Electrochemical-Physical Activation of Nickel-Cathode Surfaces

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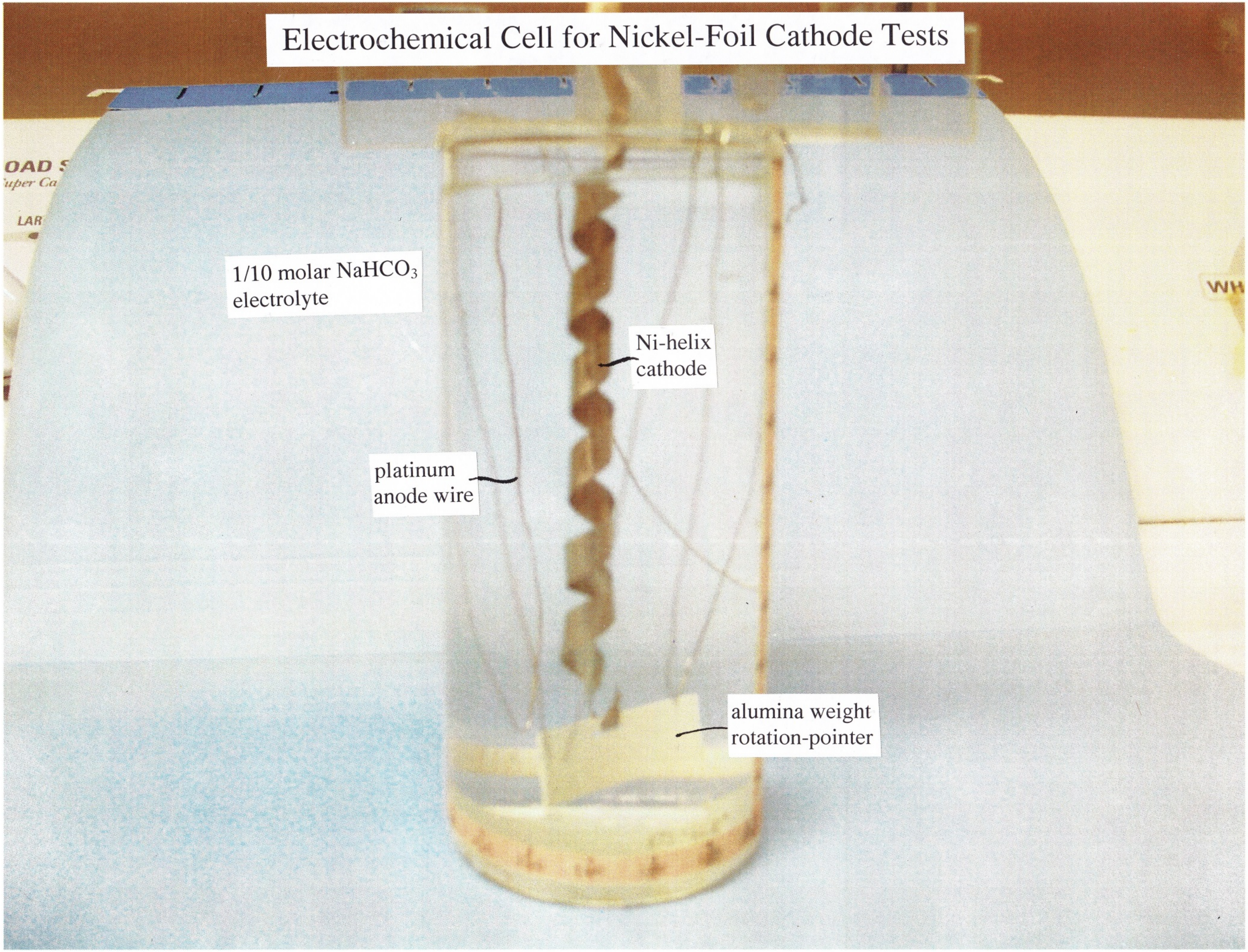
- Experimental Studies For The Investigation of Structural Surface Changes At Nickel-Foil Cathodes During Hydrogen Evolution

