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Research Article

Excess Heat From Cold Fusion Activates Nitinol

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Abstract

Nitinol was investigated as a possible sensor of CF/LANR (Lattice Assisted Nuclear Reactions) activity. Several Nitinol devices were built to examine the responses of Nitinol to both ordinary and to CF/LANR-induced excess heat. A NANOR®-type component delivered a peak power output of ∼12.17 Watts when driven with input power of 3.94 Watts. The metric of qualitatively derived RMS induced force was more useful than length measurement for both prosaic applied heat and excess heat. The Nitinol had derived RMS induced force-power response of about ∼170-250 microNewtons/Watt. The Nitinol LANR/CF Detectors were equally sensitive to both ordinary heat and to CF/LANR excess heat, and the sensitivity was only qualitative.

Keywords: Nitinol, LANR activity, active calorimetry, accelerometer, gyroscope, time-of-flight sensor, NANOR®-type component, preloaded LANR material, ZrO_2-PdD, Shape Memory Alloy

1. Introduction

Nitinol [1,2,3,10] is a Shape Memory Alloy [SMA, also known as Flexinol and Muscle Wire]. The field of CF/LANR needs improved means to detect and semi-quantitatively measure the desired XSH-producing driven state. Therefore, what was investigated here was whether Nitinol can be a possible sensor of CF/LANR activity. Two questions were paramount: 'Will A Shape Memory Alloy [Nitinol] Respond to the Heat and Excess Heat from an ACTIVE LANR system?' and 'Can A Shape Memory Alloy [Nitinol] Distinguish an ACTIVE LANR system distinguishing CF XSH from ordinary heat?'

2. Background - Successful LANR has a Single Desired Active Driven State

Cold fusion is real and achievable, and active electrically-driven systems and components are obtainable as needed for experiments, making heat and electricity, and open demonstrations. The active driven state produces excess heat (XSH) and de novo 4Helium; and is distinguishable by unique antiStokes spectra [6], [7] and unique high-Q Deuterium-line

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radiofrequency emissions at 327.37 MHz [8.9]. However, the proverbial "bad news" is that, although not usually recognized, there are two (2) driven states but ONLY ONE (1) state/mode is DESIRABLE ["Active"] making the sought for excess heat [XSH]. The other is inactive. This is true both for LANR aqueous systems and dry preloaded components [4], [5]. The existence of these two states were first suggested theoretically by the Quasi-1-dimensional model of isotope loading [which led to codeposition, OOP control, etc. (ICCF-4)]. This was later confirmed experimentally by NANOR® components driven into avalanche mode without XSH (ICCF-19), by coherent Raman spectroscopy of electrically driven CF/LANR components [6, ICCF-20], by the important single run for an aqueous CF/LANR system (shown at ICCF-21), and by RF Deuterium-Line Emissions [8, ICCF-22].

2.1. Background – Nitinol Exhibits Shape Memory

Nitinol behaves differently from normal viscoelastic materials, which after being squeezed or pulled apart, relax to a different shape from the final unstressed condition [called "General elastic recovery", 10]. In contrast, after SMA undergoes a first deformation at a high temperature [austenite phase] and is then cooled, thereafter, when squeezed or pulled apart in a second deformation, the SMA will recover the original, first deformation shape when heated to any temperature above the critical "transformation temperature". This is 'Shape Memory', and a SMA can repeatedly recover the first shape - even from severely deformed shapes. Nitinol's properties of shape memory, dramatic kink resistance, and superelastic properties have enabled new inventions from bridge and building dampers, to HVAC actuators, to medical devices [10].

Nitinol is used here as sensor to detect CF/LANR activity based on its complex unique metallurgy and its response to heat. This unusual change in shape from heat, the "magic" of Nitinol, arises from its ordered structure, unlike homogeneously mixed intermetallic alloys where the metallic components are randomly arranged throughout the volume. With active Nitinol, the atoms are arranged precisely in rows. SMA alloys of nickel and titanium have near equal atomic percentages, and are named according to the weight percent of nickel (e.g. Nitinol 55 is 55% Ni). The NOL in nitinol stands for Naval Ordinance Laboratory, where the memory properties were investigated by William J. Buehler and Fredrick Wang.

