Electrochemical-Physical Activation of Nickel-Cathode Surfaces

Arnold O. Isenberg
Advanced Oxide Ionics
Pittsburgh, Pennsylvania, USA
• Experimental Studies For The Investigation of Structural Surface Changes At Nickel-Foil Cathodes During Hydrogen Evolution
Questions:

- Can micro-mechanical effects be observed during hydrogen gas bubble generation on thin nickel foil cathodes?

- What triggers energetic events at bulk- and surface-lattice sites to cause the generation of excessive amounts of thermal energy on nickel cathodes?
Electrochemical Cell for Nickel-Foil Cathode Tests

1/10 molar NaHCO₃ electrolyte

Ni-helix cathode

platinum anode wire

alumina weight rotation-pointer
Helical Nickel-Foil Cathodes With Dual Surface Morphologies

left turn  right turn
Cathode Sand-Abrasion Experimental Setup

- vertical slide with stops
- support table
- parallel guide block
- Teflon surface
- masked cathode sheet
- electrolysis cell 5 × 2.5 × 2.5 cm
- silica sand -100 + 375 mesh
- electrolyte
- anode wire
- DC-supply contacts
Set-Up for Cathode Brush-Abrasion during Electrolysis

- vertical guide slide
- holder tube for sliding brush
- parallel guide block
- electrochemical abrasion cell
Actual Abrasion-Brush (~ 1000 Strokes)

10 mm by 2mm soft-bristle paint brush
Electroformed Nickel Foil Surface Characteristics

matt electrolyte side

SEM HV: 20.0 kV WD: 8.18 mm
View field: 37.8 μm Det: SE
SEM MAG: 5.50 kx Date(m/d/y): 06/28/13

Performance in nanospace
Nickel-Foil Cathode Appearance after Sand-Brushing

1. No current compared with

2. ~100 mA/cm²
   100 strokes/50 sec

3. No abrasion
   Original
   Shiny side
Nickel Cathode Appearance after Sand-Brushing

- No abrasion, matt original
- No current, 100 strokes/50 sec
- ~100 mA/cm², 100 strokes/50 sec

SEM HV: 20.0 kV
WD: 7.98 mm
View field: 37.8 µm
Det: SE
SEM MAG: 5.50 kx
Date (m/d/y): 06/28/13

Performance in nanospace
Observations on Nickel Cathodes

- Ni-surface lattice contracts at the critical potential for hydrogen evolution.
- Ni-surface lattice contraction is observed in acidic, and alkaline electrolytes.
- Ni-surface contraction is instantaneous, as being electrical in nature.
- Upon current interruption surface lattice expansion is equally rapid.
Nickel Cathode Conclusions

• Nickel and hydrogen form a meta-stable new surface phase at discrete electrochemical cathode potentials.

• The hydrogen in the new phase is present as protons at specific lattice sites.

• The Ni/H-alloy at the surface has a higher macro-mechanical strength than the bulk nickel metal.
Physical Nickel Lattice Activation

• Rapid electrochemical potential interruption leads to surface lattice vibration, which forces the bulk nickel lattice to respond.

• A uniform cathode potential is achieved in contact regions with electrolyte only.

• Gas bubble formation leads to localized electrolyte contact loss and causes surface phase change, lattice vibration, and surface phonon generation.

• Better synchronized lattice oscillation may be achieved by “potential-switching”.
Conclusions For Palladium Cathodes

• Pd-cathodes show a complex expansion behavior, yet show a rapid expansion/contraction effect, similar to nickel, when fully “charged” with hydrogen.

• Bulk and surface lattice vibrations must lead to failure of structural integrity.

• Pd-cathodes in known studies could not achieve maximally possible hydrogen activity due to catalytic oxygen up-take from dissolved oxygen.

• Palladium expansion measurements must be conducted under cathode operation conditions.

• High frequency conduction of Pd-cathodes will reveal stages of hydrogen up-take and loss of lattice coherency.
General Conclusions

• Observed abnormal heating in metal/hydrogen systems, when caused by high energy events, takes place at external and internal surfaces and is caused by periodic phase changes and lattice break-up events, accompanied by -yet poorly understood- condensed matter processes.

• High energy events in solid matter—caused by whatever trigger mechanism—must lead to physical/chemical alteration of the affected matter, especially when the event-density is being increased intentionally.
General Conclusions (ctd.)

- Increased -but stable- output of excessive amounts of thermal energy at cathodes can only be achieved by the engineering of mechanically stable support structures for active cathode materials.
- Present electrochemical studies, as executed in LENR-, LANR-, or other activities, must take micro-mechanical effects at cathodes into account as being potential trigger mechanisms for energetic (and possibly excessive) thermal events.