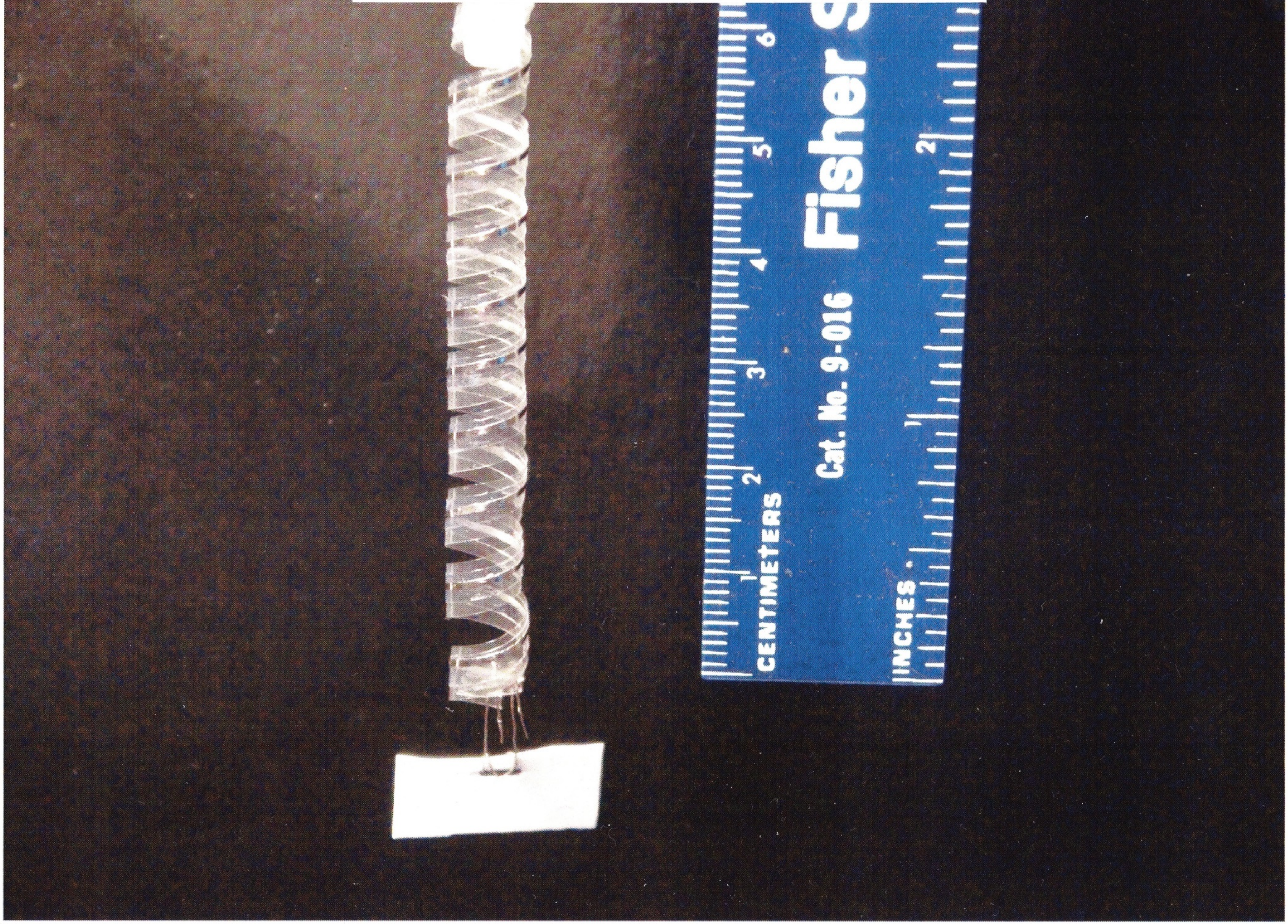
- Questions:
- Can micro-mechanical effects be observed during hydrogen gas bubble generation on thin nickel foil cathodes?

- What triggers energetic events at bulk- and surface-lattice sites to cause the generation of excessive amounts of thermal energy on nickel cathodes?

