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Electrochemical Application of Barium Sulfate Plating and Gold Plating Bath Analysis

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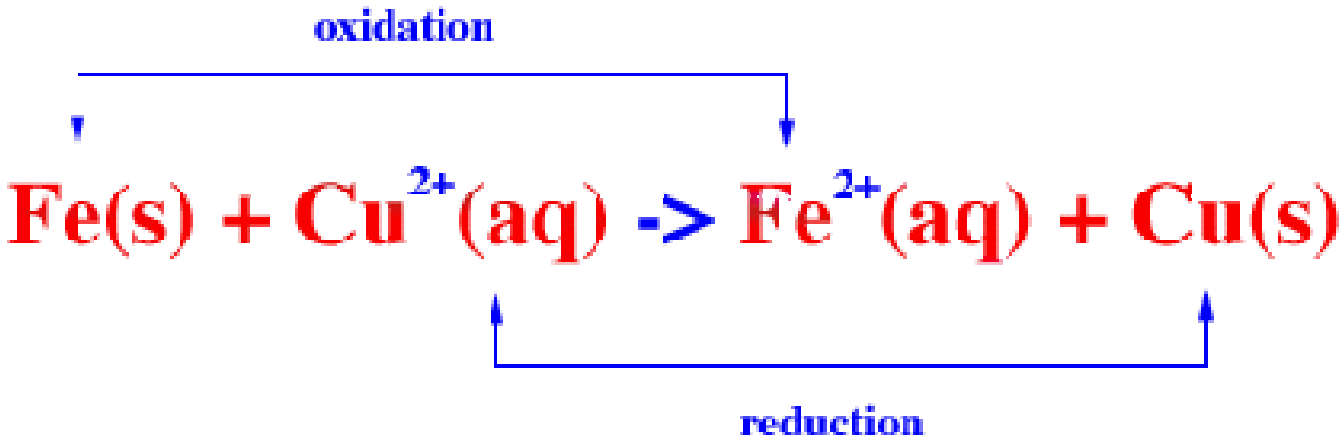
Basics of Electrochemistry

- Redox Reaction - a reaction in which there is a transfer of electrons from one species to another
- Oxidation – removal of electrons
- Reduction – addition of electrons



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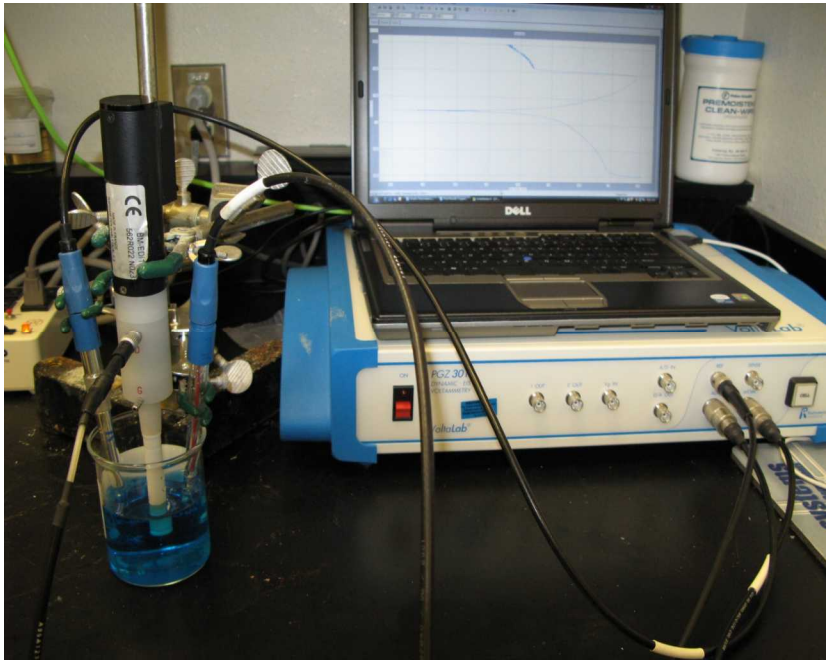
Electrochemical Cell

- Consists of two electrodes (metallic conductors) in contact with an electrolyte (an ionic conductor)
- The electrode at which oxidation occurs is called the anode, and the electrode at which reduction occurs is called the cathode.