Acquisition of the Nitinol Shape ["Shape Memory"]

The high-temperature austenitic phase, where shaping occurs, is ∼500 °C (932 °F). In this "parent phase", the SMA is "shape set". Thereafter, the martensite phase ("daughter phase") is produced by cooling. The Shape memory results from the crystallographic reversibility of the many martensitic phase transformations of martensite's crystal structure. Beginning as monoclinic, it has the unique ability to undergo limited deformation ("strain") by twinning without breaking atomic bonds and without diffusion. Energy-dispersive and X-ray analyses reveal that the base nitinol material is TiNi in the B2 phase, and confirm the presence of the Ti_2Ni intermetallic inclusions. The microdiffraction patterns reveal a polycrystalline structure. SEM images of Nitinol wire reveal nanofibers [diameter 30 –70 nm] with a longitudinal fiber size of several microns, all aligned parallel to the wire axis. Astoundingly, the martensitic state will revert back to austenite phase instantaneously, regardless of whatever deformation it was in. The original shape is recovered by a solitary "one path" transition back to the austenitic phase and shape; and 35,000 to 100,000 psi (689 MPa) become available to make this happen.

3. Experimental

Several Nitinol devices were built and examined for their responses to ordinary and CF/LANR-induced excess heat. Nitinol wire is springy, and not very difficult to bend. Soldering is very difficult, so crimping was used. For this work,

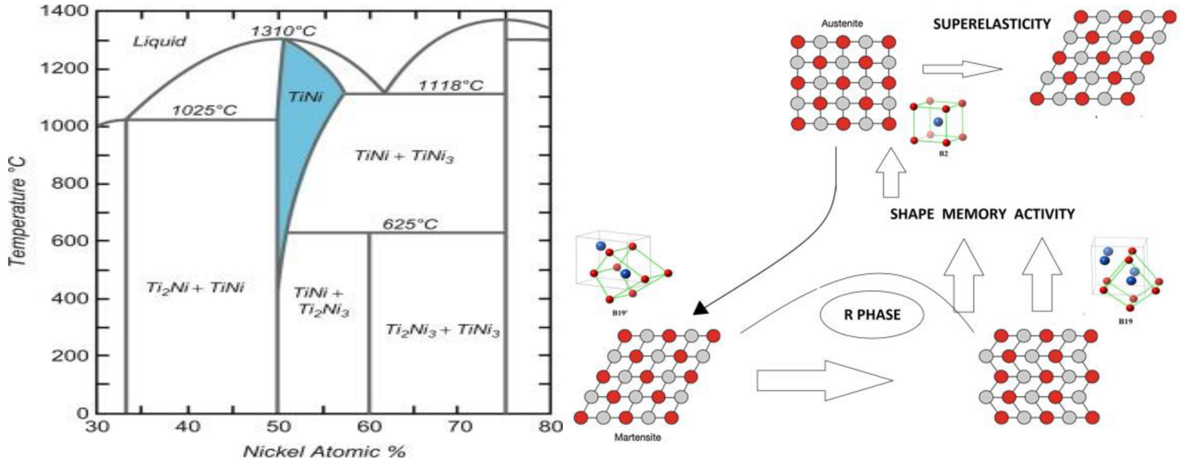

Figure 1. The Ni Ti Phase Space of Nitinol as a Function of Nickel/Titanium Ratio and Temperature. Attention is directed to the fact that that the desired region of shape memory activity (SMA) is only in the blue area. The "magic" of Nitinol arises from itfs ordered structure, unlike homogeneously mixed intermetallic alloys where the metallic components are randomly arranged throughout the volume. With active Nitinol, the atoms are arranged precisely in rows.

the high temperature Nitinol shape was a line. The LANR XSH was obtained from a dry preloaded ZrO2-PdNiD NANOR®-type LANR Component used is NANOR #7-24 which has a ZrO2-PdD core, and which delivered a peak power output of ∼12.17 Watts when driven with input power of 3.94 Watts. Controlled heating was by electrically driving an ohmic control alternating with an active NANOR®-type component (#N7-24) with a ZrO2-PdD core [4], [5]. The metrics measured were heat induced force, temperature, and changes in the Nitinol wire's length as determined by using in situ 3D accelerometers and gyroscopes, thermocouples, and a time-of-flight (TOF) optical reflection measurement along the nitinol itself, during the heating.

