Clusters with Picometer Distance of Deuterons and LENR

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The probability of pm-Ms reactions for low energy nuclear reactions LENR and the semi-empirical derivation of 2 pm deuteron screening on palladium with a reduction factor 14 in Coulomb repulsion compared with a usual plasma factor 5 [1] was confirmed later by direct experiments [2]. Generation of 2pm distance clusters of about 150 deuterons based on this screening and possibly by a Casimir force [3] permitted understanding of compound reactions as measured with the 155 nucleon minimum measured at LENR. These kinds of deuteron clusters were directly measured by SQUID [4]. Based on screening and comparable values of a Wigner-Seitz radius for very dense deuteron clusters of stable Rydberg matter in defects of iron oxide [5] with measured 2.3 pm nuclear distance is another access which may lead to an understanding of the LENR processes [6].
[1] H. Hora, J.C. Kelly, J.U. Patel, G.H. Miley, and J.W. Tompkins, Physics Letters A175, 138 (1993)
[2] K. Czerski, A. Huke, A. Biller et al. Europhys. Lett. 54, 449 (2001); A. Huke, K. Cerski, P. Heide et al. Phys. Rev. C 78, 015803 (2008)
[3] H. Hora, G.H. Miley, J. Fusion Energy 26, 349 & 357 (2007)
[4] A. Lipson, B.L. Heuser, C. Castano, G.H. Miley, B. Lyakov and A. Mitin, Phys. Rev. B72, 212507 (2005)
[5] S. Badiei, P.U. Andersson, and L. Holmlid, Int. J. Mass Spectrometry 282, 70 (2009)
[6] L. Holmlid, H. Hora , G.H. Miley and X. Yang, Laser and Particle Beams 27, No.3 (2009)

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Search for Nuclear Reactive Site

Review of peioe data suggests localized high density regions.

Reflections on prior work

- Attempts to improve Patterson cell bead type electrodes
  - Beautiful sputtered ones performed poorly compared to “poor” quality electroplated coatings
- Why???
- Other evidence for loaclized reactions
  - Craters, localized Cr 39, spotty x-ray film, profile of transmutation products

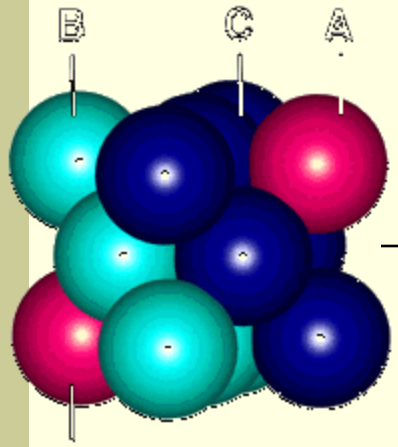
Hypothesis

- The abnormal products from thin films during electrolysis are related to the high density H/D clusters in the dislocation loops form at the multilayer thin film interfaces.

Dislocation-Loop-cluster Studies to verify this hypothesis

- Pd thin foil – 12 μm
- Grow an oxide layer on top of both side foil by heating the foil in butane torch – facilitate deuterium diffusion, prevent dislocation annihilation
- Loading and unloading deuterium/hydrogen was done by cyclically cathodizing and anodizing Pd foil

