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LENR Reactions Using Clusters

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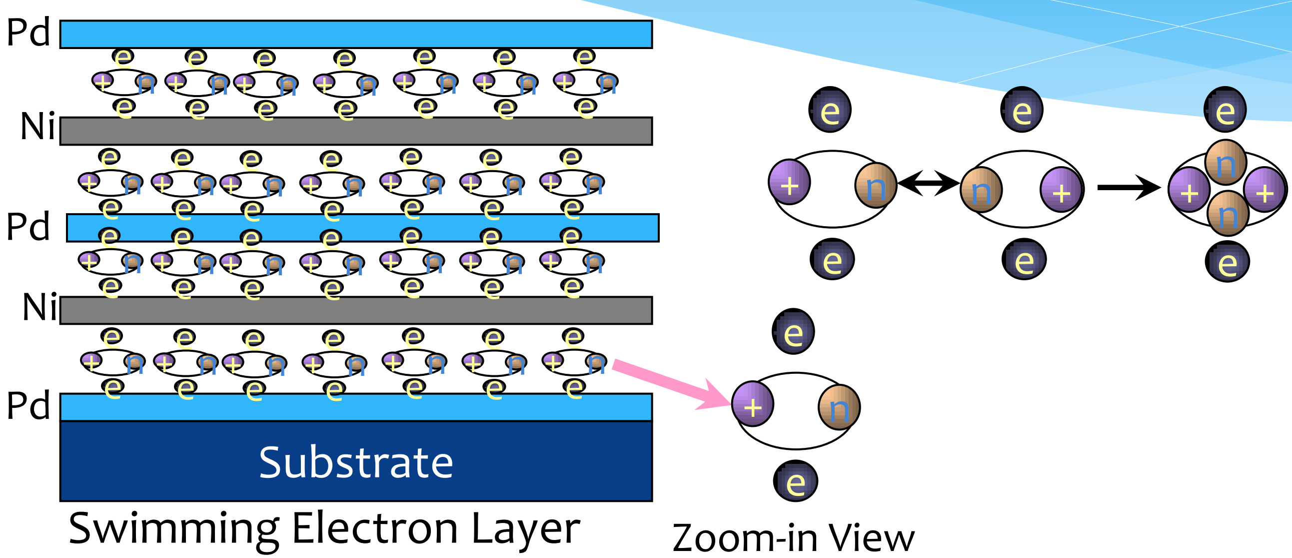
Abstract

* Our previous experimental results have demonstrated the formation of ultra high-density hydrogen/deuterium nanoclusters with 10^{24} atom/cm^3 in metal defects. Both experimental and theoretical studies have demonstrated that due to the close distance between ions in the cluster, they can easily be induced to undergo intense nuclear reactions among themselves and some neighboring lattice atoms. In view of their multi-body nature, such reactions are termed Low Energy Nuclear Reactions (LENRs) – a terminology generally accepted by workers in the cold fusion field. Since the interacting ions have little momentum, the compound nucleus formed in these reactions is near the ground state so few energetic particles are emitted from it's decay. Triggering excess heat generation, thus nuclear reactions in LENR experiments has been accomplished in various ways, all involving the loading of protons or deuterons into a solid metal or alloy material.

Discussion of our recent LENR work and ultra dense H/D clusters = the basis for LENUCO power unit development

* Outline
  * Previous experiments using thin-film plate type electrodes conditioned for D- or H-cluster formation.
  * Evidence for Clusters and Nuclear Reactions
  * Gas loaded nanoparticle experiments
  * LENR Battery/ Power Source Applications

Swimming Electron Theory (SEL) Lead to the Design of Our Early Experiments and Eventually to Current Work



Swimming Electron Layer (SEL) Theory

SEL - High density electron clouds – exists between metals of different Fermi energy, providing the necessary screening to allow ions to overcome the coulmbic repulsive force and undergo a nuclear reaction

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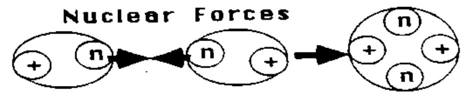
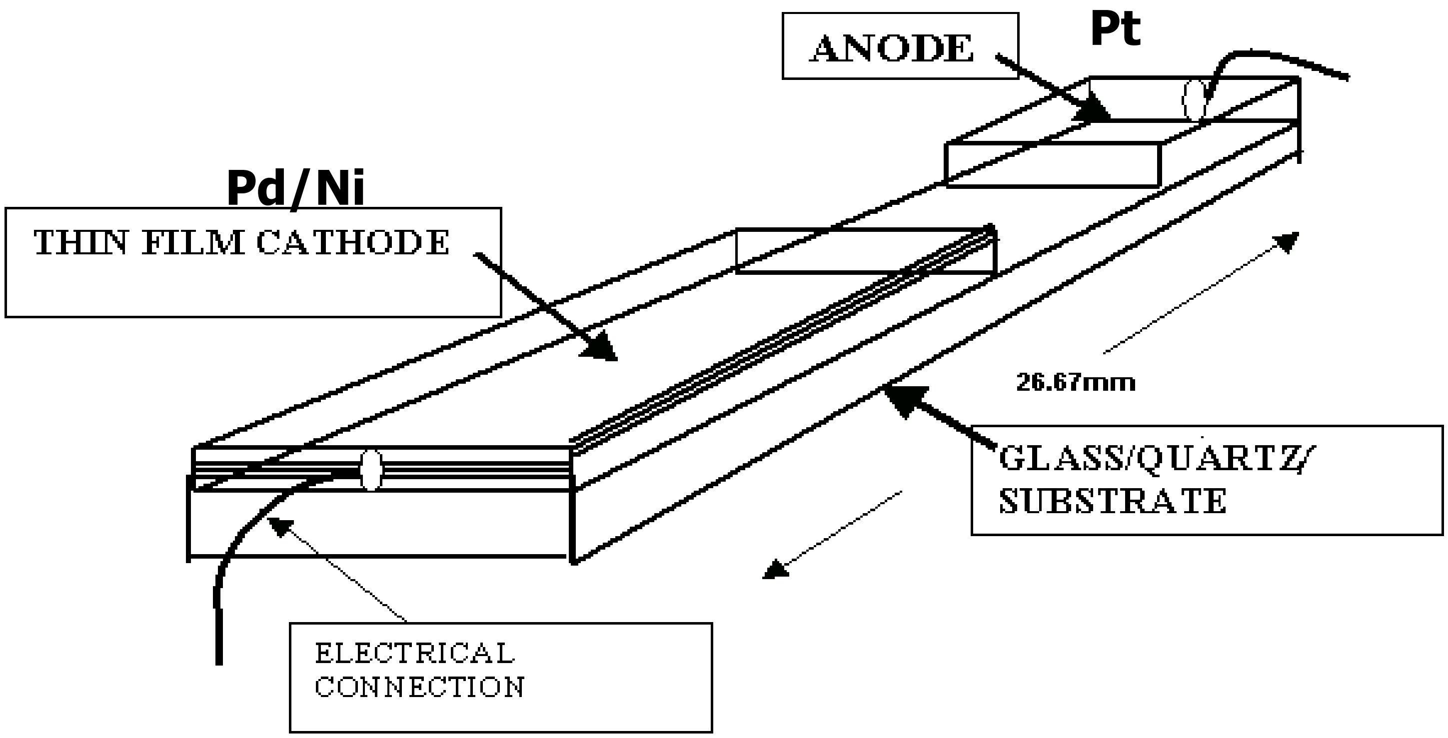
SEL Theory Lead to Multilayer Thin-film electrodes to obtain better control over manufacturing film & defects – importance of ion "flux" as well as loading. Local hot spots observed