Instrumented, Tethered CF or Ohmic Control Driven Nitinol 3D-Printed Springs

Types 2 and 3 Instrumentation was attached to a pillared single-turn spring. The PLA 3D-printed half spring had the nitinol set across the ends. The system was 3D printed as a single piece with the pillar and platform, with two 3D-printed holders to restrain the nitinol. A restoring force was included consisting of one to three elastic bands. In the Type 4 Instrumentation, the system was turned sideways and removed from the PLA half-turn spring entirely. As before, at the center of the system was a 3D-printed clip holding the ohmic control (98 ohms), the NANOR®-type component, a thermocouple, and covering all that is the thermally conductive, electrically insulating, boron nitride (the blue soft material that looks like clay) (Figure 2).

This central core consists of a "sandwich" of an ordinary ohmic resistor as a thermic control (for ordinary heat) and a dry preloaded NANOR®-type LANR component for fast, active CF/LANR excess heat [XSH]. Also present is sensitive temperature monitoring instrumentation and the Nitinol. Some restoring force on the spring was found to be needed, and provided by an elastic band added around the 3D-printed PLA semicircle.

The NANOR®-type component was NANOR® #7-24 with a ZrO_2-PdD core. It had an incremental power gain of ∼300% at peak for an electrical input power of 3.94 Watts, generating a thermal power output of ∼12.17 Watts.

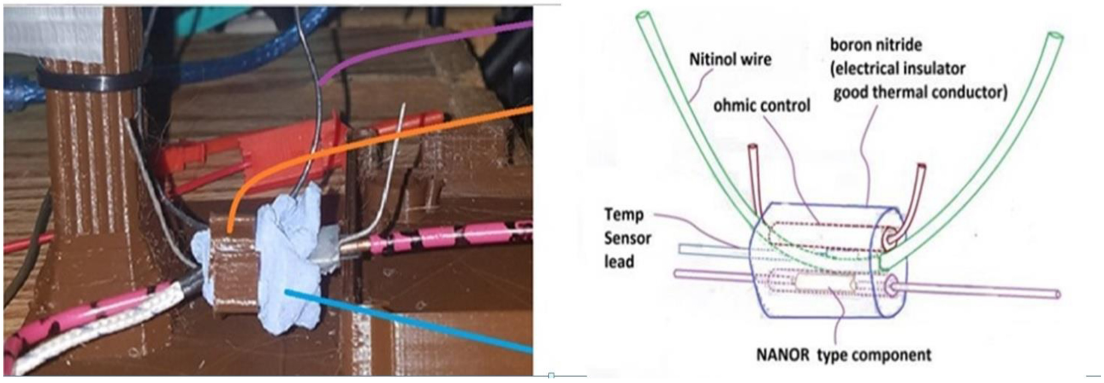

Figure 2. Experimental Core to test Response of Nitinol to Applied Heat and Excess Heat.

3.1. Metrics Examined

Temperature - Specialized thermocouples were used having very fast response times, small probe size, and low thermal mass. Two MAX6675 performed cold-junction compensation for the type-K thermocouples.

Spring diameter - Distance was determined by time-of-flight ["TOF"] optical measurement using VL6180X Time-of-Flight Distance Sensor. An integration period of 50 ms yields an incident light resolution of 0.32 lux/count and a range reading in mm.

Forces wrought - Qualitatively determined by accelerometers followed by vectorial RMS addition, and multiplication by the effective mass.

Electric Power Drive - Precision computer controlled power supply (Tekpower TP3005P) or Arduino driving a MOS-FET using PWM. Power delivered sequentially to the ohmic control and the NANOR®-type component. The applied electric power dissipation makes heat over time which makes the nitinol expand, increasing both the force and distance between ends.

Calorimetry - For good, calibrated measurements, the electrically-driven active components are always timely compared to an ohmic control. The components are wrapped in boron nitride [BN] and a larger thermal mass, along with a thermocouple.

Planned Paradigm - Confirmation of the algorithm, checking for linearity and time-invariance, and calibrating the output of the component under test, is made by reproducing the heat generated from a square wave sent to an ohmic control. As always, time integration of the power, in and out, is necessary to prove the analytic system is correct, and to rule out phase changes, and the like.

4. Results – Proof of CF/LANR Activity in NANOR®-type component Nanor 7-24

Figure 3 is a control demonstrating reproducible CF/LANR activity in NANOR®-type component Nanor 7-24 from electrical drive. The graph shows the calorimetry of electrical power delivered to an ohmic control bracketing an active Nanor®-type component. Power and energy are shown [Input power (blue lines), Output power (red lines), Electrical energy (blue, red, dashed lines)]. It is also a graph showing the calorimetry of electrical power delivered to this ohmic control (a carbon composition resistor). The thermal control and the active Nanor®-type component are in the Nitinol Arch4. Shown is the input electrical power (blue lines) to the ohmic control, the NANOR®-type component Nanor 7-24, and then the ohmic control again, as a function of time. The output thermal power are red lines.

