Anomalous Results in Fleischmann-Pons Type Electrochemical Experiments

D.D. Dominguez, D.A. Kidwell, G.K. Hubler, S-F Cheng, M.A. Imam, K.S. Grabowski and D.L. Knies U.S. Naval Research Laboratory Washington, DC 20375

> **L. DeChiaro** NSWC-Dahlgren Dahlgren, VA

A.E. Moser and J-H He

NOVA Research, Inc . Alexandria, VA

and

V. Violante ENEA Frascati, Italy











Presentation Outline:

Generation of FPE

- The addition of metals/metal salts to shorten time to onset of effect
- Focus on Pd 90% Rh 10% cathode material

Steps taken to confirm results

- Improved electrochemical cell design to eliminate the possibility of shorts to ground being mistaken for excess heat
- Implemented many additional cell diagnostics (Used redundant measurements for independent verification)
- Attempted to "crash" the VSP and initiate excess heat and RF production

Bottom Line:

- Large excess power (≥ 1kJ) events generated in 5% of Pd90Rh10 cathodes
- Failed to disprove these results →excess heat results observed at NRL are real!

Experimental Phases of FPE Work at NRL

(approximately 300 experiments in total)







January 2009 -**April 2010**







4-position Hart calorimeter

(cell design based on **ENEA / Violante work)**

June 2011 present

Basic Experimental Design





Electrolytic Loading Experiment: Original Fleischmann and Pons Approach



Many experiments, over 24 months, with consistent results

Power_{in}= Power_{out}



Teflon cell with Teflon internal parts and PEEK top (no capability for chemical additions)

Pd Cathode with No Chemical Addition



Pd95%Ru5% Cathode





Recent Result from ENEA





Examples of Trace Impurities

Inductively-Coupled Plasma Mass Spectrometric Analysis



 90
 0.12

 Old Stock L-25b
 Old Stock L-35a
 IL-40
 IL-40
 IL-40 after electrolysis
 Raw Pd Stock Old
 Raw Pd Stock New

 0.04

 Raw Pd Stock New
 Old
 Raw Pd Stock New
 Raw Pd Stock New

 0.02

 Rh103(LR)

Detection of Rhodium Only in Old lots

- Older lots of Palladium, that appeared to produce substantial heat, likely had only ONE source – Engelhard
- ICP-MS analysis shows different impurity profiles than current palladium lots
 - Older lots appear to have recycled
 Pd from catalytic converters as
 rhodium and platinum are present
 - Current lots are much purer in these elements but have zirconium, yttrium, and hafnium present
 - Likely change in crucibles for melting to zirconia
 - Rhodium prices may drive recovery as a separate element
- Are the impurities responsible for the Fleischmann-Pons Effect?

Pd90%Rh10% Cathode – "Eve"



- 10 kJ over 90 minutes 140% excess
- Event triggered by metal/metal oxide additions into 24 mL electrolyte volume
 - 5-10 mg NiSO₄ → 155 MJ/mole or
 1.6 keV/molecule



All PEEK Cell Design





Pd90%Rh10% Cathode



- Now, using all-PEEK cell to prevent shorts to ground.
- Potentially useful level of excess power!

Experimental Design – Fully Instrumented



Pd90%Rh10% Cathode

Fully Instrumented Experiment





Comparison of Power_{out} to Internal Cell Temperature Fully Instrumented Experiment





Note trends – follow until event → Instrument working!

Comparison of External Resistor Temperatures to Current Fully Instrumented Experiment



Note trends – follow until event → Instrument working!

Experimental Design



Another Pd90%Rh10% Cathode





- Excess power >> stored chemical energy
- Excess power appeared before first addition
 - o May have been due to cleanliness of cell

Pd90Rh10_60 Cathode Excess Heat Event: Low Frequency Waterfall Plot





Frequency (kHz)

Conclusions



- In Fleischmann-Pons type electrochemical experiments, we see unexplained production of
 - Excess heat without radiation
 - RF correlated with large excess heat events
- Source and mechanism of FPE unknown, BUT heat production
 - Is NOT chemical in origin as heat is too large
 - Is NOT an instrumental artifact Instrumentation is working correctly!!
 - Nothing we do can make the instrumentation misbehave
- FPE currently reproducible only about 5% of the time, but real science is present





The authors acknowledge funding from The Defense Advanced Research Projects Agency (DARPA) and The Defense Threat Reduction Agency (DTRA).

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> > **Questions???**