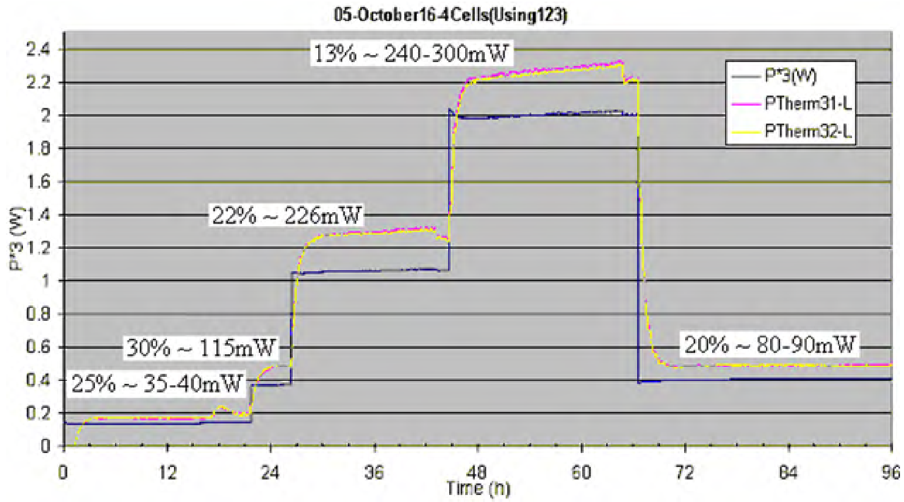




Multilayer thin-film electrode design with alternating layers of Pd & Ni.

Planar A-K structure used to maximize H2 concentration via electro diffusion

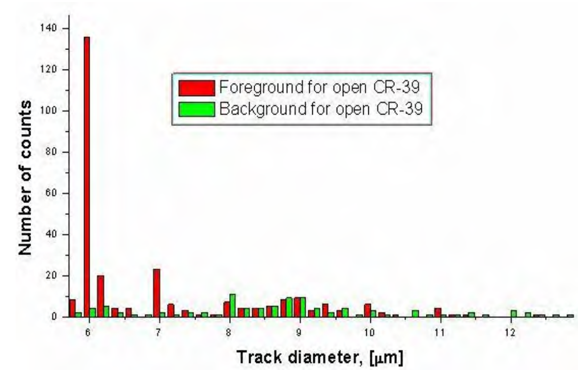
Calorimetry Shows Electrolysis Thin-Film Electrodes Produce Excess Heat when Ion Flux created by Voltage Jumps: MeV Charged Particles observed but heat balance correlates with transmutation product measurement.

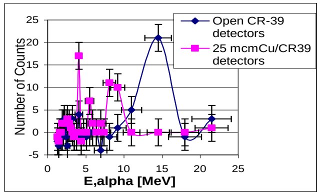


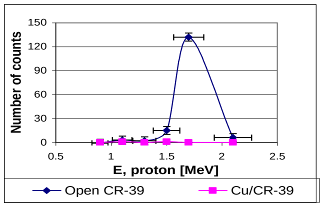
Heat measurement for two layers electrode: 8000Å Pd and 1000Å Ni on Alumina.

Run Number	*Excess Power (W)*	
	Calculated	Measured
#7	1.9 ±0.6	4.0 ±0.8
#8	0.5 ±0.2	0.5 ±0.4
#18	0.7 ±0.3	0.6 ±0.4

Low level of MeV charged-particles are detected via CR-39= Alpha-Particles and Protons



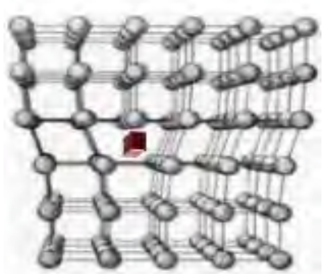


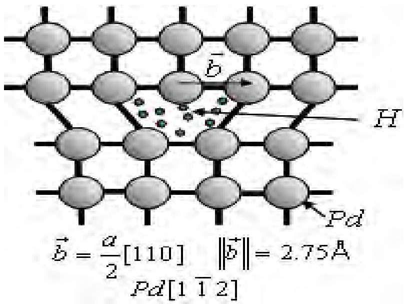


SEL Lead to Our Recent Dislocation-Loop-Cluster Studies With Thin Films. Clusters of D or H form the reactive sites for LENR reactions

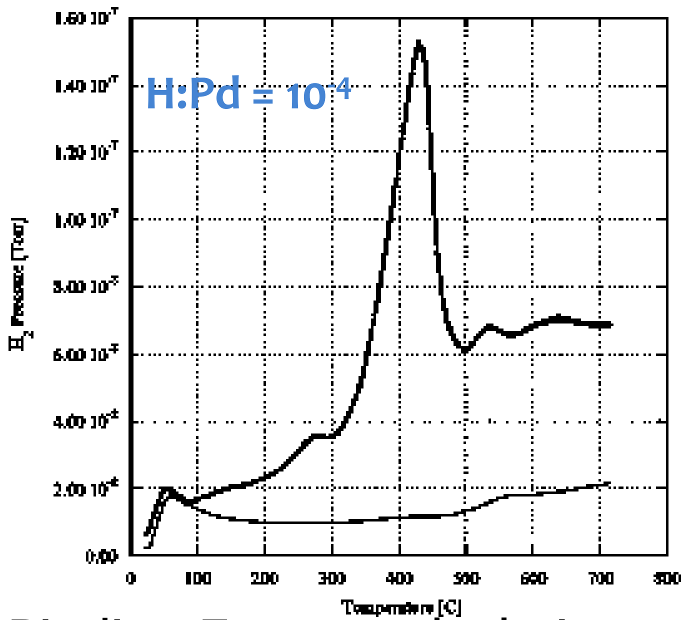
- Pd thin foil – 12 μm
- Loading and unloading deuterium/hydrogen done by cyclically cathodizing and anodizing Pd foil → dislocation loop and cluster formation

