Nb Electropolishing R&D

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Small Sample EP Process Analysis

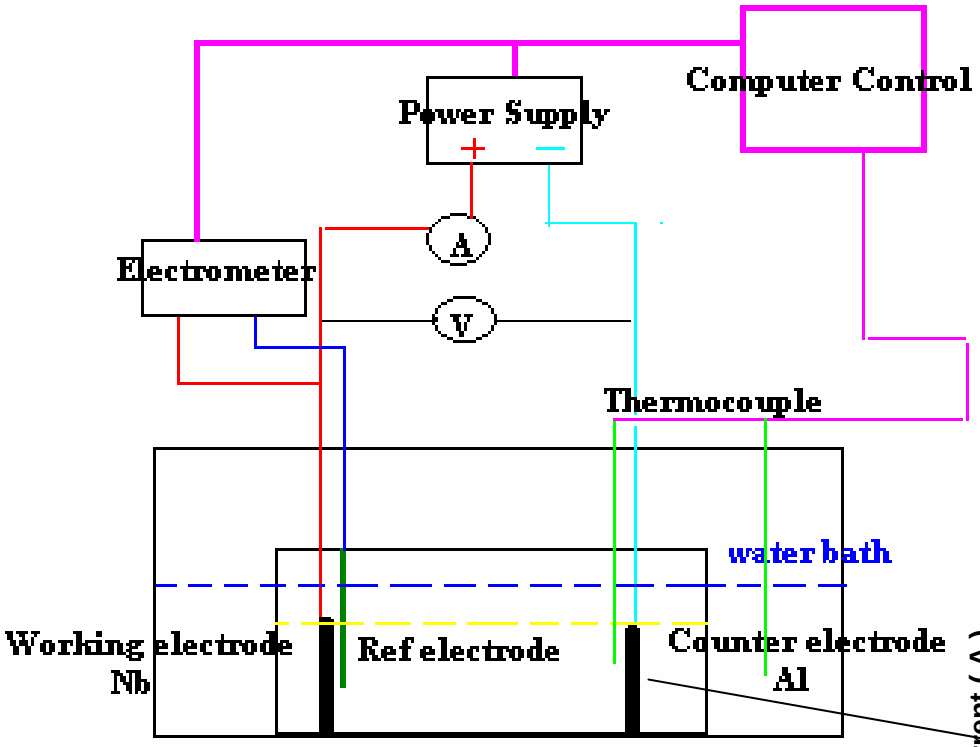
Objectives:

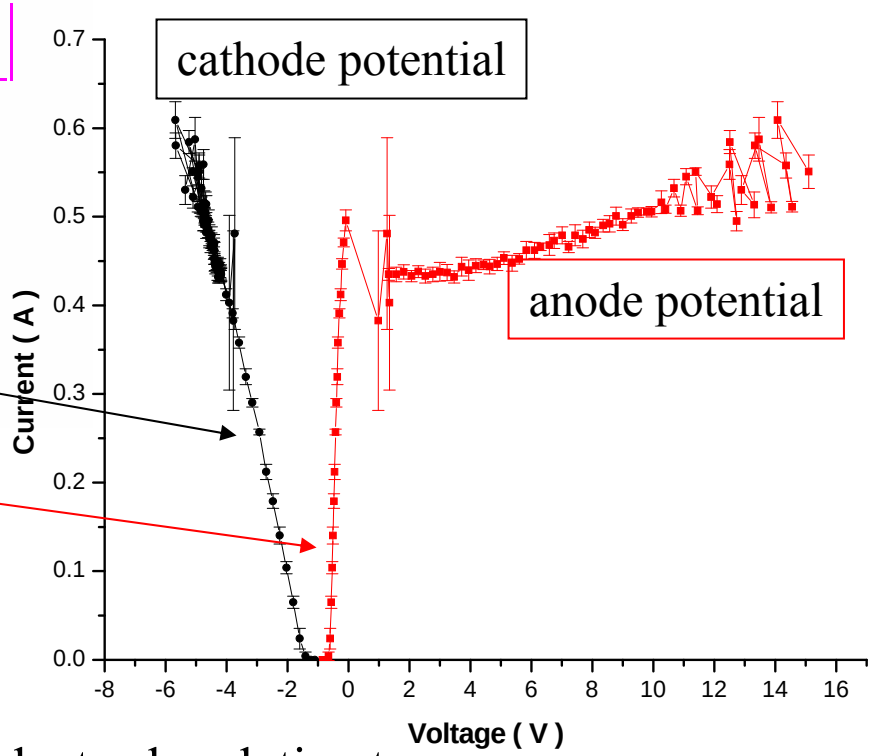
- Improve the electrochemical characterization of the Nb HF/H_2SO_4 EP process.
  - No agitation, controlled temperature and concentration
  - Flow conditions typical of cavity processing
- Establish the dependence of lateral scale of leveling on local process conditions.

