A range of experiments were conducted examining the impact of various driving sequences, and the NANOR® continued to produce excess energy. There were daily calibrations using input current and voltage standards.

The 2012 Open LANR/CF Demonstration at MIT had parallel diagnostics including calorimetry, input-power-normalized delta-T, and focused heat flow measurement, and several calibrations. One of the calibrations included an ohmic (thermal) control located next to the NANOR, used to ascertain activity. To enable demonstrations at MIT for the NANOR®-type LANR system, including in the MIT IAP class where multiple experiments had to be shown to classes, or otherwise run over times of 2 h, a specialized heat flow semiquantitative analyzer was specially developed. The heat which this preloaded NANOR®-type LANR device demonstrated was monitored three ways by three (3) independent systems for semiquantitative measurement of the energy produced. Furthermore, the output of the NANOR is compared to an ohmic control. First, the energy produced is instantaneously and kinematically determined by the ratio of the input power normalized temperature increase, called by the symbol 'delta T/P_{in}' referring to the increase of temperature (delta$T$), divided by the input electrical power (P_{in}). Second, it is also instantaneously and kinematically evaluated over a wide area by the ratio of the input power normalized heat flow leaving it, called by the symbol 'HF/P_{in}' referring to the heat flow (HF) divided by the input electrical power (P_{in}). Third, it is examined by calorimetry, calibrated by the thermal ohmic control, and confirmed by long-term time integration. These three methods of verification are pooled to derive very useful information, semiquantitatively ascertain energy produced, and infer activity.

4. Results

The self-contained CF/LANR quantum electronic component and a two-terminal NANOR®, containing active ZrO_2–PdD nanostructured material at its core, showed energy gain during, and after, the January, 2012 IAP MIT Course on CF/LANR. The results are shown in Figs. 1, 3–5. In this case, the mini-sized NANOR is a sixth generation CF/LANR device, and it is smaller than 2 cm, with less than 1 g of active material. However, this is actually a matter which is not *de minimus* because the LANR excess power density was more than 19,500 W/kg of nanostructured material. The preloaded NANOR-type LANR device demonstrated an average energy gain (COP) of $\sim 14 \times$ ($\sim$1412%) the input for a duration of several hours that it was observed during the MIT IAP course on the first day, and levels of that order continued. Over several weeks, CF/LANR quantum device demonstrated more reproducible, controllable, energy gain which ranged generally from 5 to 16 (14.1 while the course was ongoing).

In the case of this NANOR (the sixth generation of these microminiaturized CF/LANR devices), the activation of this cold fusion reaction is, for the first time, separated from its loading. In every other system known, Fleischmann and Pons, Arata, Miles, and the others, the loading was tied to activation. By contrast, in the case of the sixth generation NANOR®s, unlike the others, the preloaded devices can be simply electrically driven.

This is a high efficiency heat producing system, and within it, a unique calorimeter and a unique driving system whose design, driving configuration and implementations, in conjunction with the NANOR have made portability of LANR to MIT, and elsewhere, possible. Furthermore, the proprietary microprocessor controlled system has also led to an evolving series of improved driving paradigms to qualitatively explore and then exploit loaded nanostructured, nanocomposite, and other materials including semiquantitatively examining them for usefulness, heat-production activity, linearity, time-invariance, and even the impact of additives and contaminants.

The NANOR®-type LANR device was able to generate large amounts of heat (>100% compared to the expected dissipation by $V * I *$ time). This excess energy clearly heralds a high efficiency of driving energy use. The entire system was put onto three electronic boards enable an entire new generation of activated CF/LANR nanocomposite ZrO_2–PdNiD electronic devices. This second Open Demonstration of LANR devices featuring the preloaded NANOR turns out to have been more important than initially realized. First, this demonstration confirmed the existence, reproducibility, and now improved control, of CF/LANR reactions. For the entire months of February through April 2012, the NANOR® continued to produce excess energy, with daily calibrations against an ohmic thermal control; thus, it also confirmed the existence of CF/LANR daily during that time. By comparison, and also worth noting, the historic 2003 open demonstration of CF/LANR at MIT needed two full tables for the setup, whereas the 2012 NANOR demonstration at MIT needed only a single standard sized desk top. And most of that space was taken up by the computer and confirming meters (five of them), rather the device itself. In addition, the new calorimeter was cyclable in hours rather than requiring an entire day, making it applicable to the MIT course. In addition, compared to the 2003 LANR Open Demonstration at MIT, this second open demonstration featured a more sophisticated calorimeter shown at the MIT RLE laboratory. It had additional monitoring diagnostics for improved verification, such as the measurement of heat flow, to thereby provide for three independent ways of monitoring excess heat semiquantitatively compared to a thermal ohmic control.