Helical Nickel Electrodes for Stability Experiments

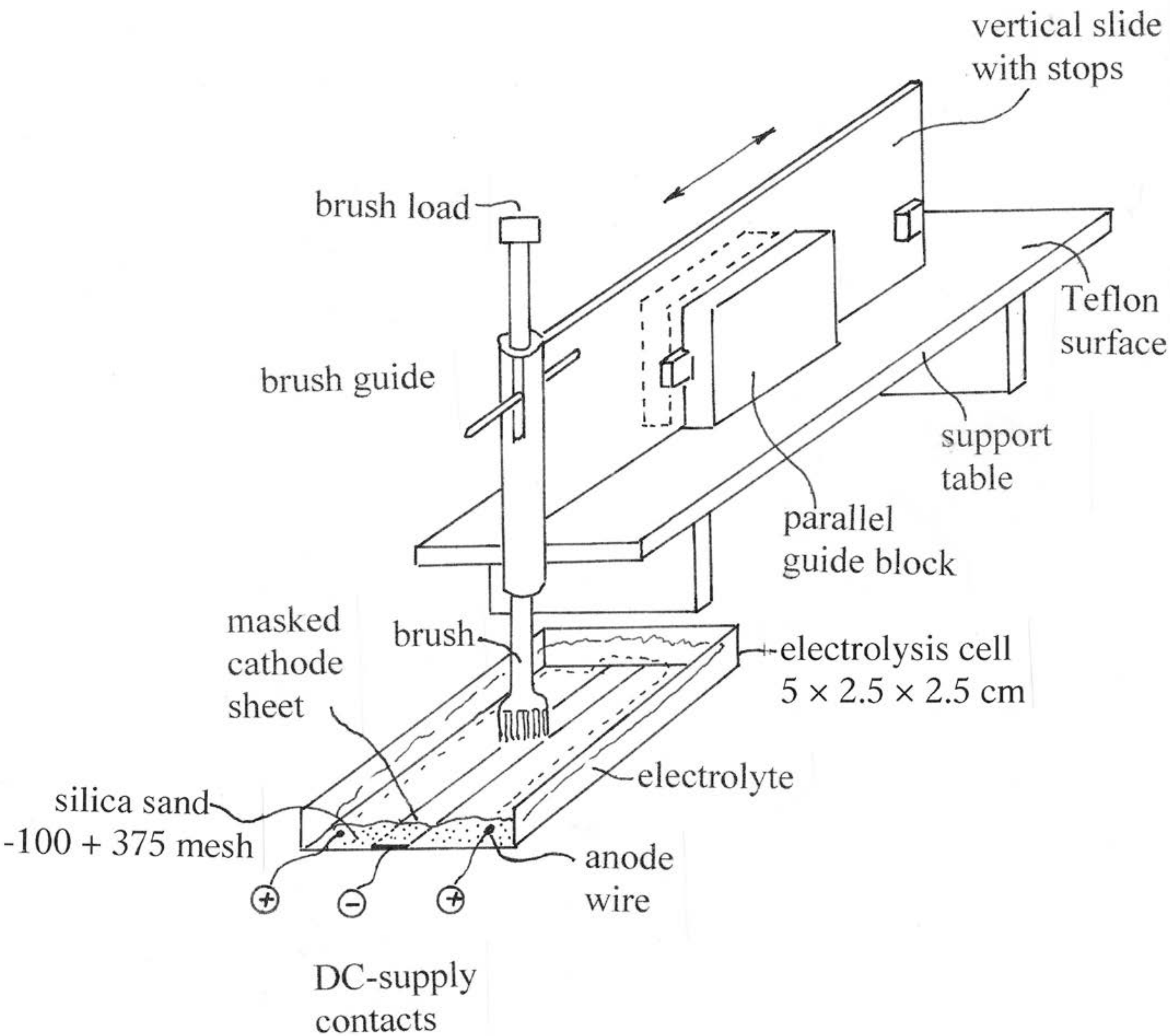

Electrochemical Cell for Nickel-Foil Cathode Tests
1/10 molar $NaHCO_3$ electrolyte
Ni-helix cathode
platinum anode wire
alumina weight rotation-pointer