In order to:

- Provide an improved technical basis for designing processes for specific effect, e.g. 9-cell cavities with < 20 nm roughness on 50 μm scale, over entire surface.

Small Sample EP Process Analysis

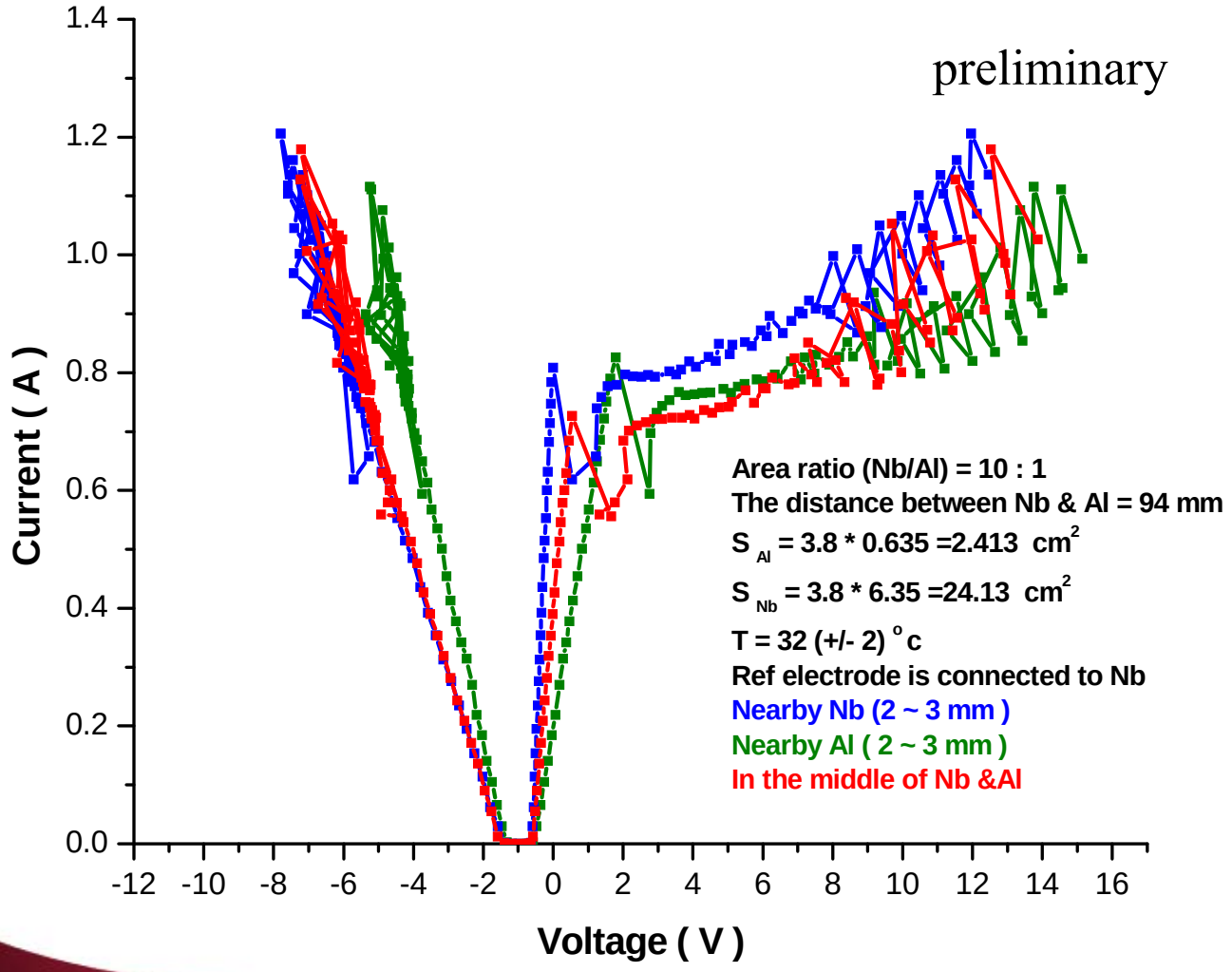




Measure potential of each electrode relative to a reference electrode (SCE) in the bath.