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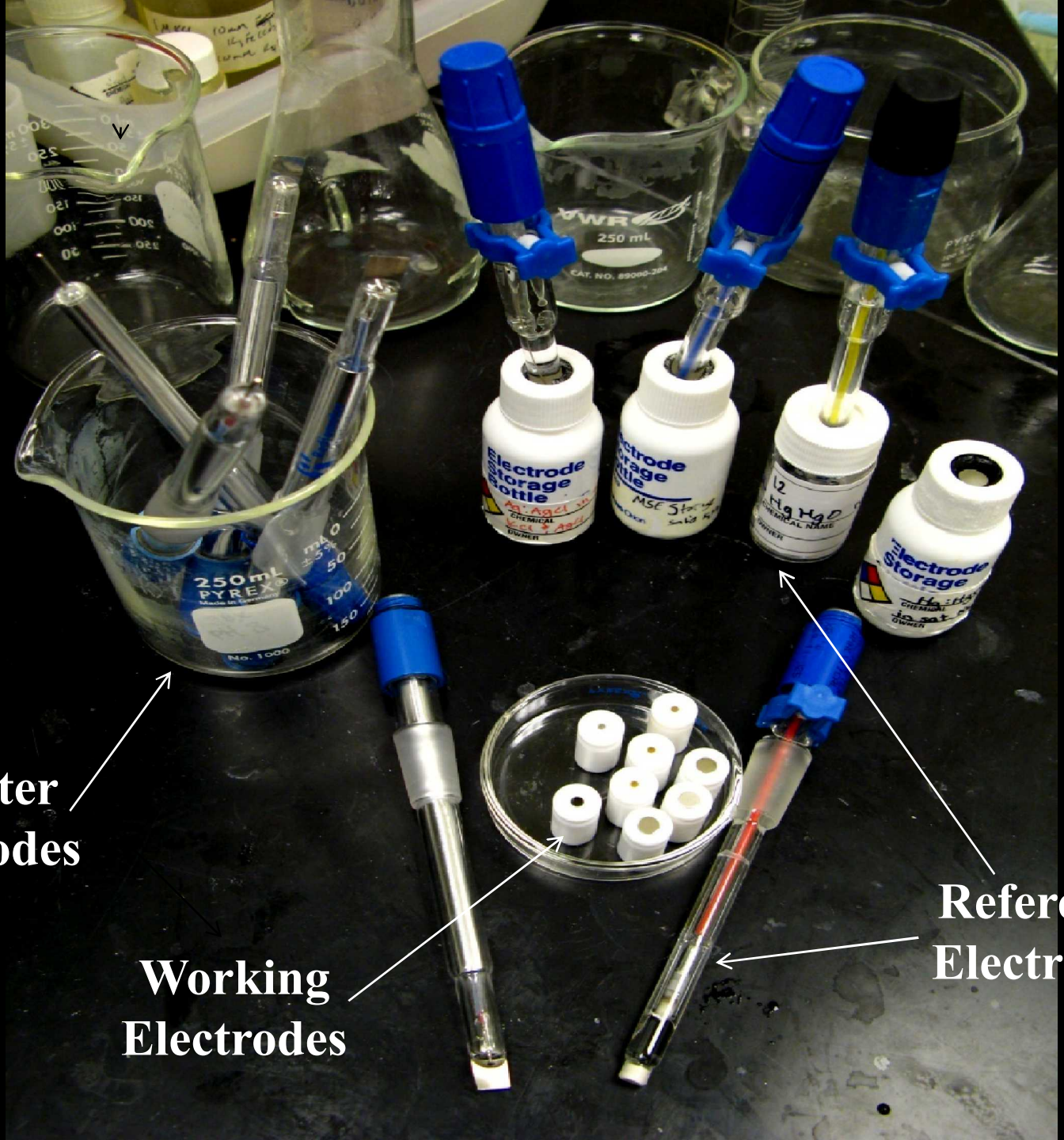
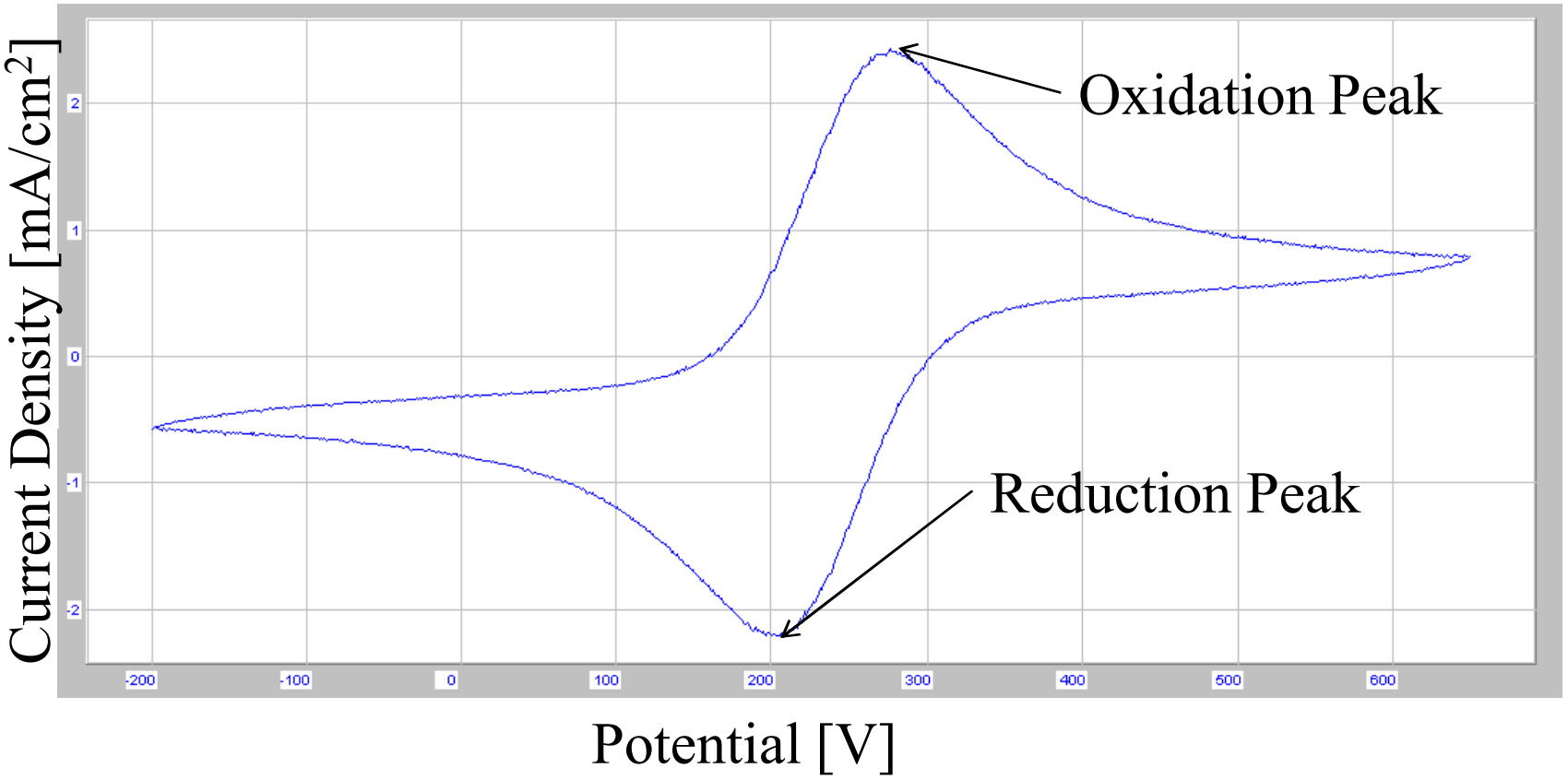