PdO
Pd
PdO

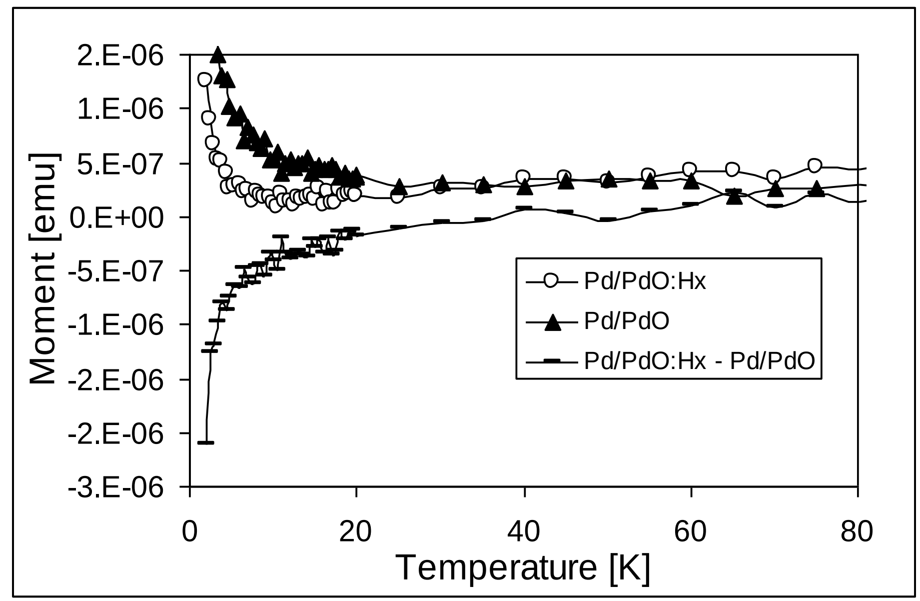




Understanding Clusters and Demonstrating their Almost Metallic Density Hydrogen Characteristic. Temperature Programmed Desorption (TPD) and SQUID Measurements



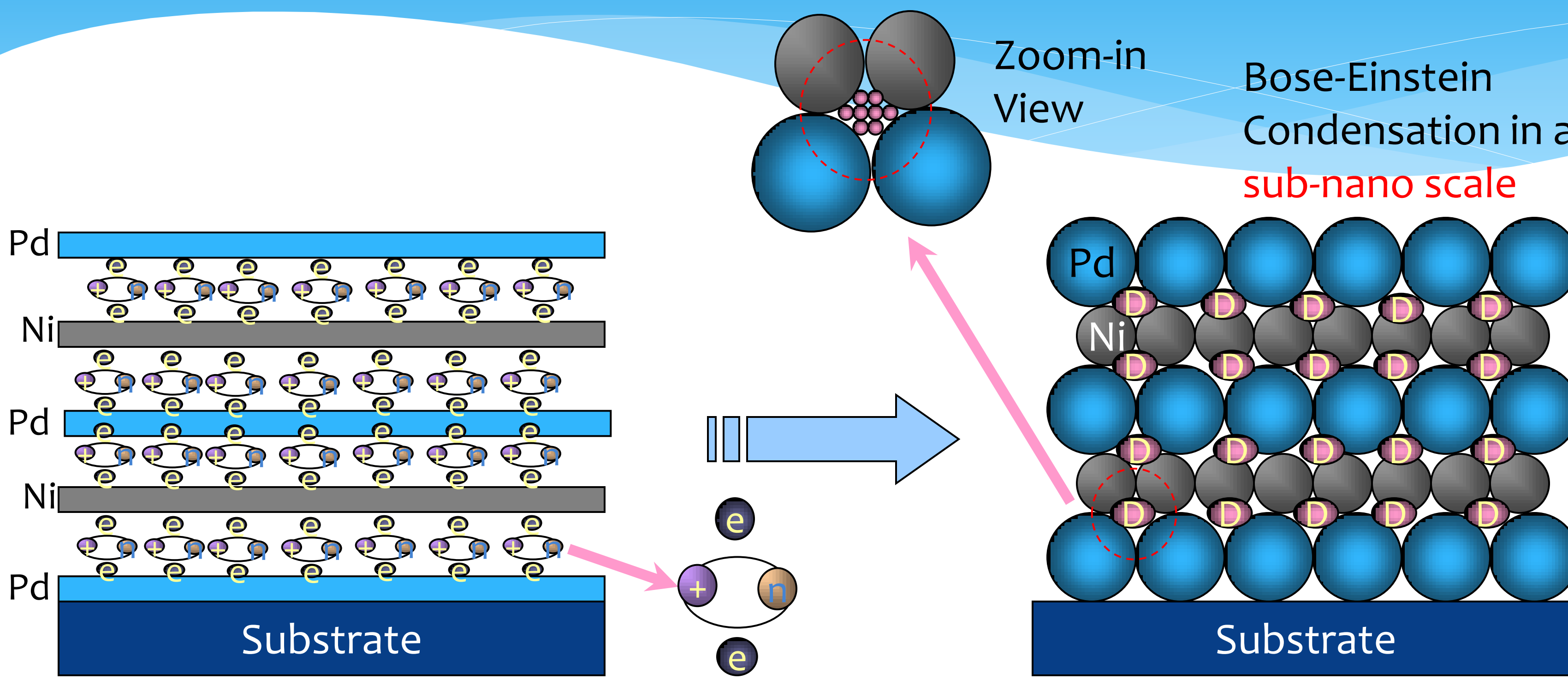
The magnetic moment of H_2- cycled PdHx samples in the temperature range of $2 \leq T < 70$ K is significantly lower than M(T) for the original Pd/PdO.



Binding Energy calculation – close to the binding energy between hydrogen and dislocations

$$\varepsilon_H = k_B \frac{T_2 T_1}{(T_2 - T_1)} \ln(P_2 / P_1) = 0.65 eV$$

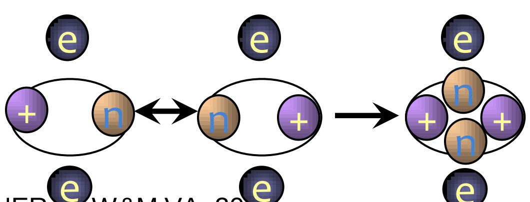
Conclusion: High density deuterium cluster formation (Pseudo Bose-Einstein Condensation) at room temperature occurs and is a way to create nuclear reactive sites for LENR



Swimming Electron Layer (SEL) Theory

Anchored D Loops

Yeong E. Kim, Theory of Bose–Einstein condensation mechanism for deuteron-induced nuclear reactions in micro/nano-scale metal grains and particles, Naturwissenschaften, 96(7):803-11 (2009)



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Recent work is designed to extend the thin-film technique to gas loaded nanoparticles.