Second, it has shown a possibly superior nanostructured material and configuration. The NANOR®-type preloaded LANR device openly demonstrated features include its convenient size (much smaller) and its superior handling properties which enable unique portability, and transportability. Like its 2003 (ICCF-10) predecessor demonstration, this preloaded NANOR-type LANR device also showed excess energy and also obvious improvements of size, response time, diagnostics, and total output energy.

Third, it had a much higher energy gain compared to the 2003 demonstration unit (Energy gain 14.1 in 2012 vs an energy gain ∼2.7 in 2003). In fact, the current NANOR Series VI NANORs have had even higher gains (to beyond 30).

Fourth, another unique quality is the graphs were generated by an open demonstration proving also precise, safer containment.

Fifth, the Internet blogs and visitors to the open demonstration have indicated that the public wants cold fusion by whatever name, and therefore, these activated preloaded CF/LANR nanocomposite materials and LANR electronic devices do have usefulness and importance.

These preloaded NANOR®-type LANR devices have shown significant improvement over theirs predecessors, including the highly successful metamaterial PHUSOR®-type of LANR device. At their core is the proprietary preloaded nanostructure material specially prepared by several new processing steps. Could these dry, preloaded, ready-to-be-activated, NANOR®-type LANR devices/systems/materials, including in preassembled IC devices and systems, be the future of clean efficient energy production [20]?

Figures 1 and 3–5 show this entirely new, more reproducible, much more powerful configuration of clean, efficient energy production from several points of view. The figures include raw data and derived information from the runs which show conclusively LANR excess energy heralded by calorimetry and by input power normalized incremental temperature (delta T) changes. These graphs shows a small portion of the collected data and derived information which was actually collected and analyzed by the class, and later in a four-month interval. Confirmatory measurement of the operability and utility of the system include the first day of the 3 months open demonstration of the NANOR®-type LANR device at MIT during the 2012 IAP course on CF/LANR in the Department of Electrical Engineering.

Figure 3 is a set of curves which plot the differential incremental increase in temperature (°C) for case with no input ("Background"), and for the case of an ohmic thermal control at the same location, and for the NANOR®-type LANR device. The graph presents several curves which plot the temperature rise in response to four different levels of electrical input power, and the response of an ohmic control to same electrical input power. The x-axis represents time, and each count represents 4 s. The y-axis on the left-hand side represents electrical input power in watts. The y-axis on the right-hand side represents the amount of temperature rise (differential temperature increase) in response to the electrical input power (°C). The input to the thermal ohmic control is shown, followed by the preloaded NANOR®-type device, as are the thermal output (heat output generated) for both the ohmic control and the preloaded NANOR®-type device. The graph shows first the response of the ohmic control, and then the response of the NANOR, then a second ohmic control. Each of the outputs are read off of the right-hand side. Calibration pulses, used for accuracy and precisions checks of voltages and currents, are also shown.

