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].

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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 localized 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 formed 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
When the stress is large enough, dislocation cores form at \(\alpha/\beta\) transformation interface with core radius of one burgers factor, 0.275nm.
Dislocation Formation 2
Measurement #1 - Temperature Programmed Desorption

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

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

\[ \varepsilon_H = k_B \frac{T_2 T_1}{(T_2 - T_1)} \ln\left(\frac{P_2}{P_1}\right) \]

H/Pd ~ 1.8
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.

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 \( d = 2.3 \, \text{pm} \) with density of \( n_D = 10^{29} \, \text{cm}^{-3} \).

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

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

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

TPS Summit, Wash. DC, Jan. 2009
Alternate use – non-crogogenic 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 electrode 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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