Counter Electrodes
Working Electrodes
Reference Electrodes
250ml PYREX
Electrode Storage Bottle
250 mL

Voltammetry



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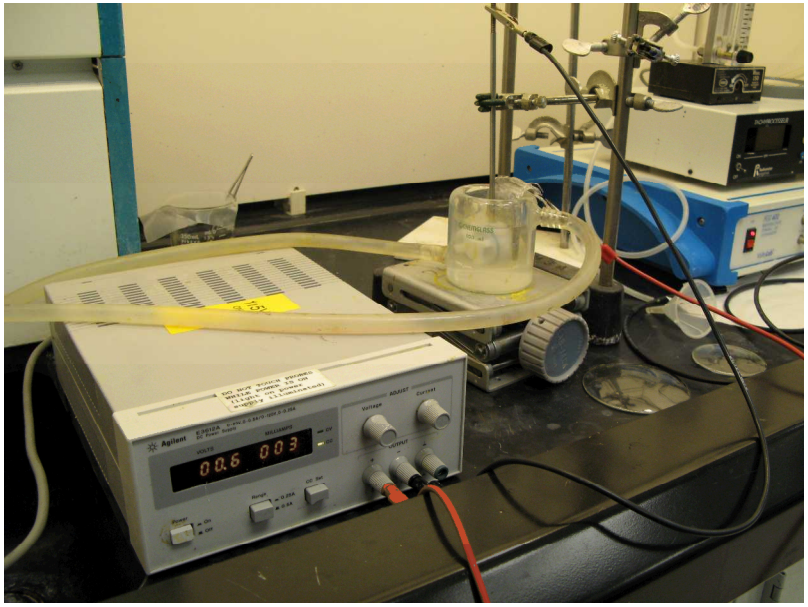
My Projects

- **Project #1 - Coating a metallic substrate with a film of Barium Sulfate for a part of an optical lens**



- **Project #2 - Analyze the effects of different additives in a gold plating bath**

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Barium Sulfate Plating

- Anode – Stainless Steel – 1cm^2
- Cathode – Platinum Mesh
- Solution – Stabilized $BaSO_4$ bath: 1:20:1 volume ratio of .025 M Barium Nitrate, .025 M disodium salt of EDTA, and .025 M Potassium Sulfate

Barium Sulfate Plating

- EDTA and Ba^{2+} form a 1:1 complex according to the equation:

$$Ba^{2+} + H_2Y^{2-} \leftrightarrow [Ba(H_2Y)]$$

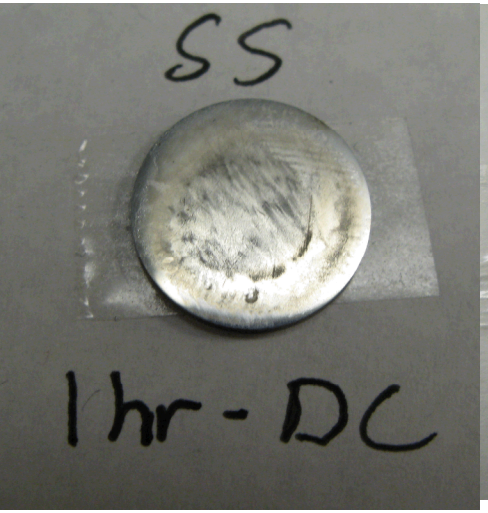
which dissociates at a pH below 8.