Small Sample EP Process Analysis

- Resistivity of bath measured by moving the reference electrode.
- For T_{bath} = 32 C, 9.4 cm separation, and typical current densities, a bath resistivity of ~8 Ω-cm^2 / cm has been observed.



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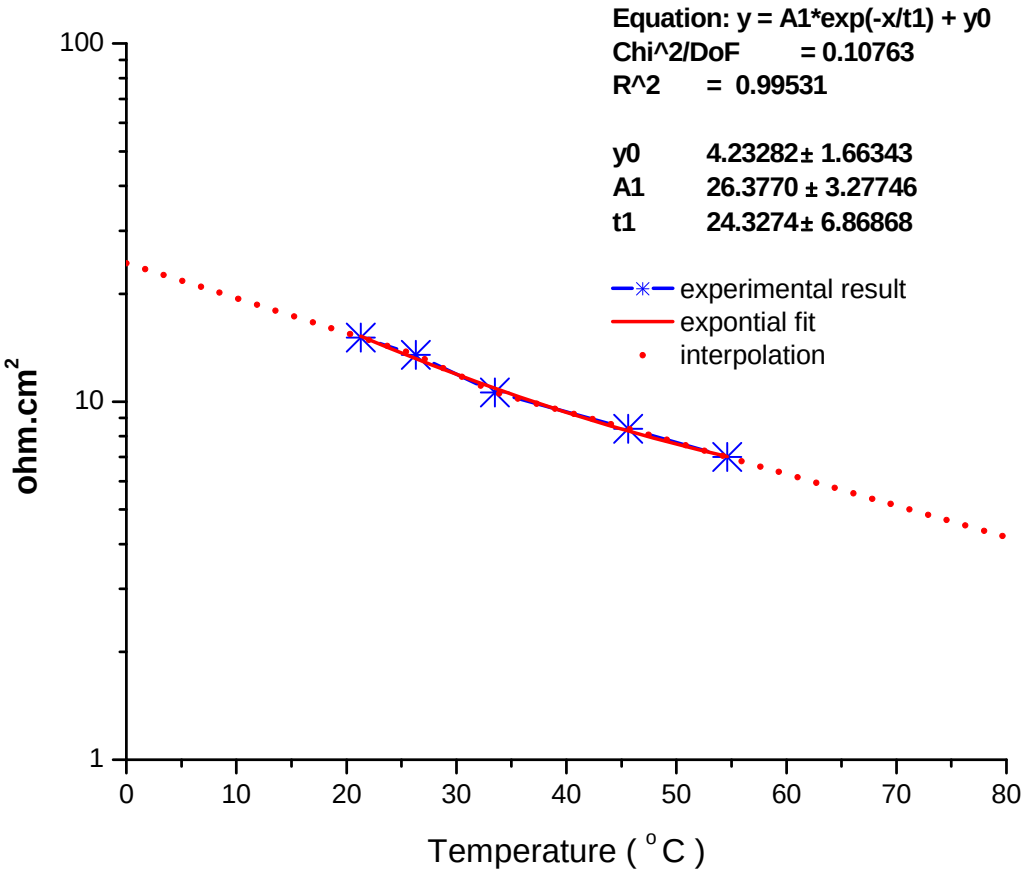
Small Sample EP Process Analysis

- The cathode polarization voltage is quite linear.
- The temperature dependence of this resistance is exponential .