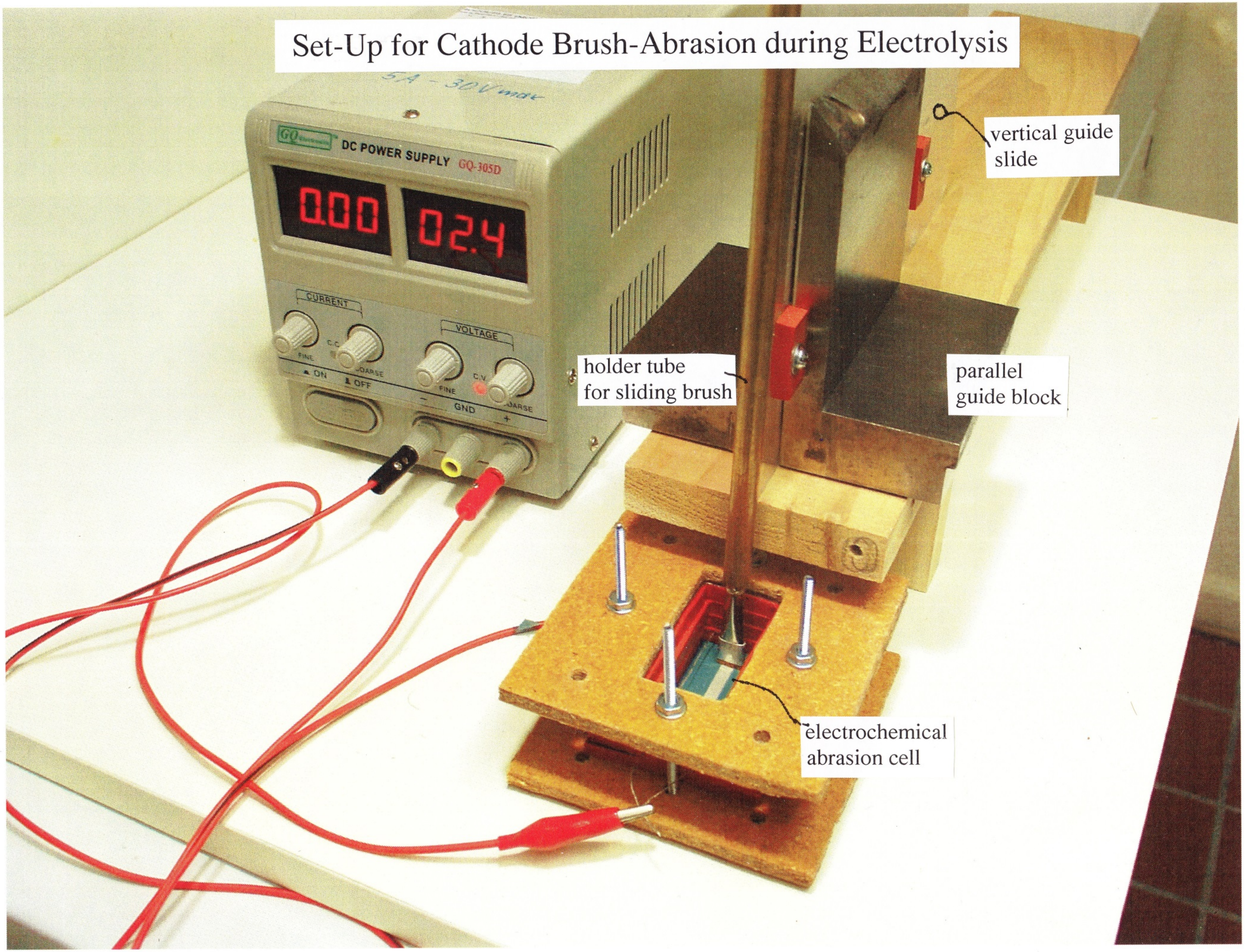
Helical Palladium Cathode (Mylar supported)