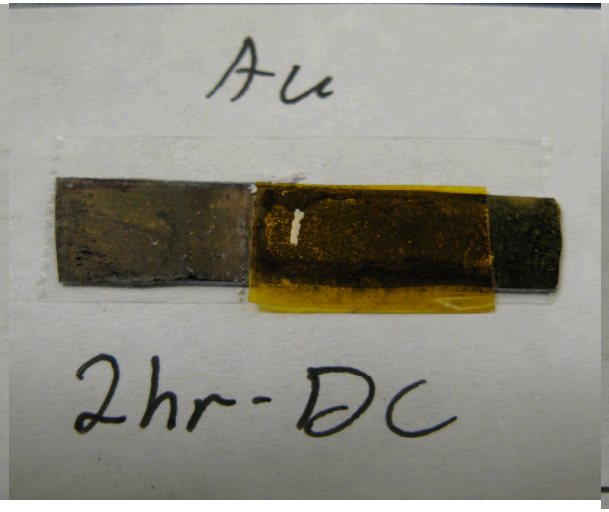
- An oxygen evolution reaction –

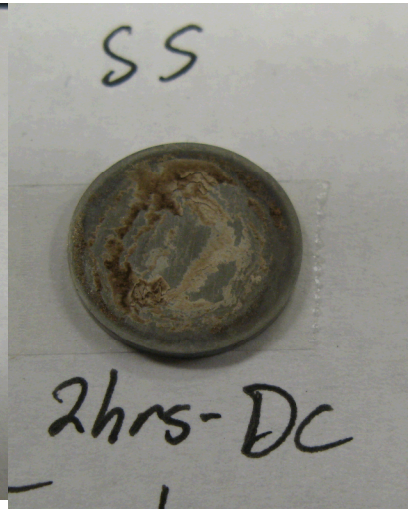
$$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$$

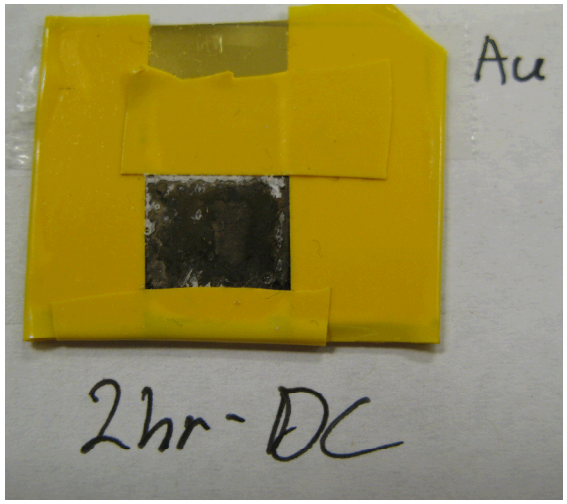
occurs at the surface of the anode, creating a steep decline in the pH of the bath. This dissociates the complex and causes deposition of $BaSO_4$ on the anode.