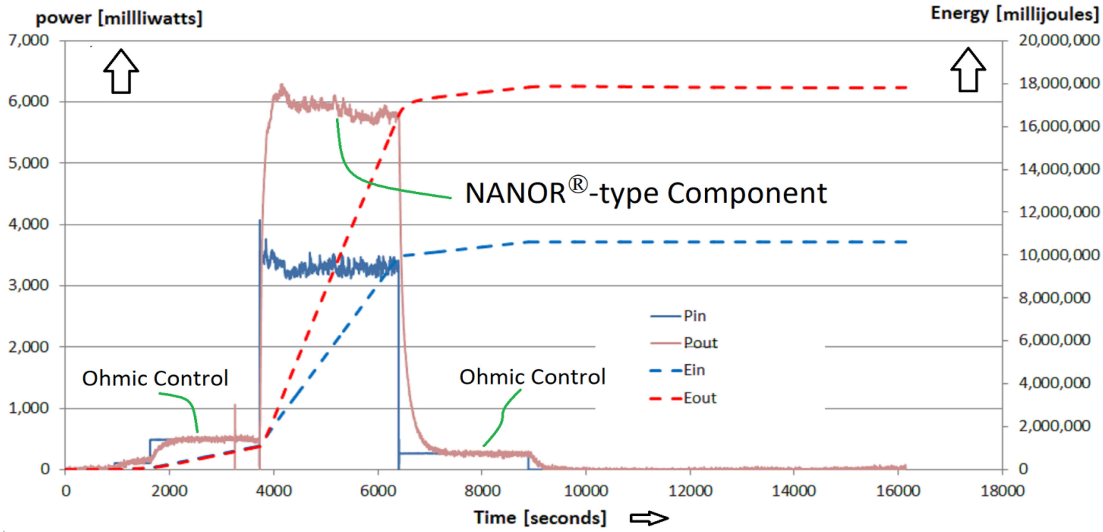

Figure 3. Test of Ohmic Control and LANR component for Emission of heat and excess heat.

It can be seen that the controls are connected and the NANOR®-type CF component is active. Excess power and excess energy are easily seen, but only for the LANR component. There is excellent LANR activity.

4.1. Results – Response of Nitinol to Input Power Delivered to the Ohmic Control

Figure 4 shows the thermometry of the ohmic control alone against the Nitinol. The peak force wrought was about 224.24 $(+/-26.1)$ microNewtons/Watt. This figure shows the thermometry of the ohmic control alone against the Nitinol. Shown is the input electrical power (red line), and the responses: including temperature (pink line) and the qualitative derived induced RMS force ("milliNewtons").

Note the short delay of the Nitinol response. It can be seen that the input electric power-induced temperature changes lag as the component and surroundings absorb heat according to their heat capacity, before the temperature is sufficient to induce the mechanical change anticipated.

4.2. Results - Response of Nitinol to Ohmic Control & Nanor®-Type Component 7-24

Figures 5 and 6 are two coupled graphs of same experiment which show the Calorimetry of, and then the Nitinol response to, and active electrically driven CF/LANR NANOR®-Type component.

Figure 5 is the Calorimetry. The graph shows the input electrical power delivered to an ohmic control and then NANOR®-type component, and the resulting output thermal power from both. The input electrical power (blue lines) to the ohmic control and CF/LANR component are shown as a function of time. Also shown is the output thermal power (red lines) from each. Finally, also shown is the integrated energy in and out from each, which is a requisite to check the calorimetry.