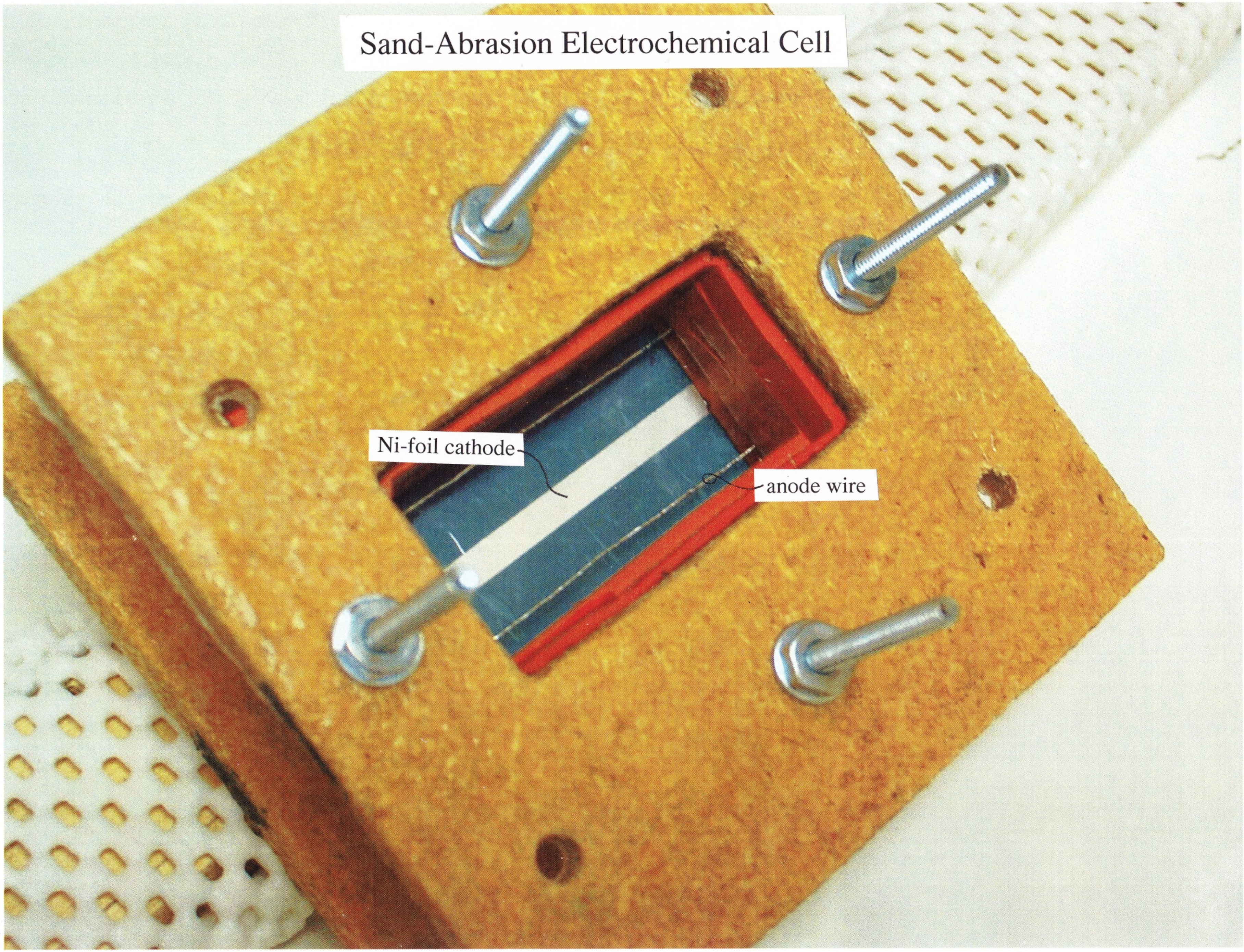
Helical Nickel-Foil Cathodes With Dual Surface Morphologies