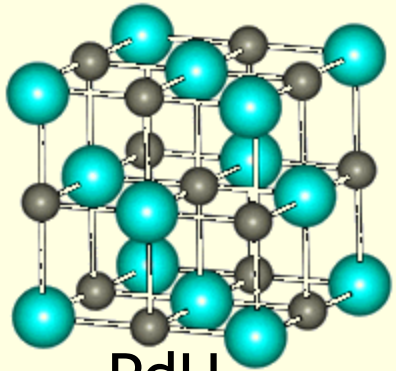
Dislocation Formation 1



H2 charging →

$PdH_{0.015}$
α-phase
09/29/2009

H2 charging →



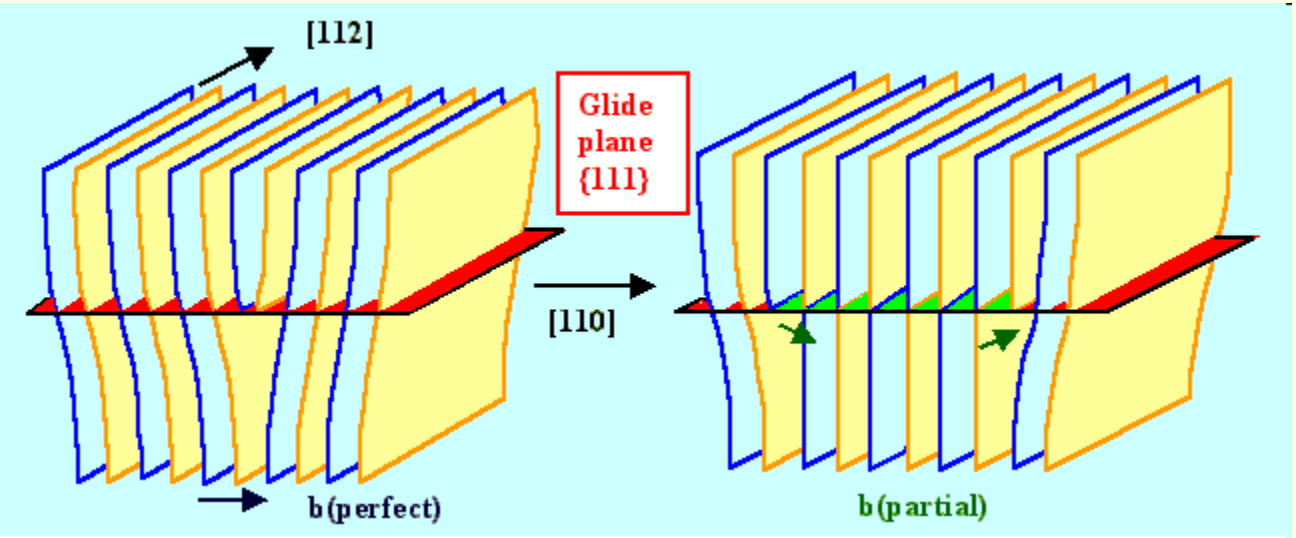
$PdH_{0.6}$
β-phase

Palladium lattice

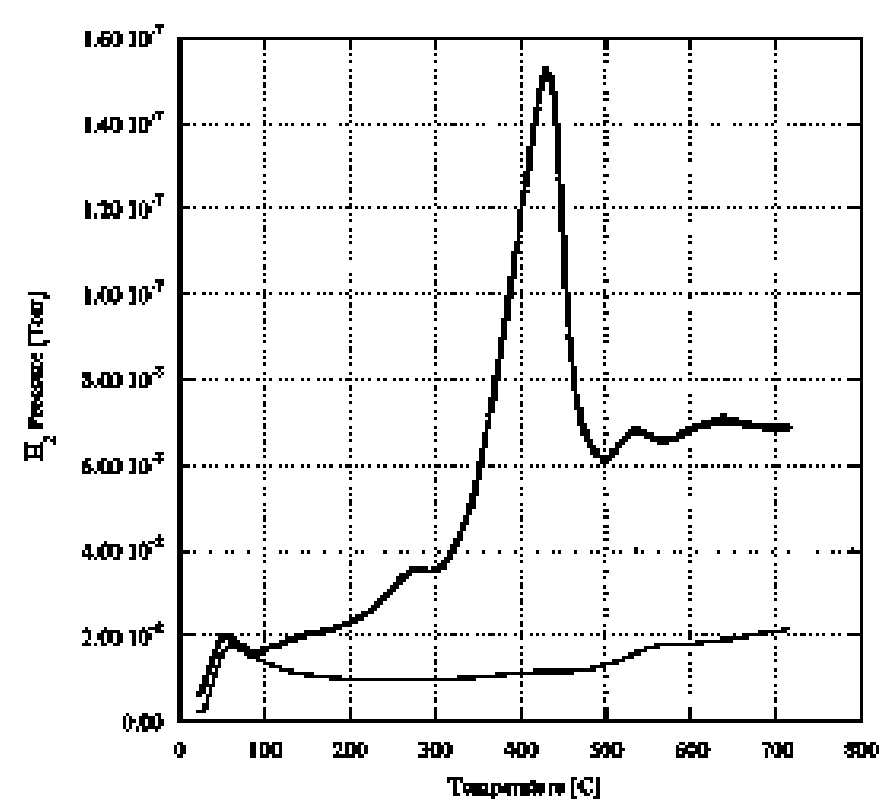
3.889 Å 3.889 Å 4.025 Å

When the stress is large enough, dislocation cores form at α/β transformation interface with core radius of one burgers factor, 0.275nm.

Dislocation Formation 2



Measurement #1 - Temperature Programmed Desorption