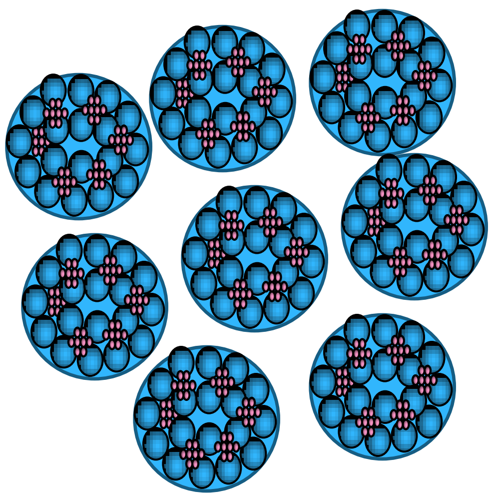
- **Larger surface area particles – lower input power needed = larger "excess power".**

Avoids constraint of being limited by the boiling temperature of the fluid.

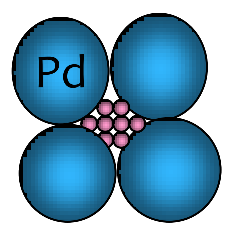
Allows use of other materials, e.g. H_2 and Ni.

Cluster Formation in Nano-Materials

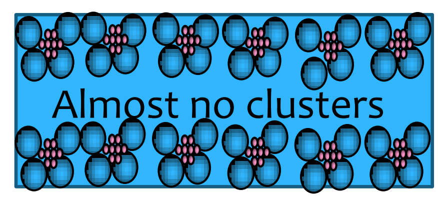
- Clusters mainly form in pores close to the surface.
- Nano-Materials have more surface area, thus have good ability to form abundant clusters