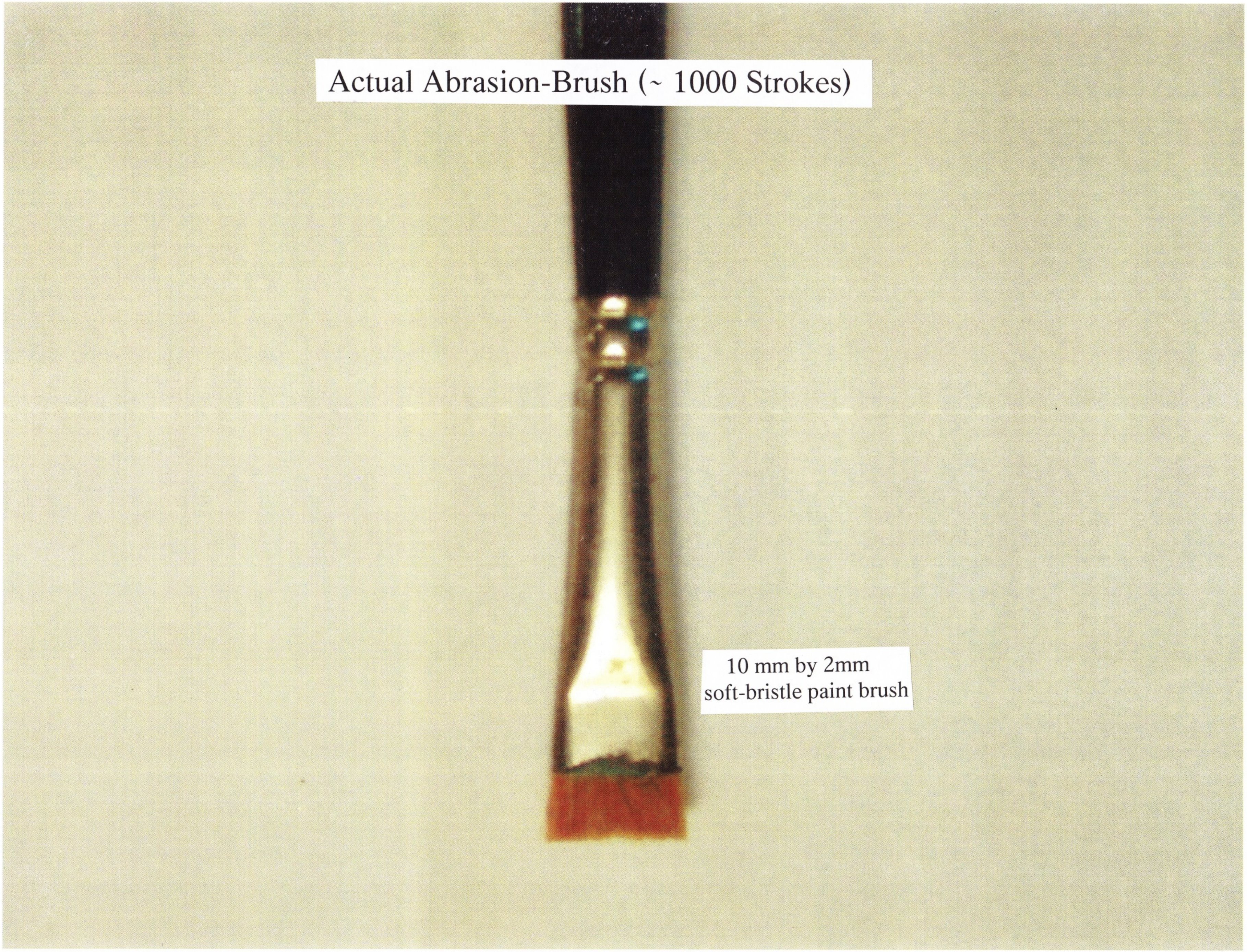
Cathode Sand-Abrasion Experimental Setup