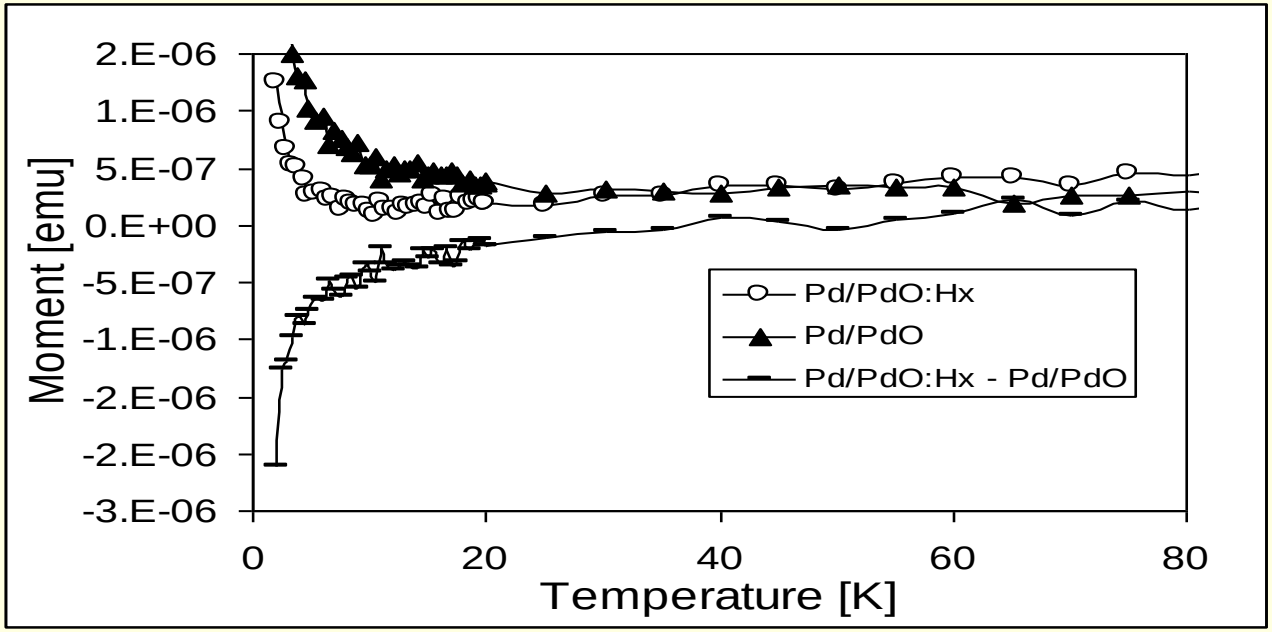
Binding Energy calculation – close to the binding energy between hydrogen and dislocation

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

H/Pd ~ 1.8

After the loading foil was annealed under 300 ^{o}C for 2 hr, the temperature was ramped from 20 ^{o}C to 800 ^{o}C at 9 ^{o}C /min.

Measurement #2 - Magnetic Moment Measurements show superconducting state



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.

