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Research Article

# Direct Electricity Production from NANOR®-type $ZrO_2$-PdNiD Components Using Ultrasound

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**Abstract**

This paper describes new features of the NANOR®-type CF/LANR component technology. We report direct production of "excess electricity"; ∼655% higher than anything seen of any control. Thus, deuterated NANOR®-type components now appear to offer two methods of energy production. Direct LANR electric output may eventually bypass the need for thermoelectric energy conversion handicapped by Carnot inefficiency.



*Keywords:* Electricity production, excess electricity, NANOR®-type components, ultrasonic irradiation, LANR energy conversion

## 1. Introduction

$ZrO_2$-PdNiD nanostructured LANR (lattice assisted nuclear reaction) materials [1] contain deuterated PdNiD core islands that are electrically isolated by the zirconia ($ZrO_2$) dielectric. They have exquisite sensitivity to ultrasonic irradiation [2], [3], [4], including the generation of heat [5]. NANOR®-type components were examined for their ability to convert energy obtained from ultrasonic irradiation (US, or simply 'ultrasound') to DC electricity.

We report production of "excess electricity"; ∼655% higher than anything seen of any control. Deuterated NANOR®-type components now appear to offer two (2) methods of energy production. Direct LANR electric output may eventually bypass the need for thermoelectric energy conversion handicapped by Carnot inefficiency [Figure 1].

In Figure 1, the available electricity (derived from an electrometer) and the resultant temperature rise for a series of US pulses are shown for the NANOR®-type $ZrO_2$-PdNiD component and for ohmic controls. These are shown both with and without an additional applied magnetic field intensity. Each US pulse had the same level of power output delivered from the ultrasonic unit as described in the Experimental section. The power levels of the US irradiated was fixed, and the durations are shown along the time axis (horizontal). The left vertical axis was derived from the output of a very high-input impedance Keithley electrometer which was contacting both sides of the NANOR®-type two terminal LANR component. The colors of the pulses in the figure identify if, and when, a continuous magnetic field was added (brown) or not, or if an ohmic control was substituted for the NANOR®-type component (blue pulses), or if only US was used without an applied magnetic field (green). The green line is the output from a NANOR®-type component with US alone, and no additional magnetic field. The results of ohmic controls alone are shown as blue.

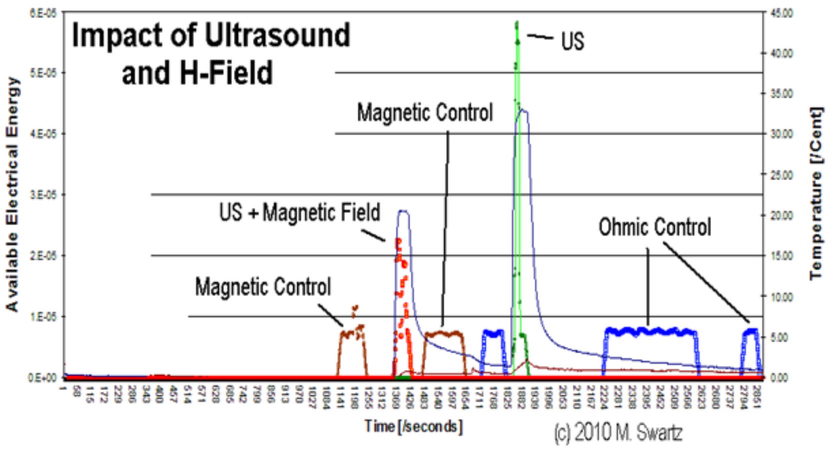


**Figure 1.** Direct Electricity Production from LANR using Ultrasonic Irradiation (US). The left axis show the obtained relative electrical energy available. The pulses show when ultrasonic irradiation was delivered. The key to the results follows: Brown spots, and brown line, show the Magnetic control's electrical output under an applied magnetic field with no additional ultrasonic irradiation (left axis); Red spots: NANOR®-type component electrical output under ultrasonic irradiation also with the applied magnetic field (left axis); Green line: NANOR®-type component electrical output under ultrasonic irradiation (left axis) but without the applied magnetic field; Blue lines – Electrical output of ohmic controls; Thin Blue lines: Temperature of the volume containing the NANOR®-type component and the ohmic control (right axis); Purple thin line: Temperature of the bulk aqueous tank surrounding the ohmic control and NANOR®-type component [called a 'large angle detector' (shown on the right axis).