Nanoparticles

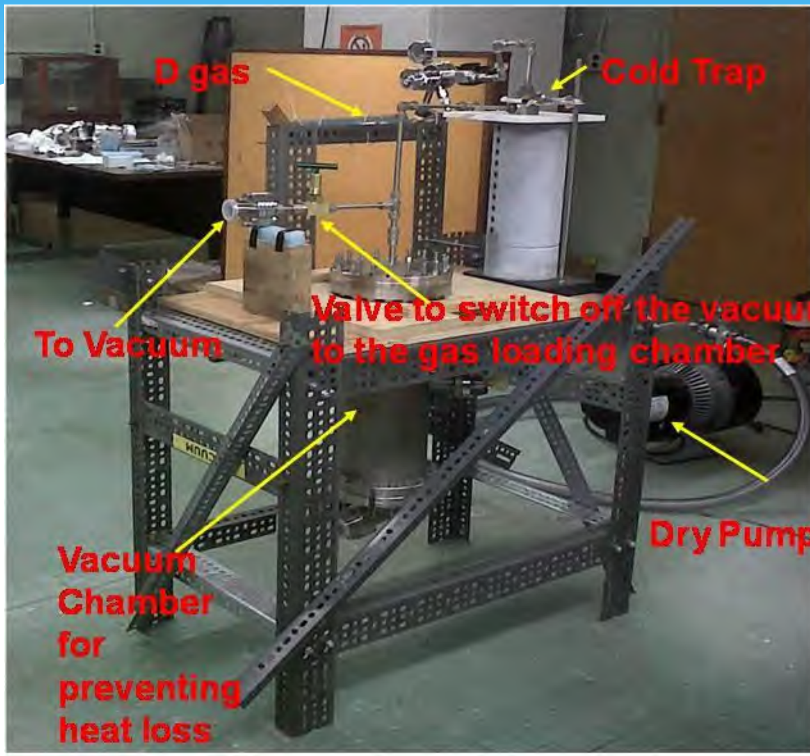


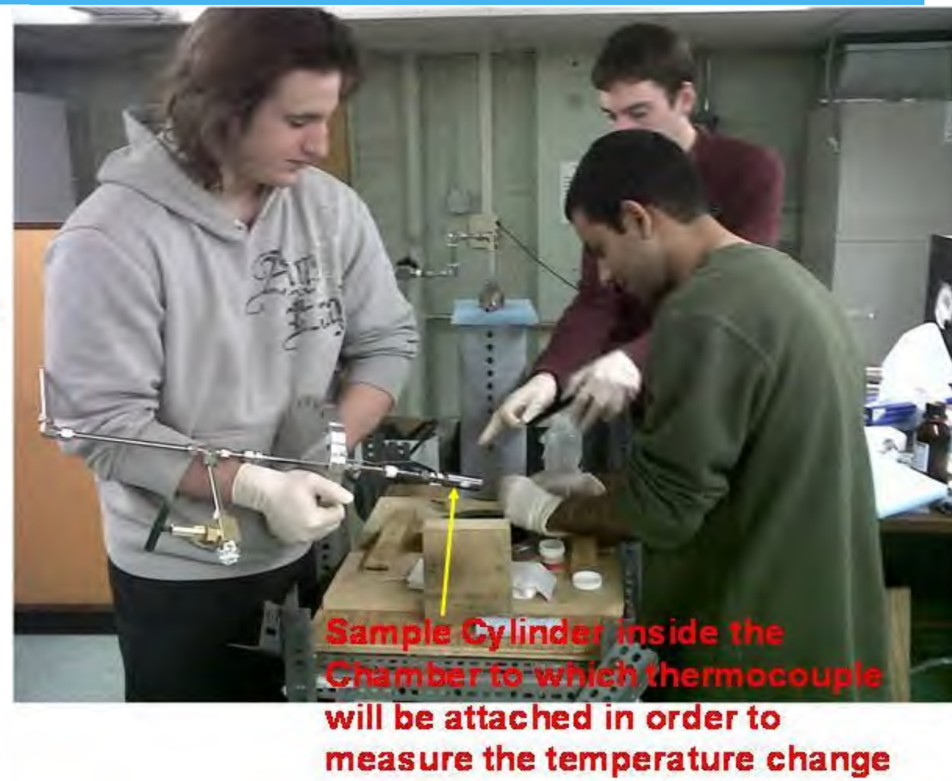
Clusters zoom in



Thin film

Our Gas Loading System





2.2cm inner diameter
25cm^3 total volume

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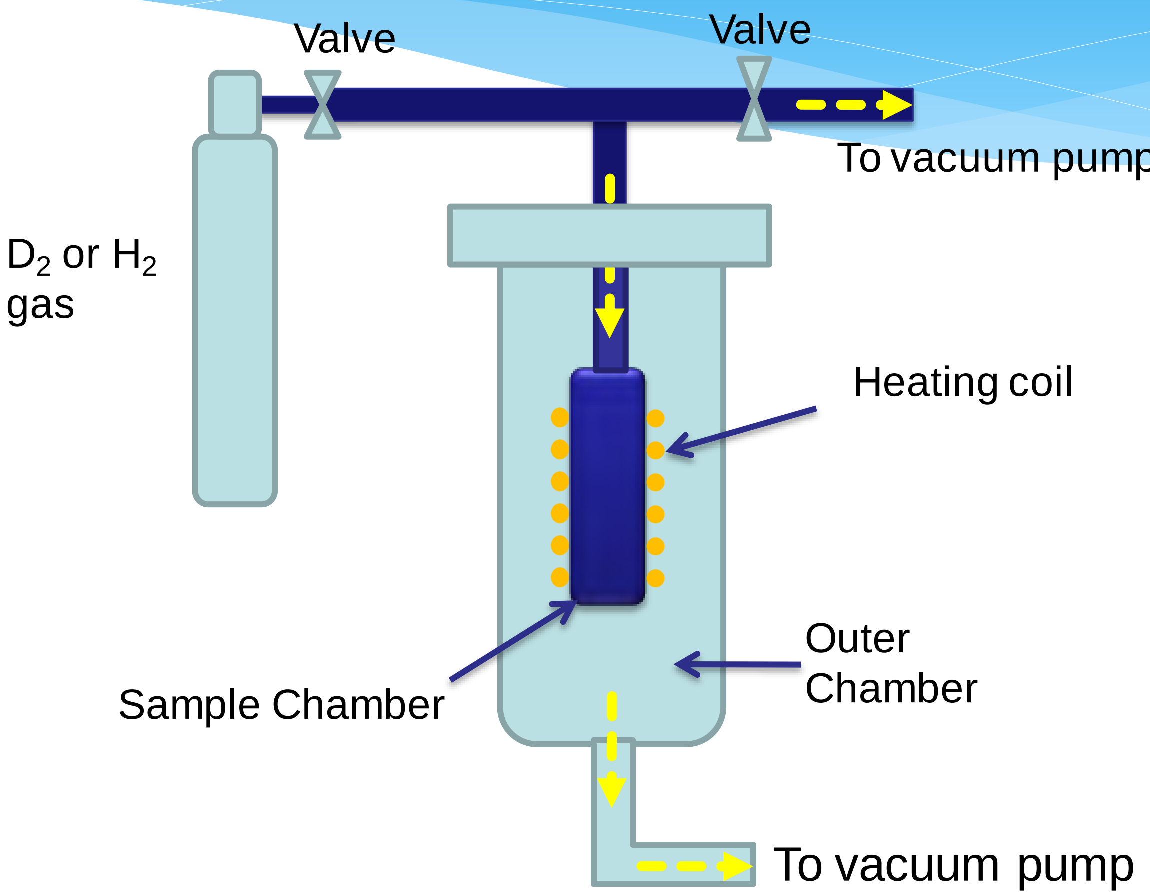
Inside View



Valve
Valve
To vacuum pump
D_2 or H_2 gas
Heating coil
Outer Chamber
Sample Chamber
To vacuum pump

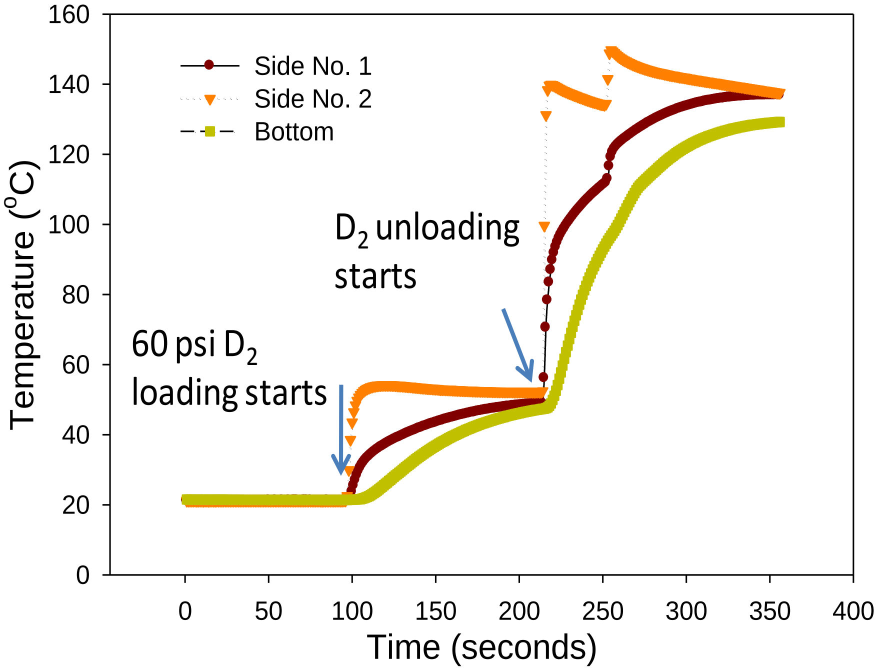
Comments about nano-particles

- We have produced 4 different types of alloys (4-5 components) which are milled and annealed to form nanoparticles for these experiments. Details are covered in one of our patents recently filed.
- Two Ni rich alloys (#3,#4)are for hydrogen loading
- Two Pd rich alloys (#1,#2) are for D_2 loading.
- #1 with D_2 discussed here

Kinetic Measurement Using Our Gas Loading System to Illustrate Key Features .Note- dominate “input power” due to chemical reaction contributions when loading, deloading.

High purity (99.999%) D_2 gas at 4 Atm
23g nanoparticles #1
Room temperature.

Adsorption: Exothermic chemical reaction
Desorption: Endothermic chemical reaction
Chemical reaction Energy = $\Delta H \times M_{D2}$
ΔH = -35,100J per mole of D_2



Energy analysis of this 300 second Kinetic Measurement Shows "Excess Energy" production attributed to LENR.

Adsorption

Exothermic energy from chemical reaction --- **690J**

Actual measured energy -- 1479J – roughly double the possible chemical contribution. Added energy is attributed to LENR reactions.