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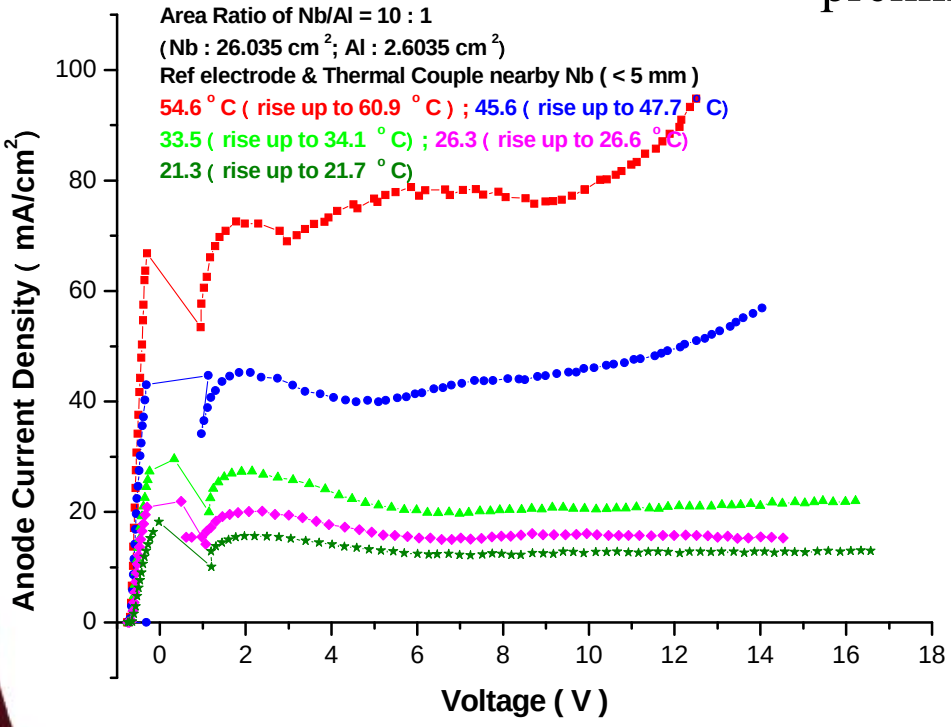
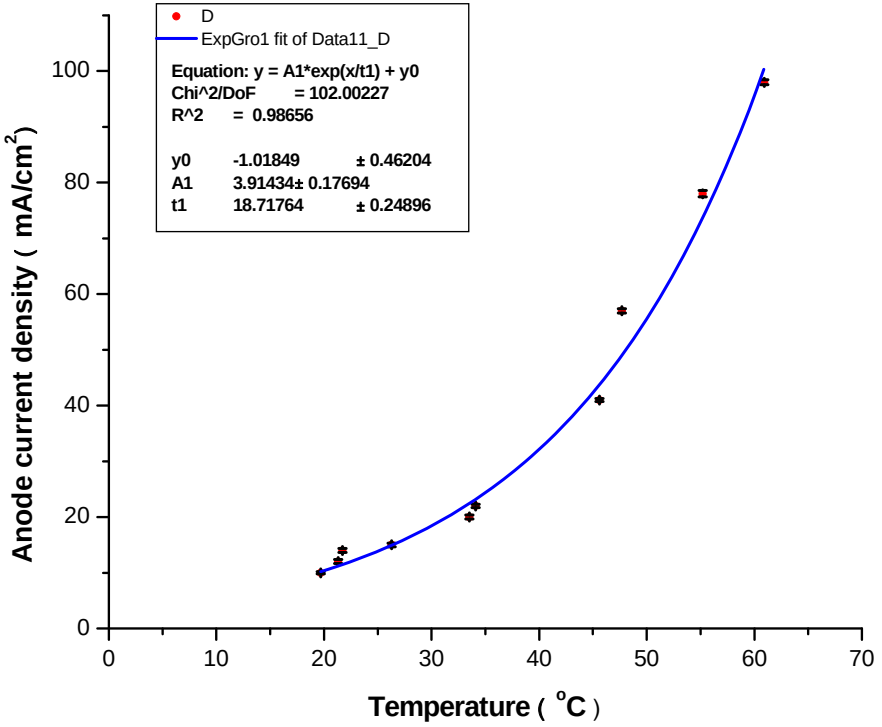
Small Sample EP Process Analysis

- The anode plateau current density increases exponentially with temperature.

preliminary





(Cavity wall temperatures have been measured to vary between 40-50 C during EP, while the exiting electrolyte temperature is regulated to 30 C. Consider the implications for the uniformity of polishing.)

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Small Sample EP Process Analysis

- The plateau current increases linearly with HF concentration (by volume).