For this run, two (2) temperature detecting probes were used. Hence there are two continuous lines showing their temperature (right vertical axis). One was a sensitive small-angle [i.e. small area subtended] detector located exactly behind the NANOR®-type component (shown as the smaller amplitude purple/red line). The other was a wider angle detector, larger and behind all of the components irradiated (blue continues line; also right vertical axis).

## 2. Experimental

We examined these deuterated devices for electricity output and possible heat generation during various types of activation including while being ultrasonically irradiated. These components were also examined by electric, magnetic and ultrasonic fields. In the past publications, the NANOR-type component was connected and driven by an essentially DC power supply to bring out the excess heat, to reveal the electrical avalanches, and to elicit both the antiStokes spectra and the deuterium line RF spectra near 327 MHz. These were not driven by applied electricity. Instead, the NANOR®-type component, and the ohmic controls were only attached to the electrometers terminals so that its very high impedance could be used to measure their electrical output, if any.

These devices were constructed with their two terminals only connected to the Keithley electrometer. Therefore, in none of the following cases which are shown to manifest a temperature rise is that due to an applied electric field to the NANOR component or the ohmic control.

In a similar way, the ohmic controls which are usually used for the evaluation and calibration of any excess heat released by the electrically-driven NANOR, were not used for that reason here. There was no effort here to measure the excess heat, unlike the previous papers. The temperature detectors were added only to determine the local, and regional, temperatures around the irradiated NANOR type component.

Thus, here they were used to see if they were responsive to the incident ultrasound irradiation, as a control. Therefore, they were wrapped (thermically) into a large mass with the NANOR-type component and temperature

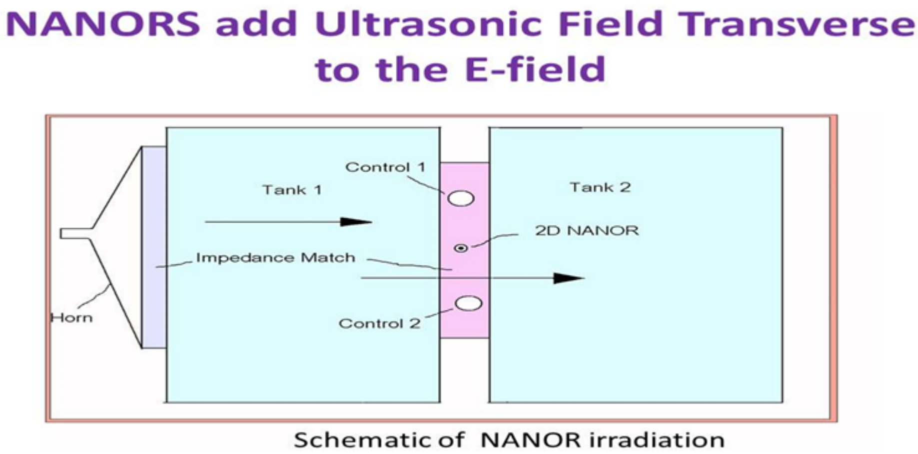


**Figure 2.** This is a schematic illustration/cartoon of the direction of ultrasonic radiation made through two tanks of water and the irradiated samples. The bath was larger than the irradiated area. Of more importance is that the author used quarter-wavelength impedance matches to minimize ultrasound reflectance (and this is not often done in this field). The matching impedance is obtained from the square root of the involved impedances. For palladium and heavy water, this quarter wavelength material can often be matched with a portion of red building bricks.

sensor. This larger single mass was wrapped into a larger volume with an additional metallic component acting as a local temperature sink. In fact, this tying together of their thermal masses into a larger thermal mass is commonly done in our systems and especially calorimeters, and it is also why the monitored temperatures often decreases so slowly in many of these experiments.

Temperatures (degrees C) were monitored at the LANR core, and at both ohmic controls, and at other background locations as further controls, and within two adjacent water tanks which absorbed the ultrasonic radiation and also provided thermal stabilization.