Compare the output for NANOR®-type LANR device to the thermal (ohmic) control. Figure 3 clearly demonstrates the larger differential incremental increase in temperature (°C) for the NANOR® compared to the ohmic. Attention

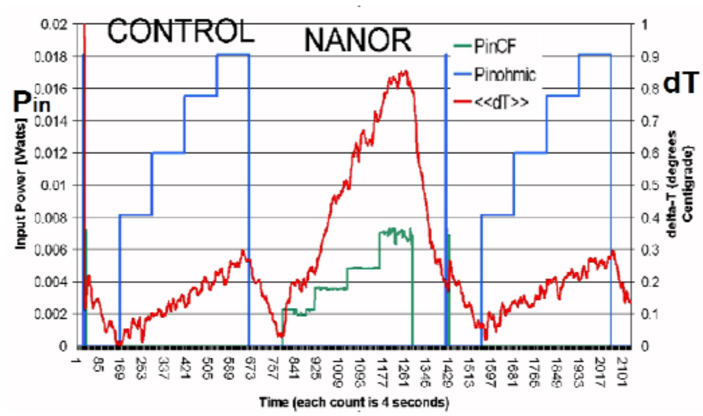

Figure 3. Input power and incremental output temperature rise of a self-contained CF/LANR quantum electronic Series VI NANOR® device. These curves plot the raw data as incremental temperature rise and the applied input electrical power.

is directed to the fact that the active preloaded LANR quantum electronic device clearly shows a larger, significant improvement in differential thermal output compared to a standard ohmic control (a carbon composition resistor). That amount of differential temperature increase for the preloaded NANOR®-type device heralds great utility for the energy output as a heat source.

Figure 1 is set of curves which plot the temperature rise (delta T (in °C)) of the preloaded NANOR®-type LANR device and the ohmic control normalized to four levels of input electrical power. Each is shown with as a thermal output response to its electrical input. The several regions present the differential temperature rise normalized to input electrical power for the preloaded NANOR, for the case with no input power ("Background"), and for the case of input to the ohmic thermal control, located at the core. The x-axis represents time, and each count represents 4 s. The y-axis on the left-hand side represents electrical input power in watts. Each of the outputs are read off of the right-hand side. The y-axis on the right-side represents the amount of temperature rise (differential temperature increase) normalized (that is, divided by) to the electrical input power. The units of this axis are in °C/W. Calibration pulses, used for accuracy and precisions checks of voltages and currents, are also shown.

Figure 1 heralds the excess energy achieved by the NANOR type of LANR device. Compare the delta T output normalized to input power for preloaded NANOR®-type LANR device to the thermal (ohmic) control. It can be seen that the input power normalized delta measurements suggest strongly the presence of excess heat. Observe that despite lower input electrical power to the NANOR, the temperature rise normalized to input electrical power observed in the core was higher than expected, as compared to the ohmic control. Attention is directed to the fact that the active preloaded LANR quantum electronic device again clearly shows significant improvement in thermal output, here input-power-normalized compared to a standard ohmic control (a carbon composition resistor).

Figure 4 is set of curves which plot the heat flow, normalized to input electrical power, leaving the system while driving the preloaded NANOR®-type LANR device and the ohmic control at four different electrical input powers. The heat flow is in response to the electrical input. The figure presents the output heat flow for the preloaded NANOR, for the case with no input, and for the ohmic thermal control, located at the calorimeter's core. The$x$-axis represents time, and each count represents 4 s. The y-axis on the left-hand side represents the electrical input power in watts. The y-axis on the right-hand side represents the Heat Flow output normalized (that is, divided by) to the electrical input power. Calibration pulses, used for accuracy and precisions checks of voltages and currents, are also shown.

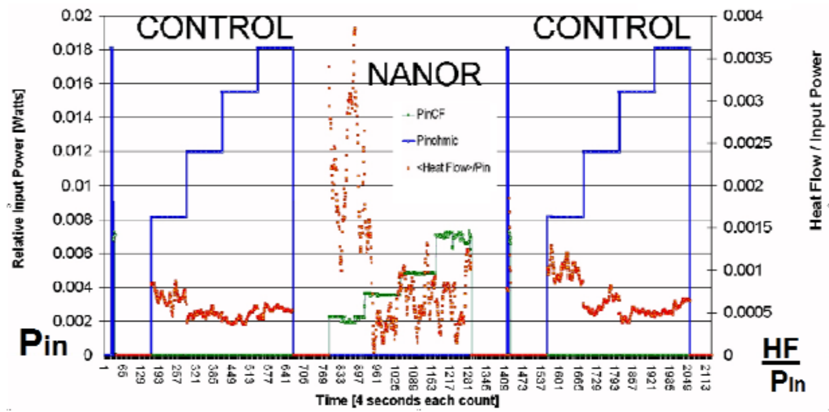

Figure 4. Input power and output heat flow normalized to input electrical power of a self-contained CF/LANR quantum electronic component NANOR 6-33.