LENR (Nuclear) Power Density -- ca. 1kW/kg at 4 Atm., over short run 300 sec. time

Desorption

Endothermic chemical Reaction – should show rapid temperature drop, but instead an increase is observed – attributed to continuing LENRs produced by increased ion flow out of particle during desorption = "life after death"

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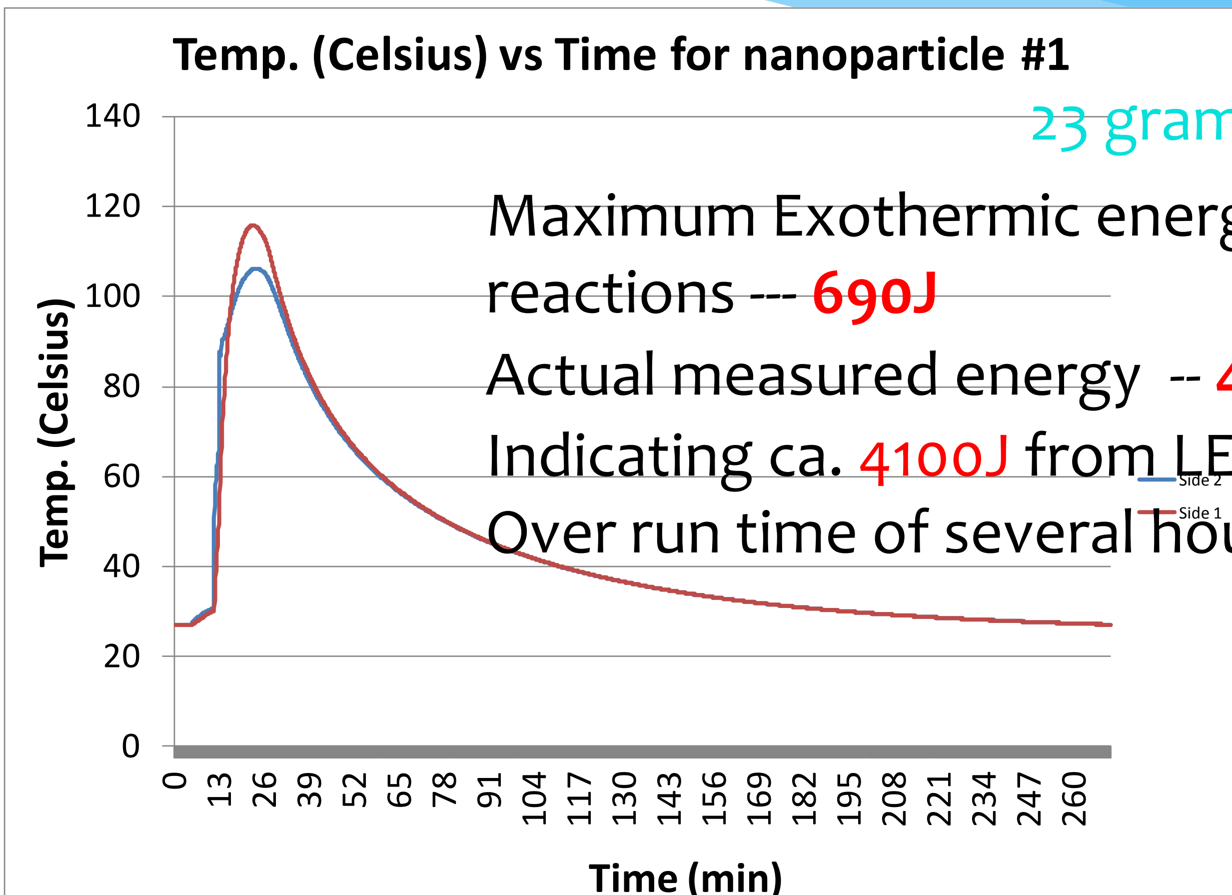
The Chemical contribution to energy production only occurs once = during initial pressure loading. Thus longer Run = w/o use of control system demonstrates larger LENR energy vs. chemical: Here about 7X.



23 gram Nanoparticle #1

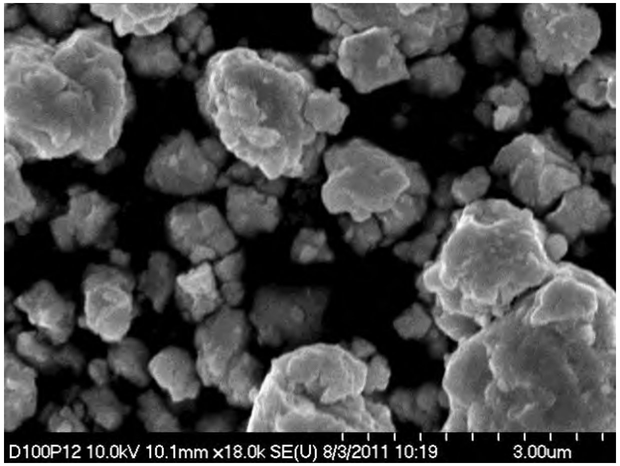
Maximum Exothermic energy from chemical reactions --- **690J**

Actual measured energy -- **4769J**

Indicating ca. 4100J from LENR

Over run time of several hours

Illustration of nanoparticle run time issue – sintering can occur w/o careful temperature control.