Temperature measurements were made by specialized electrically-insulated thermocouples [accuracy $+/-0.8$ deg.K, precision $+/-0.1$ deg.K]. The temperature probes were calibrated by an Omega IcePoint Cell. Peripheral temperatures were maintained by feedback control using a Yellow Spring Thermal Controller Model 72 [bandwidth of 0.2 K] within a Honeywell water circulation zone controlled room ($+/-$ 2.5 degrees K). The temperature sensors were provided to measure the local temperature of the NANOR®-type components and the other irradiated components, and to measure the regional bulk aqueous volume to which they were connected thereto (shown in Figure 2).

Calorimetry used ohmic controls and also paired water tanks for an ultrasonic control. Other controls included dry, gas deuterated, and $D_2O$-solvated nanomaterials, supplementing the background, magnetic, and thermal (including ohmic) controls. Two types of thermal controls were used. First, two ohmic resistors were included. The resistors were 100,000 and 10,000,000 ohms; a value selected to be in the range of the nanostructured material core. Next, the third control was a water container which surrounded the samples and controls and irradiators, minimized reflections, and was used to accumulate the heat and improve the calorimetry.

Ultrasound irradiation (0.3 to 25 W/cm$^2$) was delivered and subtended over an active area of $\sim$0.02 cm$^2$ of LANR component (Figure 2). In each case the same bath setup was used. The ultrasonic irradiator was a modified Dallons Medi-Sonic Ultrasonic generator (Model U-111). The device, and manual, state that it was operating at a nominal 1 Megahertz.

In a typical run such as Figure 1, pulses of ultrasound irradiation delivered 0.5 W/cm$^2$ (5 W total). For, or if there were two pulses of ultrasound irradiation; first 3 W (0.3 W/cm$^2$) for 5 minutes, and then 10 Watts (1 W/cm$^2$) for 1 minute.

Controls included thermal (ohmic) resistors also irradiated. They are seen only in cross-section.

The two ohmic resistors were designed to be included in the irradiation field so as to interact with the ultrasonic radiation. The area subtended by them is 0.35 and 0.78 cm$^2$. By contrast, the area subtended by the LANR nanostructured material core is 0.02 cm$^2$.

Electrical conductivity of the components, before, during, and after irradiation, was followed by 4-terminal electrical measurements. In addition, to measure the electricity generated (if any), the electrical output was coupled to a Keithley electrometer (Model 610A and 610B) and then a voltage follower. The system was examined at rest, during ultrasonic irradiation (such as 0.5 W/cm$^2$), and in the absence and presence of a continuous magnetic field intensity. Electrical conductivity of the components, before, during, and after irradiation, was followed by 4-terminal electrical measurements. The magnetic field intensity was estimated at 0.2 Tesla near the surface of the magnet, but there was not a measurement at the components, which were located about 1 to 2 cm away.

Some of these results are shown both with and without an additional applied magnetic field intensity. Most importantly, the NANOR®-type components are shown both with and without an additional applied magnetic field intensity. However, the additional control(s) of magnetic field intensities applied with the ohmic controls was not used in this run, unfortunately.

Outputs were calibrated by ohmic (thermal) controls and confirmed by adequate Nyquist sampling.

## 3. Results

### 3.1. Electricity Production

$ZrO_2$-PdNiD NANOR®-type LANR components are highly sensitive to sound generating both direct electrical energy and heat. Ultrasound impacting the LANR-type components does create direct electrical energy, far above the noise level. Of note, the temperature only changes with the simultaneous applied ultrasonic field.

For these results, a single NANOR®-type component was used in Figure 1 and 4. In Figure 1, the single component was irradiated along with various controls with measurement of each of their generated electricity over time.

Three different NANOR®-type components of different loadings were irradiated in the run in Figure 3. This graph shows the fundamental importance in the deuteron in these reactions.

The ultrasonic irradiation upon the NANOR®-type component in Figure 1 (and all components in Figure 3) is believed to be the sole reason for the temperature changes which are read off the right hand side of Figure 1. The more power irradiation upon all components is the reason for the temperature changes which are read off left hand side of Figure 4.

First, Figure 1 shows this direct relative electrical energy obtained from ultrasonic irradiation impacting a NANOR®-type device, and controls. The Figure also shows the impact of a magnetic field alone, ultrasound alone, and the combination of US and an applied magnetic field. Additional controls were (thermal) ohmic resistors. The marked increase in electrical energy happened only with ultrasonic irradiation of the NANOR®-type component.