In Fig. 4, compare the output heat flow normalized to input power for NANOR®-type LANR device to that for the thermal (ohmic) control. The long term heat flow measurements (using calibrated devices) confirm the presence of excess energy, and validate the other measurements. It can be seen that despite lower input electrical power to the NANOR, the heat flow out in response, normalized to input electrical power observed in the core, was higher than expected, as compared to the ohmic control – especially at lower input power levels. The response of the NANOR®-type LANR device is consistent with very efficient energy gain, with the energy output as heat. The changes of the output with input power is consistent with the optimal operating point manifold of the LANR material. Therefore, the figure heralds the great efficiency of, and the excess energy coming from, the preloaded NANOR®-type of LANR device. Attention is directed to the fact that the active preloaded LANR quantum electronic device clearly again shows significant improvement in energy generated compared to a standard ohmic control (a carbon composition resistor) by this method, too, using heat flow. This information corroborates the marked and substantive incremental increase in energy output as heat for the preloaded NANOR®-type of LANR device.

Figure 5 shows curves which plot the electrical input power, at several input power levels, and the calorimetric responses of both the preloaded NANOR®-type device and the ohmic control. The x-axis represents time, and each count represents 4 s. The y-axis on the left-hand side represents electrical input power in watts. The y-axis on the right-hand side represents the amount of energy released. The units of this axis are in joules. The figure shows the input, and the calorimetry, of preloaded NANOR along with that for the ohmic thermal control used to calibrate the system. Those calibration pulses, used for accuracy and precisions checks of voltages and currents and time, are also shown. The inputs to the thermal ohmic control, followed by the preloaded NANOR®-type device, are shown, as are the calibrated calorimetric outputs for both.

Each of the outputs are read off of the right-hand side. The latter curves represent time integration to determine total energy. They thus rule out energy storage, chemical sources of the induced heat, and other sources of possible false positives. Compare the output for NANOR®-type LANR device to the thermal (ohmic) control. As can be seen, this semiquantitative calorimetry, itself calibrated by thermal waveform reconstruction, was consistent with excess heat being produced only during energy transfer to the NANOR®-type LANR device.

Notice that the active preloaded LANR quantum electronic device clearly shows significant improvement in thermal output compared to a standard ohmic control (a carbon composition resistor). The graph, taken from the MIT IAP January

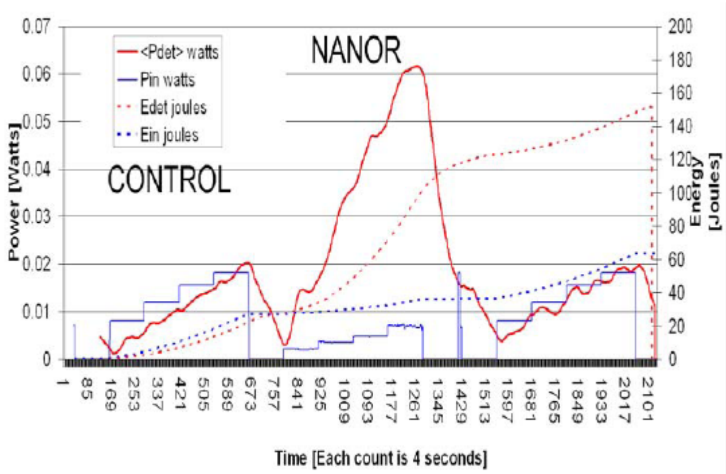

Figure 5. Input and Heat Output of a two terminal NANOR®-type device Series 6-33 device, showing the calorimetric response at several input powers, for the device and the ohmic control.

2012 class, is representative of the NANOR-type of CF/LANR technology, and its shows quite clearly demonstrated over unity thermal output power from the NANOR, at a level close to 78 mW.