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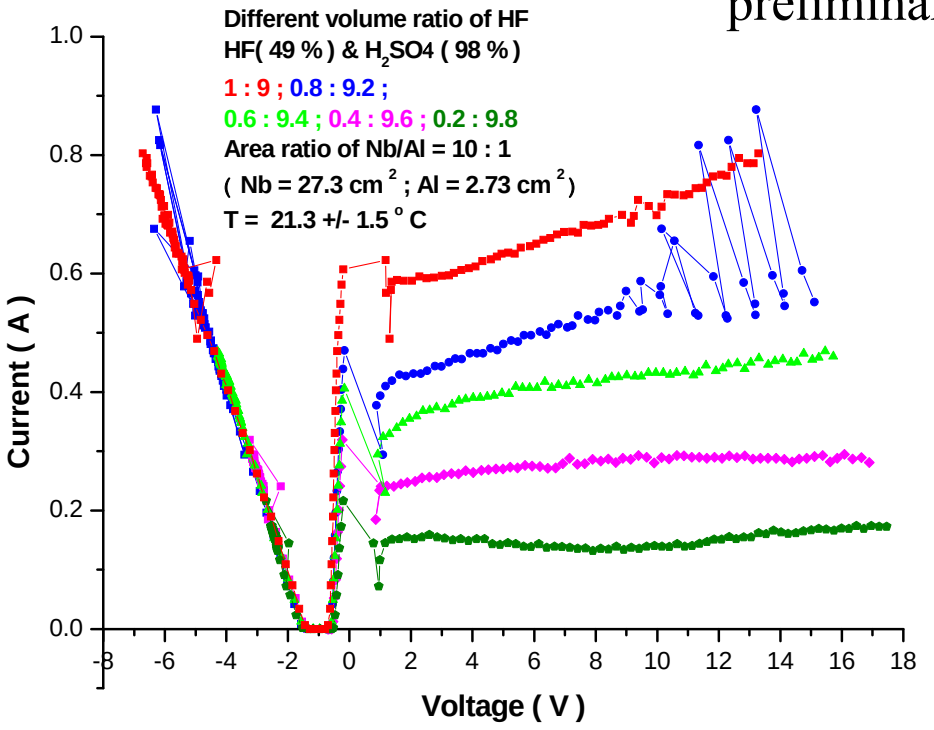

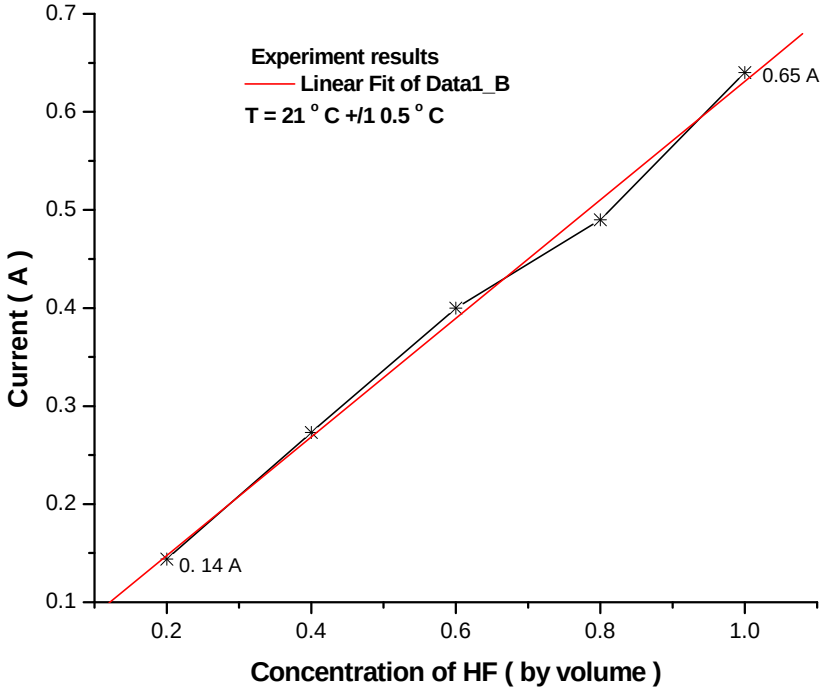

This is consistent with characterizing the process as “acceptor-diffusion-limited”.

If so, the polishing effect is created by the gradient in F^- concentration near the surface.

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Next steps

- Incorporate fluid flow adjacent to the anode by making a rotating anode assembly, look at the effect of "gentle" flow and in /out of bath as occurs in horizontal rotating cavity.

- Characterize the specific scales of smoothing effects for well-controlled EP conditions via profilometry & AFM.