Also, note that the temperature rise lasted longer than the falloff of the voltages. This demonstrates the LANR components create electricity, and it is not from the temperature rise.

Despite the marked differences in area subtended, with the LANR device having an area ratio of only 0.026 to 0.059 of the controls, it is important to note the very exquisite sensitivity of the LANR nanostructured material to ultrasonic irradiation for both electricity production and heating. The "excess electricity" was 655% higher than anything seen of any control.

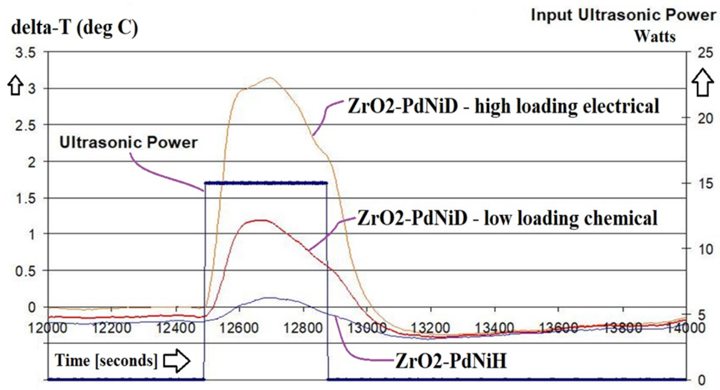


**Figure 3.** Thermometry of three NANOR®-type components to ultrasonic radiation (15W/cm$^2$), surrounded by two aqueous reservoirs for cooling. One has LANR nanomaterial, the second and third had increasing amounts of deuterons, added by heavy water and an additional electric field. This graph shows the fundamental importance of the deuteron in these reactions.

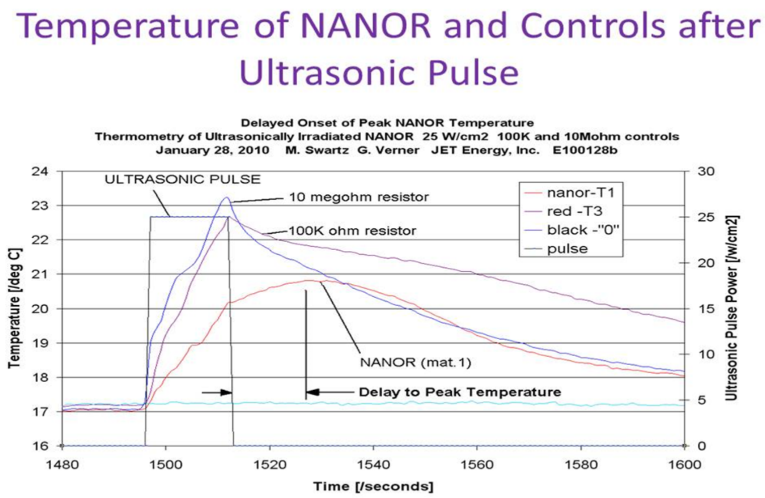


**Figure 4.** Thermometry of a NANOR®-type component and two additional ohmic controls. The LANR device has an area ratio of only 0.026 to 0.059 compared to the controls. Notice the delay of the peak temperature from the NANOR®-type component until after the end of the ultrasonic radiation (25W/cm$^2$).

Regarding impact of a magnetic field in combination with the ultrasound irradiation. As demonstrated in Figure 1, the magnitude of the electricity output was actually decreased by the applied magnetic field, applied orthogonal to the direction of induced electrical current.

### 3.2. Deuterons are the Fuel

Figures 3 and 4 show the temperatures (degrees Centigrade) of NANOR components and the ohmic controls, while being between two water tanks which absorb some of the ultrasonic radiation and provide thermal stabilization. They also reveal the fuel of CF/LANR. Figure 3 also shows the secondary heat redistribution to the larger water tank, as the temperatures fall while the ultrasonic irradiator continues.