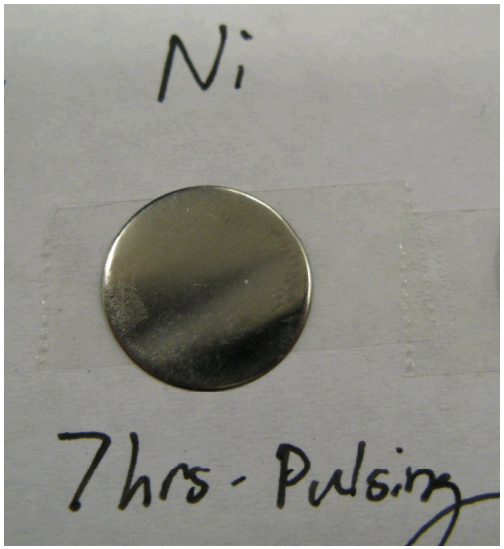
Barium Sulfate Plating Results

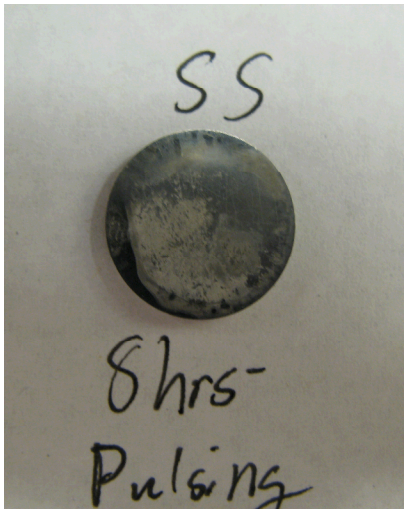




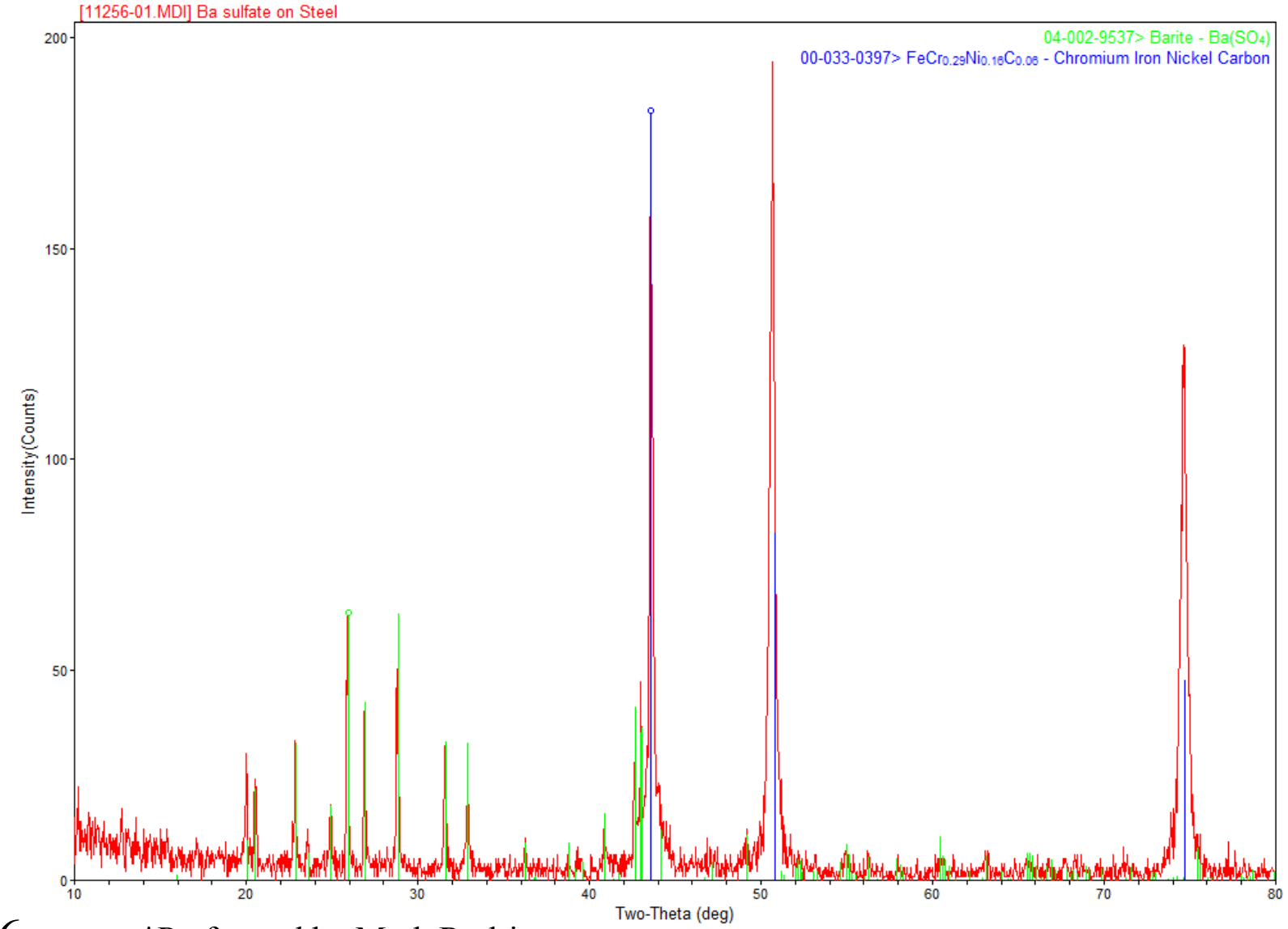






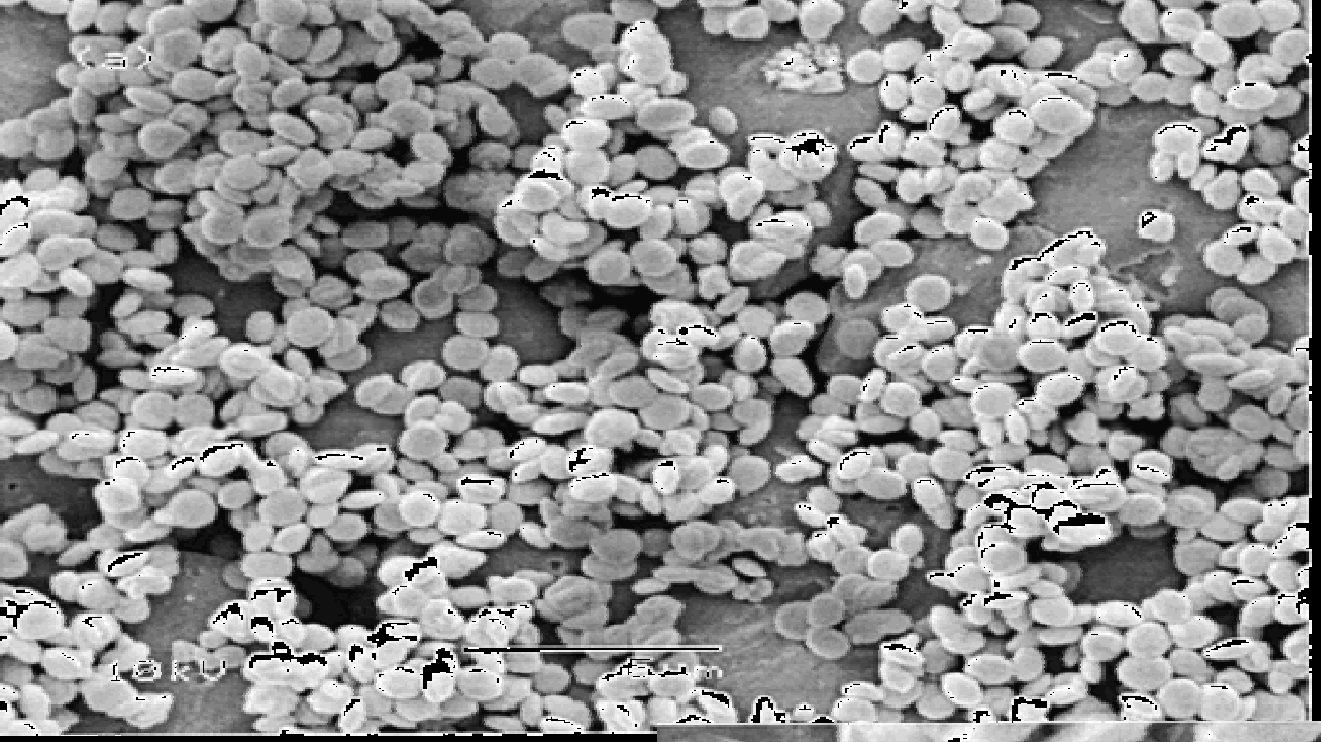