Figure 6 shows a graph presenting the Nitinol response wrought first from the heat delivered from the electrically-driven ohmic control and then the response to the heat from the electrically-driven NANOR®-type component 7–24. The data shows the thermometry (left) and Nitinol response (right) wrought by the heat during a single run using the

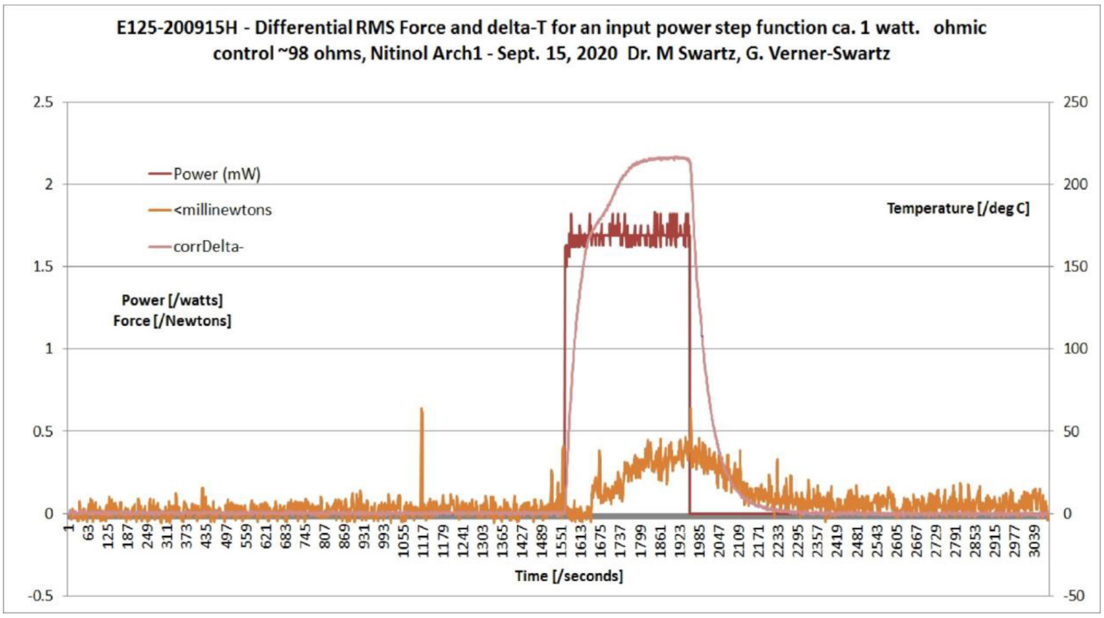

Figure 4. Impact of Ohmic Control on Nitinol - Step Response, Note Delay of Nitinol Response.

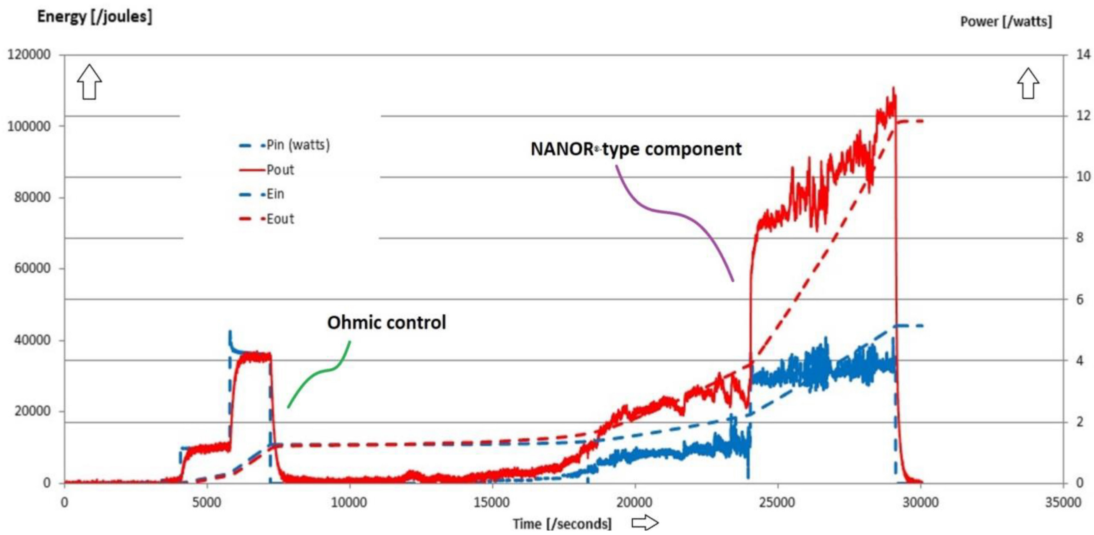

Figure 5. Calorimetry of an Ohmic Control & Nanor®-type component 7-24 next to Nitinol.