The curves in Figure 3 show the response to ultrasonic irradiation of three NANOR®-type components to a single square wave pulse of 15 watts. The lowest curve is of $ZrO_2$-PdNiH which shows a minimal, but clear, response. The curve above it is the response of $ZrO_2$-PdNiD, obtained from heavy water, chemical loading. It has a significantly greater response. The top curve, with the greatest amplitude, is the response of the $ZrO_2$-PdNiD, obtained from a proprietary electrical loading method,

To compare the differences between these curves, compare the integrals over time (area under the curves). Importantly, Figure 3 shows the crucial role of deuterons as the fuel of these desirable At lower input irradiation powers, there is an exquisite sensitivity of the LANR nanostructured devices by electricity output or temperature rise [degrees C] when ultrasonically irradiated. There is a sudden rapid rise in the temperature of the NANOR®-type component, exceeding that of the ohmic resistors (even though they subtend larger areas to the ultrasonic irradiation). Only at much high irradiation powers will the temperatures of the controls exceed the LANR component, such as in Figure 4.

The curves in Figure 4 show the thermometry response of a NANOR®-type component and two additional ohmic controls to ultrasonic irradiation with a square wave pulse of $25W/cm^2$. In this case, notice the delay of the peak temperature from the NANOR®-type component is AFTER the end of the ultrasonic radiation ($25W/cm^2$). This is unlike the ohmic controls.

Notice also that these LANR components also demonstrate some late-occurring temperature responses, continuing after the ultrasound is turned off, in contrast to the control materials. This heralds secondary reactions occurring after the end of the triggering ultrasonic pulse.

## 4. Interpretation

NANOR®-type LANR components now offer two methods of energy production – both direct electricity production and the conventional LANR-induced excess heat. Importantly, this device for the direct production of electricity from nuclear LANR process bypasses the previous need for LANR heat generation followed by thermoelectric energy conversion, which is so handicapped by Carnot and other inefficiencies.

The “excess electricity” of the $ZrO_2$-PdNiH NANOR®-type LANR component is 655% higher than anything seen of any ohmic control. However, this electrical energy produced so far is microscopic in this initial system. However, the efficiency of energy conversion is small [$10^{-13} - 10^{-14}$ of the transiting ultrasonic energy] at this time. Thus, there is considerable engineering left to do, and some issues to consider.

### 4.1. Important Issues to Consider

It is important to consider several issues. First, why does an alternating symmetric ultrasonic wave here produces a direct electrical voltage or current. Specifically, what might be the source(s) of the dissymmetry that transforms the alternating US into a DC current. When the NANOR-type components were manufactured, i.e. including preloading, there was developed an *ab initio* inherent asymmetry because the deuterons are injected into, and enter only on one side of the component. That asymmetry from initial preloading may have been the reason why the voltage appeared on the Keithley electrometer. In the future, as a result of the question, (and in retrospect we should have looked closer) we will also add a series of electrical diodes and amplifiers to learn more, including how this electrical output could be maximized.

It is also important to consider if the small electrical output might have been an effect of the observed temperature rise. We believe that it is unlikely that the small electrical output(s) are an effect of the temperature rise. The electrical load is at the Keithley electrometer, and it is noted that the observed voltage at the Keithley electrometer decreases and falls before the fall off of temperature. This heralds that the voltage arises from other reason than the temperature rise.

What might be the role of electrical noise? The output of the LANR component was certainly not a result of electrical noise. It is less clear regarding the ohmic controls which were irradiated. However, the very low outputs of the controls in Figure 1 may have been limited the baseline sensitivity of Keithley electrometer in our system. The US-irradiated NANORs (+ or − magnetic field intensity) far exceeded that lower possible detection limit.

It is also finally important to consider and remove a possibility that the additional heating of the NANOR®-type components might be the result of energy input from loading. That is not possible because these components were preloaded weeks before they were driven for these experiments. There could be no temperature rise here, occurring from the earlier preloading which happened long before the experimental use of the components here.

## 5. Conclusions

In summary, these acoustic-driven, vibration-driven PdNiD-$ZrO_2$ NANOR®-type components offer new methods of energy production and energy conversion from LANR systems with direct electricity production augmenting conventional LANR-induced excess heat. This discovery may add more tools to the armamentarium of CF/LANR, as well.

The incremental LANR-catalyzed induced electrical energy from vibration(s) both augments yet is dwarfed by, the induced heat. But, it has that one advantage of totally bypassing Carnot-inefficient thermoelectric energy conversion. We are developing both more robust LANR NANOR®-type components, and ancillary control systems to harvest the electricity for storage and use.

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