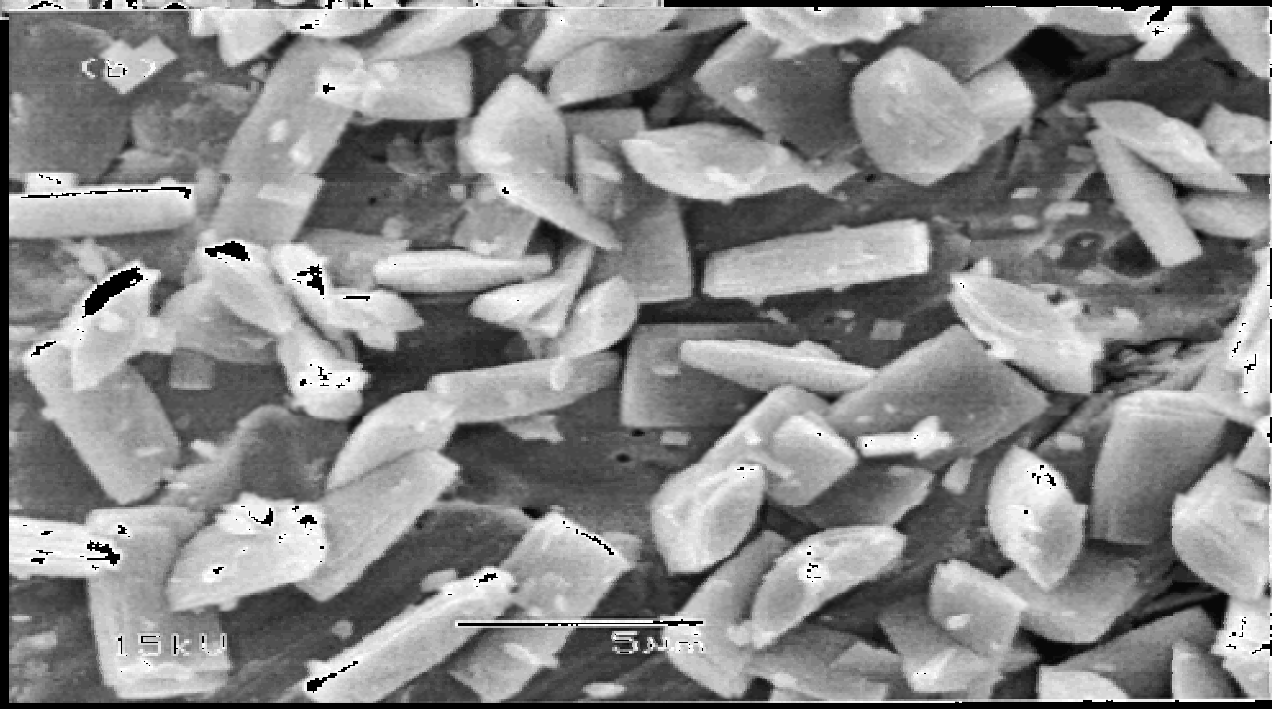
XRD confirms $BaSO_4$ powder present on stainless-steel substrate



*Performed by Mark Rodriguez

[S930003|marodri]<z:\theta-theta\DATA_DIR\DATA-11> Tuesday, June 28, 2011 04:42p (MDI/JADE9)