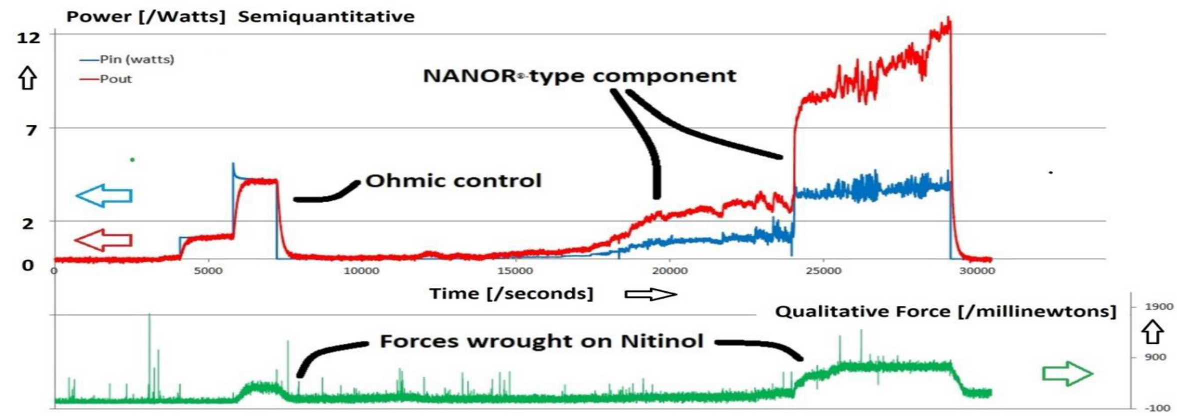

Figure 6. Response of Nitinol to Heat from Ohmic Control & Nanor®-type component 7-24.

ohmic resistor as a control. The input electrical power delivered to each (blue lines), and the resulting output thermal power (red lines) from each are shown, along with the kinematic responses from the Nitinol [as an RMS force].

There is excellent LANR activity. Excess power and excess energy are easily seen, but only for the LANR component. The ohmic control has an incremental power gain of 1.00 (100% or less of the input electrical power), The NANOR®-type component at the first lower power input level, has an incremental power gain of 239%. At the end, the incremental power gain is about ∼300% [For an electrical input of 3.94 W there is a thermal power output of circa 12.17 Watts. At the end of the run the excess energy produced is ∼51, 147.6 Joules.

5. Conclusion and Summary of Results

Several Nitinol devices were built to examine the responses of Nitinol to both ordinary and to CF/LANR-induced excess heat. As a control for heat, a 98 ohm resistor was used. For excess heat, a NANOR®-type component delivered the XSH. It had a peak power output of ∼12.17 Watts when driven with input power of 3.94 Watts.

Ordinary heat and true CF/LANR excess heat are not distinguished; as the Nitinol Detectors were equally sensitive to both ordinary heat and to CF/LANR Excess Heat.

Although the biggest problem is that Nitinol CF/LANR sensors are non-selective for ordinary heat versus true excess heat from active CF/LANR devices/components, the second biggest problem is that Nitinol is non-linear. This is in part because it is associated with a preliminary phase change, and its transitions have hysteresis. For whatever combination of reasons, there do occur irregular movements in Nitinol which must be considered, then controlled/minimized/avoided to make this type of measurement/monitoring device useful even for qualitative measurements. Then, the Nitinol preliminary phase change must be addressed, as it requires a precise heat absorption before the Nitinol will work as expected. Without this, the Nitinol will not change shape immediately and accurately as, and when, expected.

It has been discovered that the metric of qualitatively derived RMS induced force was more useful than length measurement for both prosaic applied heat and excess heat. The Nitinol had a derived RMS induced Force-Power response of about ∼170-250 microNewtons/Watt.

Thus, Nitinol can be used as a qualitative heat sensor in this field BUT it is not selectively specific for LANR/CF-induced excess heat, although it can detect the excess heat. Furthermore, Nitinol sensors are not as sensitive, and are not as reliable, and also are more difficult to use, than other sensors described in the cold fusion literature. They are probably limited in the future to qualitative corroboration [10]. By contrast, full calorimetry (with ohmic controls, time integration and checks of the algorithm and calorimeter), and coherent antiStokes (CMORE) spectroscopy [6], [7], and Deuterium Line radiofrequency (RF) spectroscopy near 327 MHz [8], [9] remain the sole, superior methods to selectively, specifically, and semi-quantitatively detect ACTIVE states/modes in driven CF/LANR/LENR systems and components.

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