A. Lipson, B.I. HeuserC. Castano, G.L. Miley, B. Lyakov & A. Mitin, **Physical Review B 72**, 212507/1-6 (2005):

Conclusion: superconductivity state < 70 K and D Cluster condensation at room temperature

Predictions

LENR cell with high packing fraction (>10%) of cluster forming defects leads to large (> 500%) excess heat.

New quest – large # of cluster sites /cc

- 5 methods under investigation
- Down select based on desorption measurements
- Further down select based on chg pt and excess heat studies// or ICF scans
- Use in proto power cell.

Requirements - classical loading and flux no longer figures of merit.

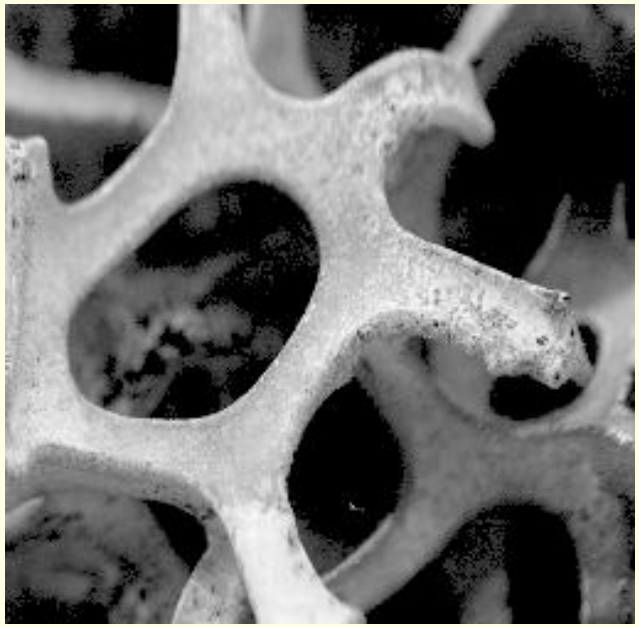
- Loading equivalent in clusters – 10^{18}/cc
- > 100 atoms / cluster
- Proper trigger
  - Pulsed current
  - Pulsed diffusion flux
  - Particle-photon stimulation
  - [compression] = icf target

5 types Nano-Structured electrodes under study-- Ex 1

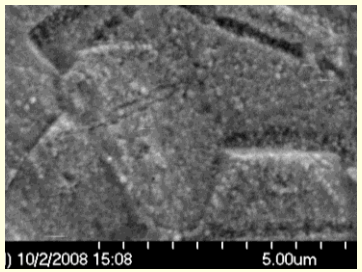
- Objective – mimic dislocation loop structure obtained from cycling, but –
- Increase the density (#/cc) of loops

Nano-Structure electrodes

Ni felt



Ni Foam



Zoom-in view Showing Pd nanostructures on the Ni Foam

Ex 2 - Clusters in Rydberg Matter and in Inverted Rydberg Matter

Known from space chemistry: New catalytic generation of deuterium clusters in surface defects of iron oxide. Emission of clusters and laser irradiation confirms binding energy of 620 eV and distance between deuterons of **d = 2.3 pm with density of nD = 10^{29} cm^{-3}**.

S. Badiei, L. Andersson & L. Holmlind, Intern. J. Mass Spectrometry 282, 70 (2009)

Rydberg Matter

Atoms where the orbital quantum number $\ell = 1$ or higher

distance of atoms in H2 molecules is 74 pm, but with $\ell = 1$, distance is 150 pm.

In Universe: these atoms form clusters called H(1) or D(1)

Inverted Rydberg matter

Binding of a deuteron in the field of an electron: state D(-1)