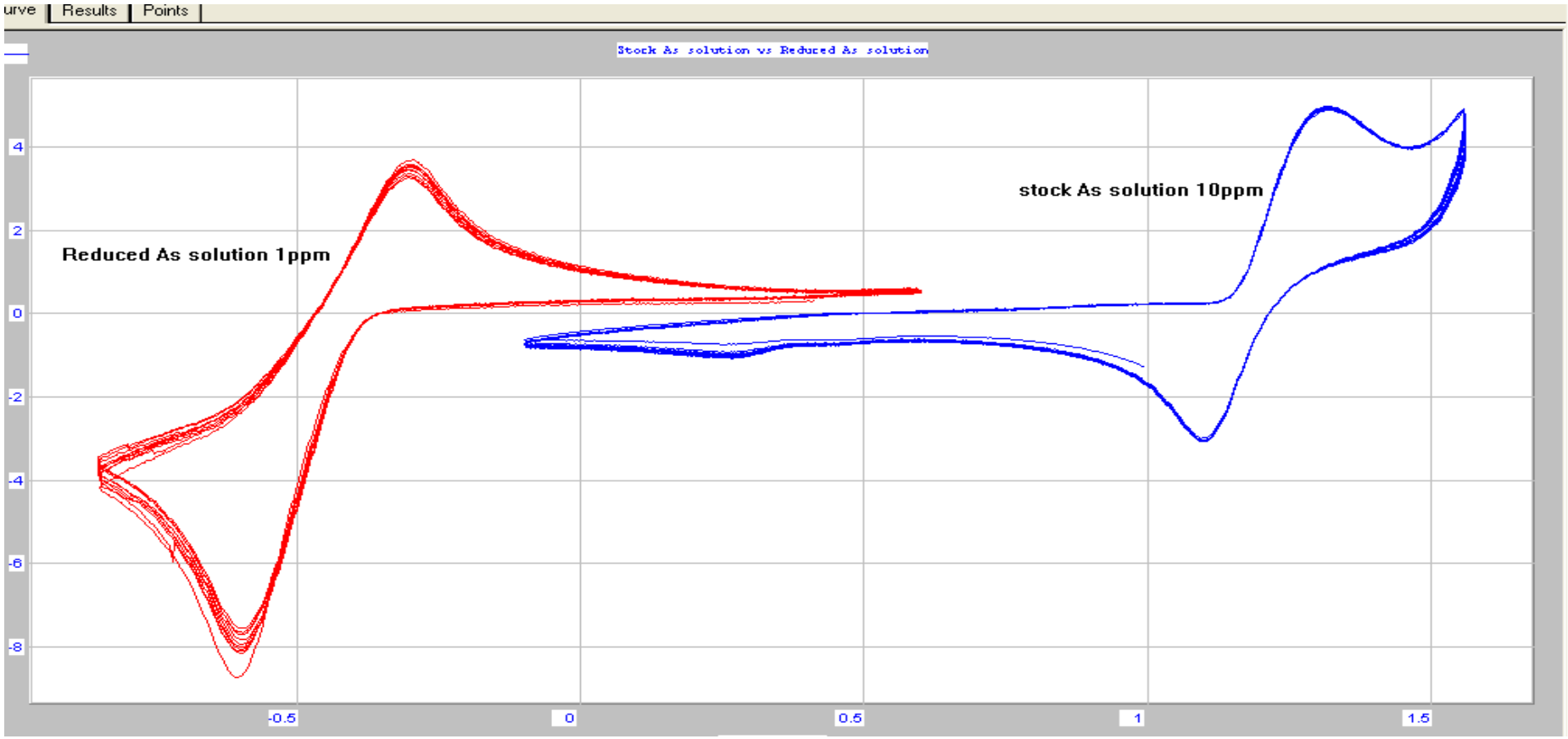

(a)
10kV
5μm


(b)
15kV
5μm

Gold Plating Bath

- Variables Tested:
  - -Time
  - -Temperature
  - -Arsenic Concentration
  - -Au Conducting Salt
  - -Sodium Thiosulfate

As solutions (stock and reduced)



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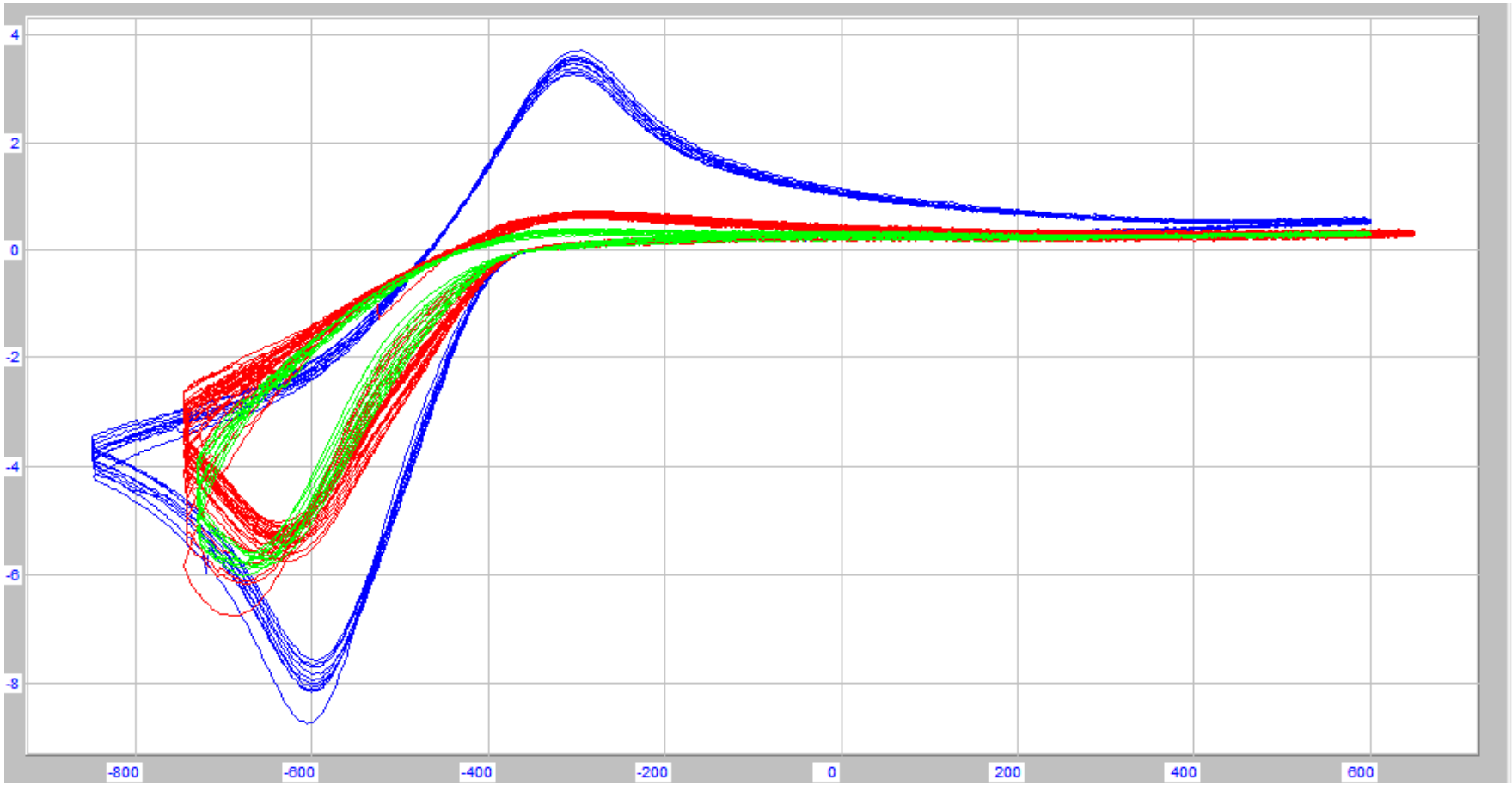
As Solution Over 3 days