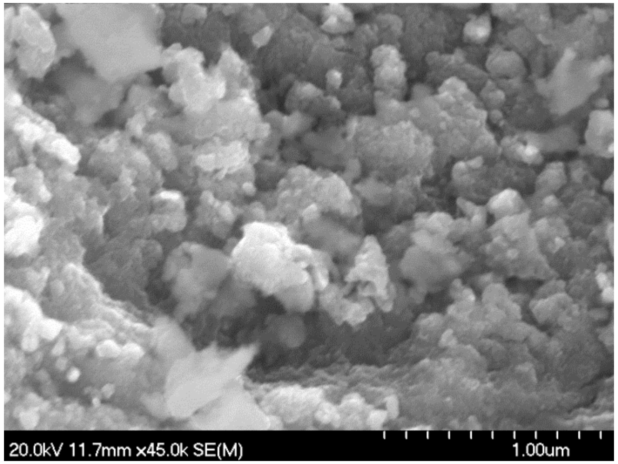
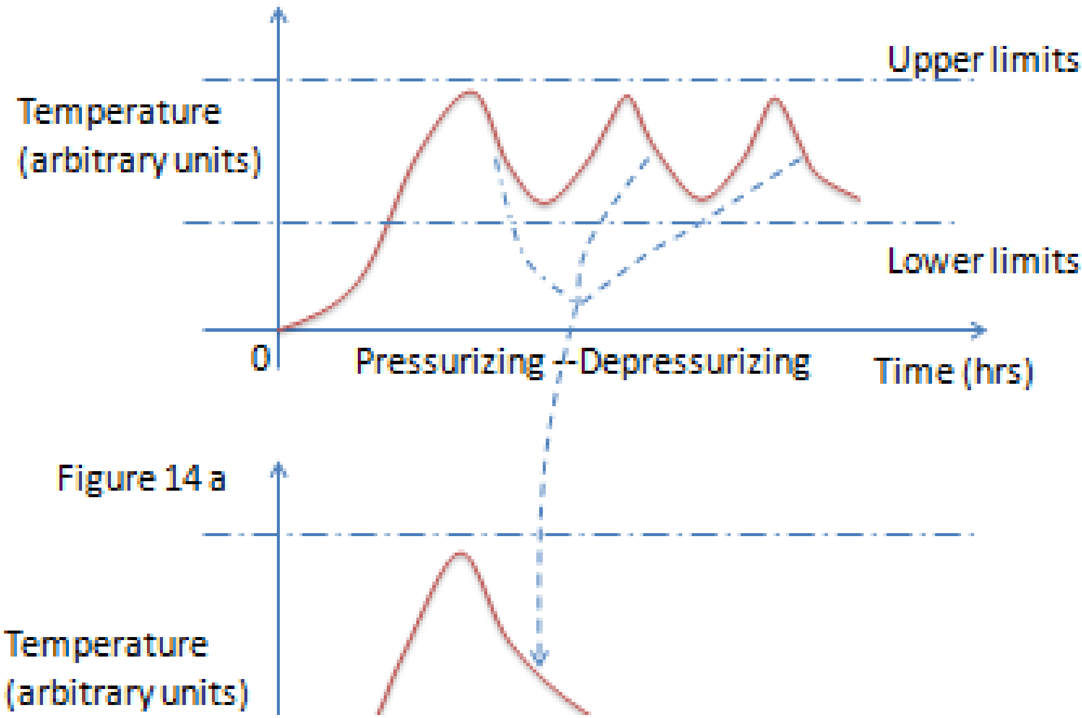


Figure 14. SEM image of the nanoparticles #1 before (left) and after (right) deuterium gas loading experiment

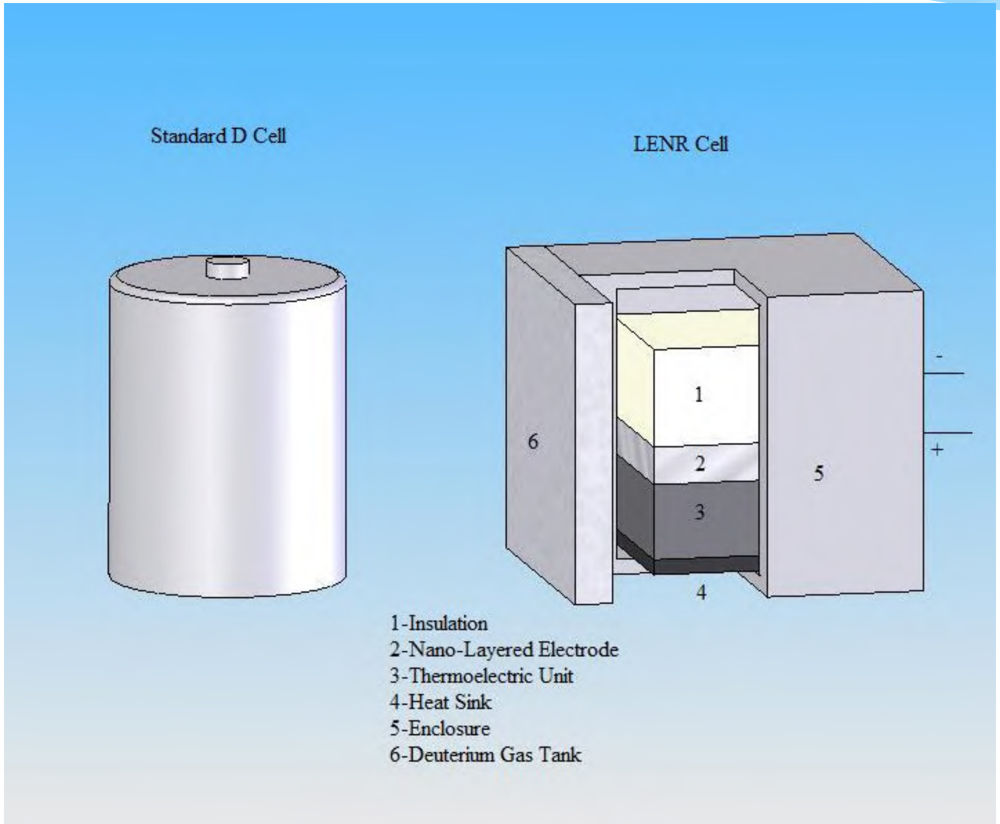
Our approach to temperature control for long ~ constant temperature runs – requires control method – e.g. pressure variations to maintain ion flow in particles as shown in earlier kinetic energy measurement. At the same time the control band will be set at the highest possible temperature to achieve efficient energy conversion to electricity. This maximum temperate will be limited by the need to avoid damage to the nano-particle (discussed next)