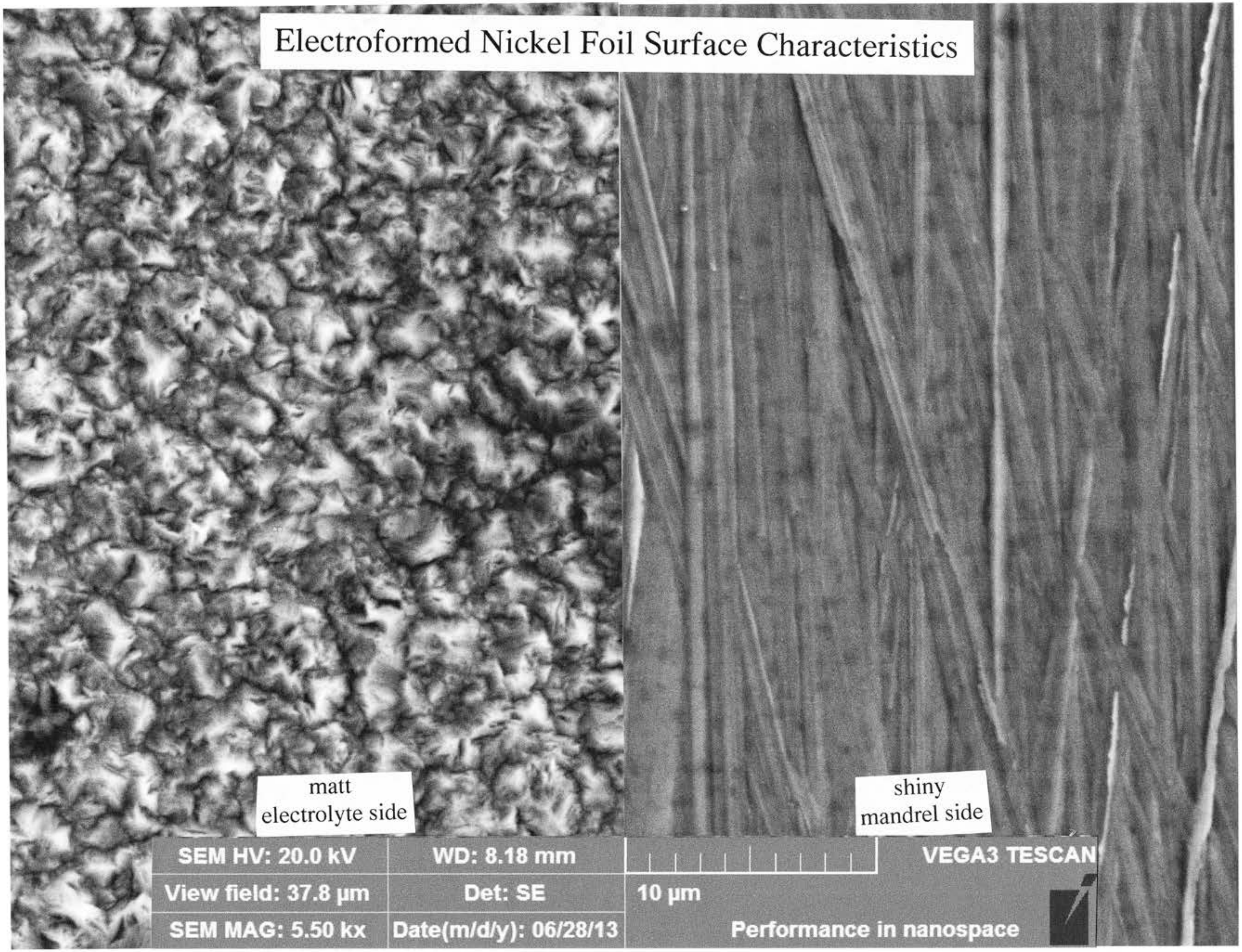


Set-Up for Cathode Brush-Abrasion during Electrolysis

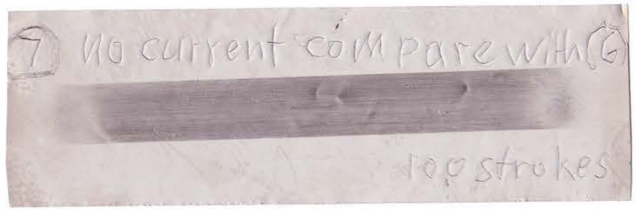

Sand-Abrasion Electrochemical Cell
Ni-foil cathode
anode wire



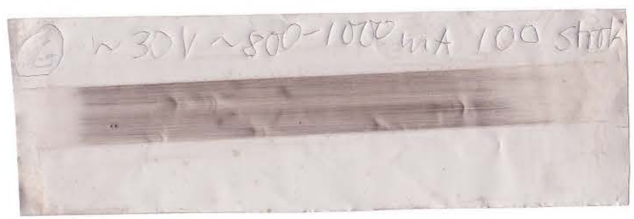
Actual Abrasion-Brush (~ 1000 Strokes)


Electroformed Nickel Foil Surface Characteristics
matt
electrolyte side
shiny
mandrel side
SEM HV: 20.0 kV
WD: 8.18 mm
VEGA3 TESCAN
View field: 37.8 µm
Det: SE
10 µm
SEM MAG: 5.50 kx
Date(m/d/y): 06/28/13
Performance in nanospace