5. Conclusion

In summary, the uniqueness of the preloaded LANR nanostructured material-device includes its high activity, its preloaded nature, its dryness, its precise containment, and its easy portability. It begins a new generation of CF/LANR nanostructured materials and devices. In the case of this NANOR (the sixth generation of these CF/LANR devices), the activation of this cold fusion reaction is, for the first time, separated from its loading. In every other system known, Fleischmann and Pons, Arata, Miles, and the others, the loading was tied to activation. As importantly, the semiquantitatively measured output energy IS a significant energy gain. This has always been a ‘goal post’ for cold fusion, one which so far remains beyond the realm for hot fusion on Earth. The present device and driving technology have provided high-efficiency pre-loaded energy-, heat-, and product-producing devices which can be electrically driven and has provided a method of improved activation and reproducibility for controlling lattice assisted reactions and their generated products using nanostructured, nanocomposite, and other materials.

Preloaded CF/LANR nanocomposite materials in CF/LANR Electronic Devices do have usefulness today and tomorrow. Today, they can be clearly examined with this system for demonstrations of their CF/LANR activity, linearity, time-invariance, and the impact of additives. For example, the present device, and controlling/driving system provided a reliable low power, high-efficiency, energy production device for demonstration and teaching purposes of size smaller than a centimeter, with an active site weight of less than 100 mg. The preloaded nanostructured LANR material and accompanying controller and driver have shown at MIT a successful (second) open demonstration of CF/LANR heat production and energy conversion device. This confirms LANR/CF. Also, compared to the first LANR/CF open demonstration at MIT, the new device and accompanying driver and other technologies have shown obvious improvements of size, response time, diagnostics, and even total output energy.

This open demonstration over months has demonstrated that microprocessor controlled integrated circuits using LANR quantum optical devices containing preloaded nanostructured LANR material can be used as an effective very clean, energy production system, apparatus, and process. We have run the component over a year with evanescent loss which is attributed to fuel loss, or redistribution, or inactivation (perhaps by reaction with another material). Whether they can be refueled or simply replaced, is under investigation. In addition, elsewhere, this driving and monitoring system was useful to easily convert conventional monitoring and conventional thermometry into fine calorimetry. Calorimetry and input-power-normalized delta T were used to ascertain activity. For example, this system has been used to show the calorimetry of a nanostructured composite CF/LANR Device using twenty different levels of input. This method is similar to, but beyond, that suggested by Dr. Robert W. Bass [18]. After testing it, we have determined that it was highly useful, and now use it routinely, wherever possible.

Tomorrow, preloaded LANR nanostructured materials and devices will also be useful for integrated circuits and other applications using a pre-activated nanostructured and other materials. These include high power, effectively ‘over-unity’, self-contained, microprocessor-controlled, preloaded, energy production devices and systems enabling their remote activation for electronic, bioelectronics, space and avionic circuits, IC devices, and AI systems.

Acknowledgements

The authors gratefully thank Gayle Verner and Jeffrey Tolleson for meticulous help in the manuscript, and Jeffrey Tolleson for help with the computer programming; also Jeffrey Shapiro, Alex Frank, Allen Swartz, Charles Entenmann, Alan Weinberg, Dennis Cravens, Dennis Letts, Brian Ahern, Jeff Driscoll, Larry Forsley, Pamela Mosier-Boss, Robert Smith, Robert Bass, Robert Godes and the late Talbot Chubb; and JET Energy and New Energy Foundation for support. NANOR®-type and PHUSOR®-type technologies, and other discussed IP herein, is protected by USA Patents D596724, D413659 and other Patents pending.

References

[1] M. Swartz, Survey of the observed excess energy and emissions in lattice assisted nuclear reactions, *J. Sci. Exploration* **23**(4) (2009) 419–436.

[2] M. Swartz, Can a Pd/D_2O/Pt device be made portable to demonstrate the optimal operating point? Condensed Matter Nuclear Science, *Proc. of ICCF-10*, Peter L. Hagelstein, Scott, R. Chubb (Eds.), World Scientific, NJ, ISBN 981-256-564-6, (2006), pp. 29–54.