“Bohr”-radius d is reduced

$d_R/d_{R*} = (m_D/m_e)^{1/2}$

Distance = 2.4 pm

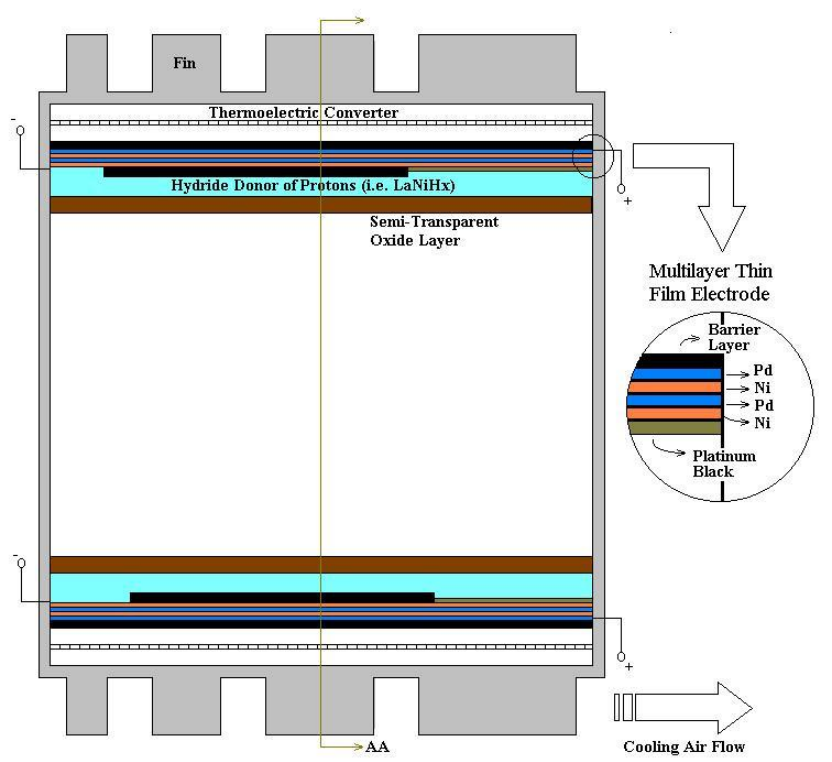
Measured: 2.3 pm

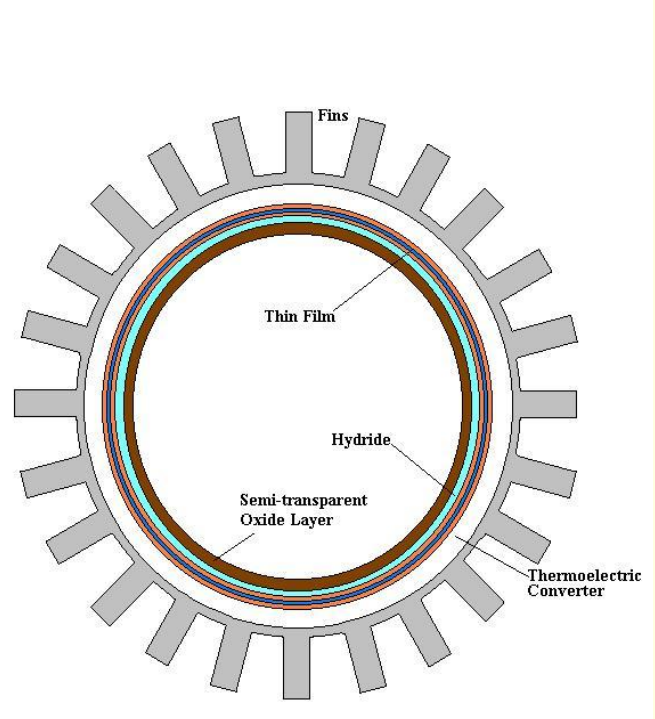
Catalytic Generation of D(1)