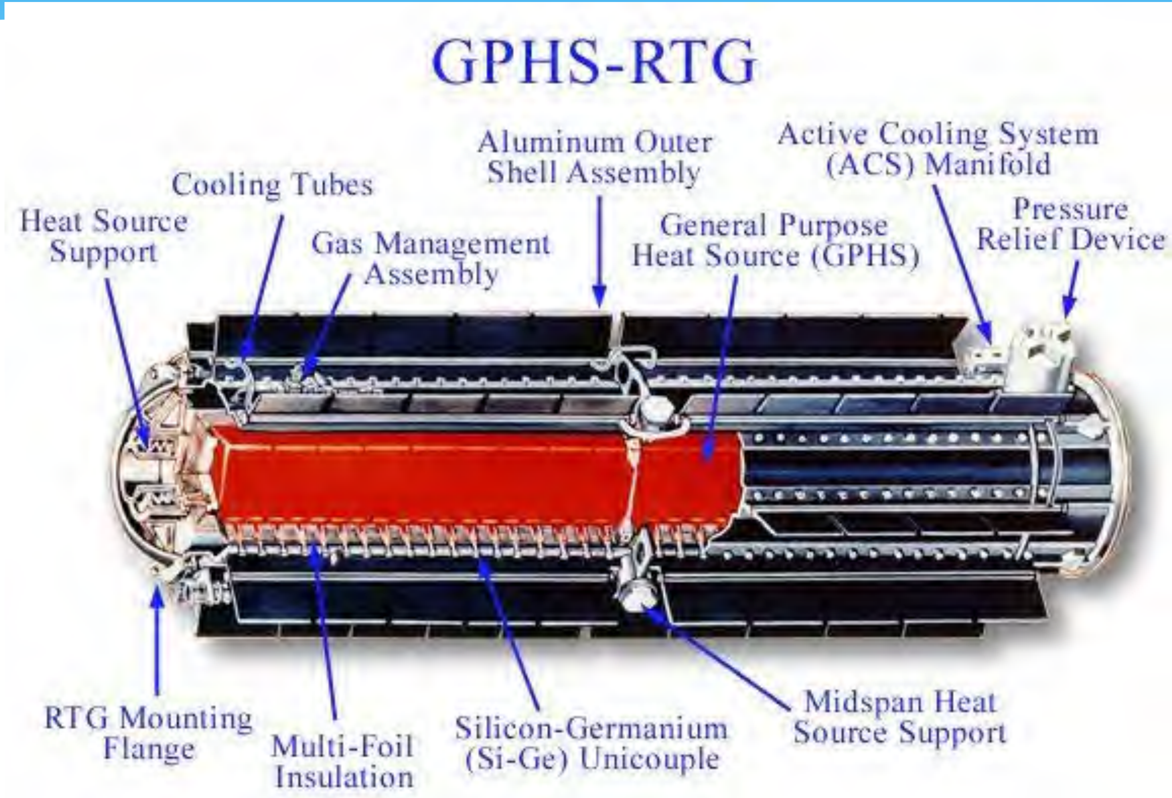
Methods to prevent sintering of nano-particles and allow higher control point temperatures now under study

- Increase surface oxide layer thickness
- Changes in composition
- Embed particles in foam
- Control bed temperature profile to avoid hot spots.

An example- Small Power LENR Unit



The LENR power cell is well suited for use as a "New Type RTG" for use in NASA space probes where the LENR cell replaces the PU^{238} currently used.



Drawing of an GPHS-RTG that are used for Galileo, Ulysses, Cassini-Huygens and New Horizons space probes. (source:http://saturn.jpl.nasa.gov/spacecraft/safety.cfm)
Advanced high temperature LENR heat sources might also be used in "next step" sterling engine heat to electric power systems under study by NASA

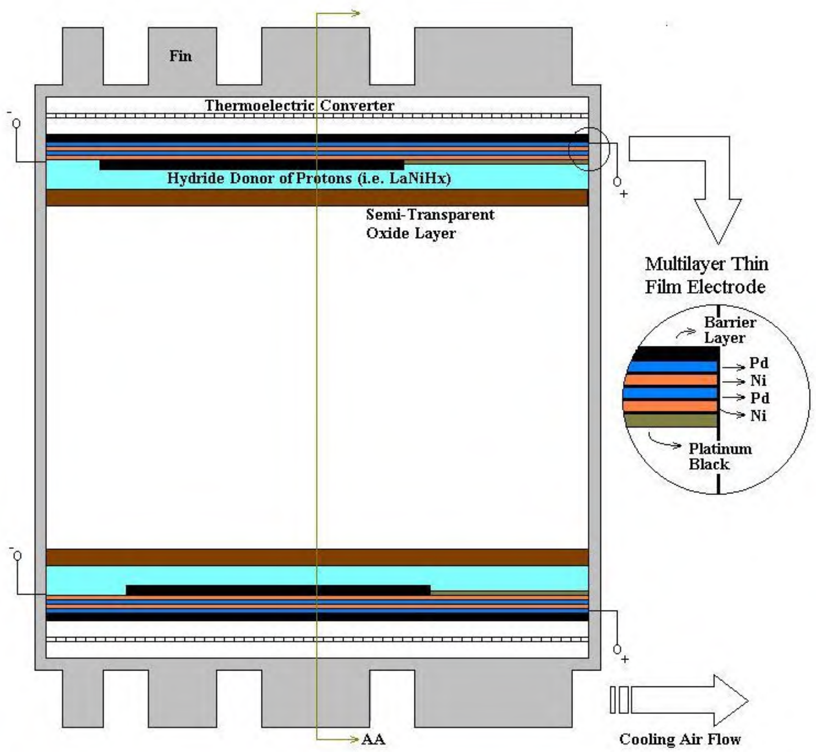
LENR heat unit compares favorably with Pu^{238} (used by NASA for RTG units in all remote probe missions in recent years), but avoids the intense radioactivity and disposal problems of Pu^{238}

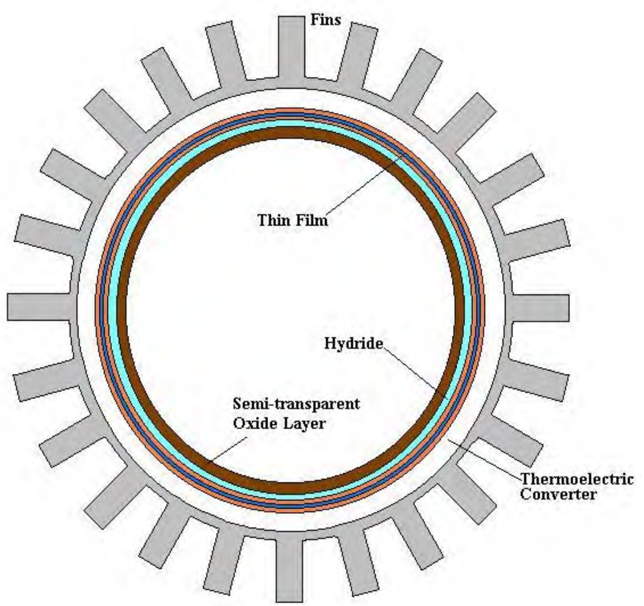
- Pu^{238}: 540 W/kg
  3 kW = 5.6kg; 0.28L
- LENR: 1kW/kg at 4 Atm and room temperature (present data)
  3kW = 3kg; 2.3 L nanoparticles

Thus on a weight basis LENR unit offers approximately same power, but uses somewhat larger volume.

(Based on exiting our data for LENR – should be very conservative compared to a next stage optimized LENR system)

A Hydride Gas-Loaded Thin Film or Nanoparticle Electrode Cell – one concept for 3 kW units for distributed power . Could be scaled to higher power units with some thermal power handling modification. Alternately for some uses these could be combined in parallel or series for higher powers and for voltage-current matchin





Conclusion

- EXPERIMENTAL REULTS WITH CKUSTER LOADED MATERIALS VERY ENCOURAGING
- WORK CONCENTRATRATING ON RUN TIME AND CONTROL ISSUES

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Thanks for your attention

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