[3] M. Swartz, Excess power gain using high impedance and codepositional LANR devices monitored by calorimetry, heat flow, and paired stirling engines, *Proc. ICCF-14*, 10–15 August 2008, Washington, D.C., David J. Nagel and Michael E. Melich (Eds.), ISBN: 978-0-578-06694-3, 2010, p. 123.

[4] M. Swartz and G. Verner, Excess heat from low electrical conductivity heavy water spiral-wound Pd/D_2O/Pt and Pd/D_2O–$PdCl_2$/Pt devices, Condensed Matter Nuclear Science, *Proc. ICCF-10*, P. Hagelstein (Ed.), Chubb, World Scientific, NJ,, ISBN 981-256-564-6, 2006, pp. 29–54.

[5] M. Swartz, The impact of heavy water (D_2o) on nickel-light water cold fusion systems, *Proc. of the 9th Int. Conf. on Cold Fusion (Condensed Matter Nuclear Science)*, Beijing, China, 2002, pp. 335–342.

[6] M. Swartz, Optimal operating point manifolds in active, loaded palladium linked to three distinct physical regions, *Proc. of the 14th Int. Conf. on Condensed Matter Nuclear Science and the 14th Int. Conf. on Cold Fusion (ICCF-14)*, 10–5 August 2008, Washington, D.C., ISBN: 978-0-578-06694-3, 2010, p. 639.

[7] M. Swartz and G. Verner, The Phusor®-type LANR cathode is a metamaterial creating deuteron flux for excess power gain, *Proc. of the 14th Int. Conf. on Condensed Matter Nuclear Science and the 14th Int. Conf. on Cold Fusion (ICCF-14)*, 10–15 August 2008, Washington, D.C., ISBN: 978-0-578-06694-3, 2010, p. 458.

[8] M. Swartz, Quasi-one-dimensional model of electrochemical loading of isotopic fuel into a metal, *Fusion Technol.* **22** (2) (1992) 296–300.

[9] M. Swartz, Consistency of the biphasic nature of excess enthalpy in solid state anomalous phenomena with the quasi-1-dimensional model of isotope loading into a material, *Fusion Technol.* **31** (1997) 63–74.

[10] Y. Arata and Y.C. Zhang, Observation of anomalous heat release and He4 production from highly deuterated palladium particles, *Jpn. J. Appl. Phys.* **38** (Part 2, No. 7A) (1999) L774–L776.

[11] M. Swartz, G Verner and J. Tolleson, Energy gain from preloaded ZrO2-(PdNi)-D nanostructured CF/LANR quantum electronic components, *Proc. ICCF17*, 2012.

[12] M. Swartz, Impact of an applied magnetic field on the electrical impedance of a LANR device, Volume 4, *JCMNS*, *Proc. 239th Am. Chemical Soc*., 2011.

[13] M. Swartz, LANR nanostructures and metamaterials driven at their optimal operating point, 3rd Vol *LANR/LENR Sourcebook*, October 21, 2011.

[14] M. Swartz, Codeposition of palladium and deuterium, *Fusion Technol.* **32** (1997) 126–130.

[15] M. Swartz, G.Verner and A.Weinberg, Non-thermal near-IR emission from high impedance and codeposition LANR devices, *Proc. of the 14th Int. Conf. on Condensed Matter Nuclear Science and the 14th Int. Conf. on Cold Fusion (ICCF-14)*, 10–15 August 2008, Washington, D.C., ISBN: 978-0-578-06694-3, 2010, p. 343.

[16] M, Swartz and G. Verner, Bremsstrahlung in hot and cold fusion, *J. New Energy* **3** (4) (1999) 90–101.

[17] M. Swartz, P.L. Hagelstein, G. Verner and K. Wright, Vacancy-phase nickel cathodes, Abstracts ICCF7, 1997, p.137.

[18] R.W. Bass, Five frozen needles CF protocol, *J. New Energy* **6**(2) (2002) 30.

[19] These low power NANOR® -type components have been driven up to the two watt level.

[20] Similar aqueous systems of Pd D indicate the fuel, D, is used to make ^{4}He (Miles), and there are no biologically significant neutron, or ionizing radiation, output hazards known.