Nickel-Foil Cathode Appearance after Sand-Brushing



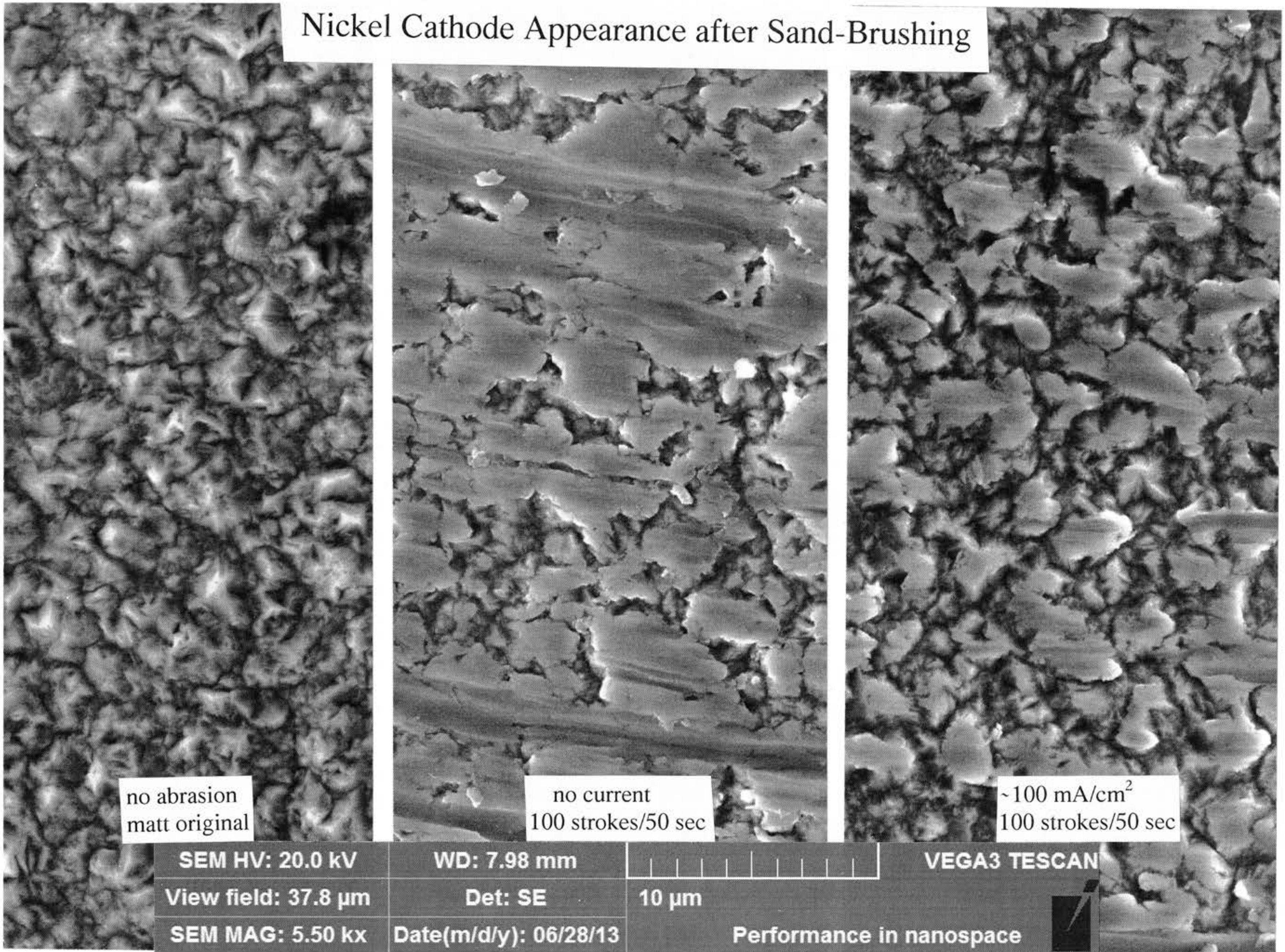
no current
100 strokes/50 sec



~100 mA/cm^2
100 strokes/50 sec

no abrasion
original
shiny side

Nickel Cathode Appearance after Sand-Brushing



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.