Clusters in defects in iron oxide for low temperature generation

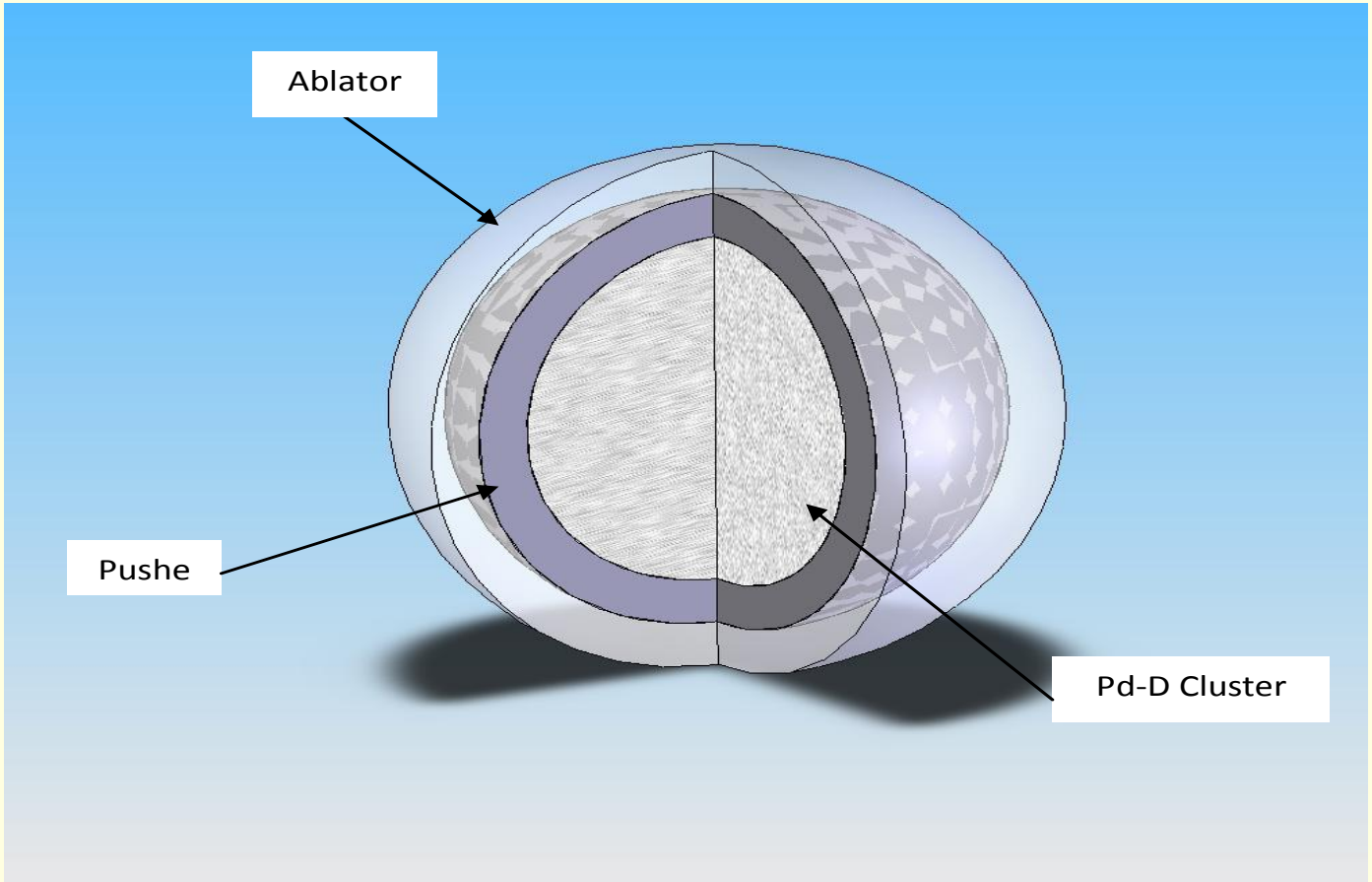
Our recent experiments verified this using a laser to expel the electron and a TOF measurement of ion recoil energy.

Cluster view = road map to high gain cell - Current view of a Hydride Gas-Loaded Thin Film Cluster-type Electrode





Alternate use – non-crogenic ICF targets. Cluster give ultra high compressed density and fusion reaction rates



I st exps to test compression scheduled at LANL in fall

Conclusions

- Experimental evidence confirms cluster formation in dislocation loops
- Methods to fabricate high loop density under study
- Conceptually offers a high reaction rate electrod for LENR or for ICF target
- First test – ICF target shots at LANL in fall.
- LENR cell studies to follow down selection process – hopefully late fall.
- Many issues remain –

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