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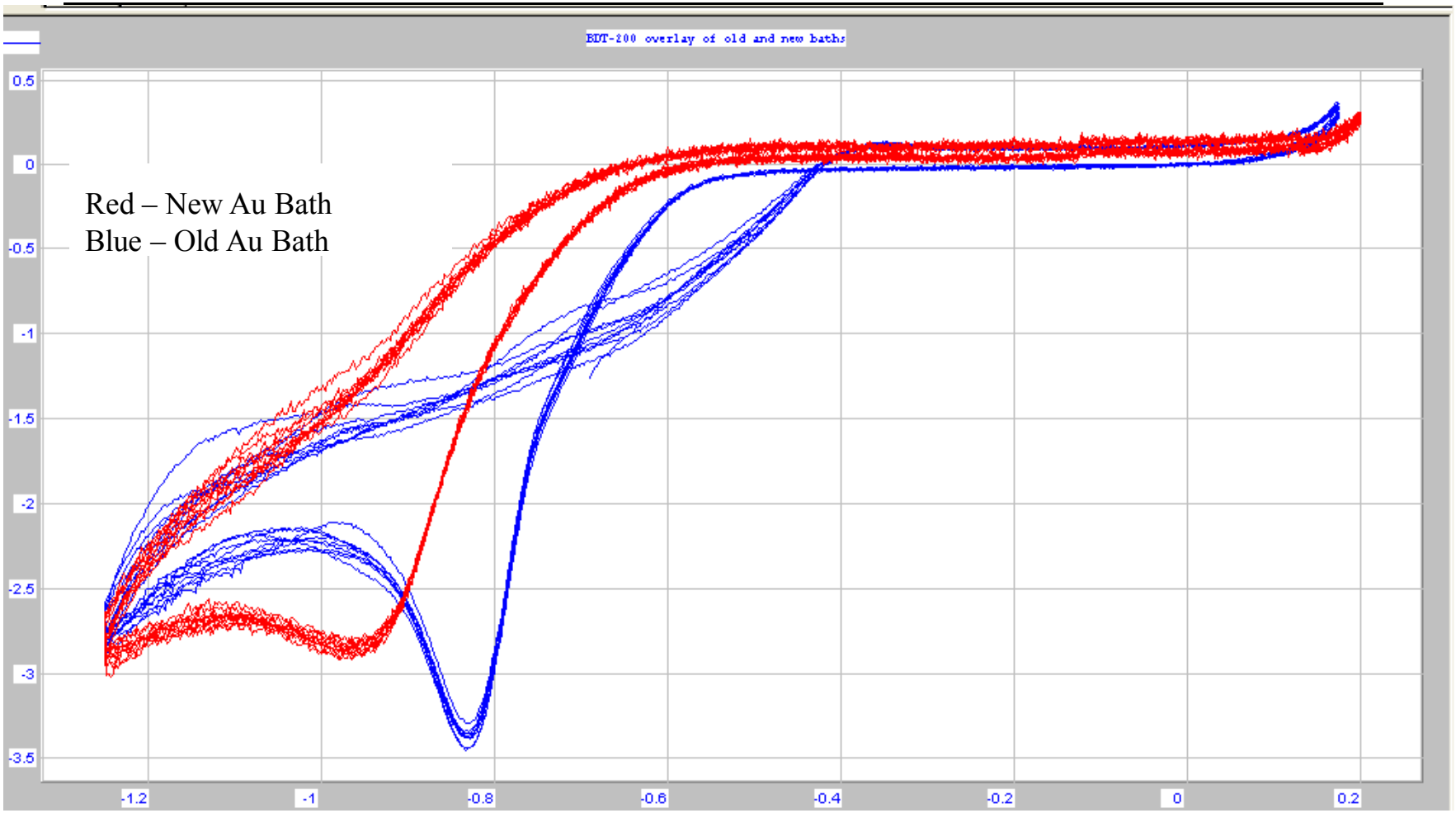
Au Plating Bath - chemistries (old &new)



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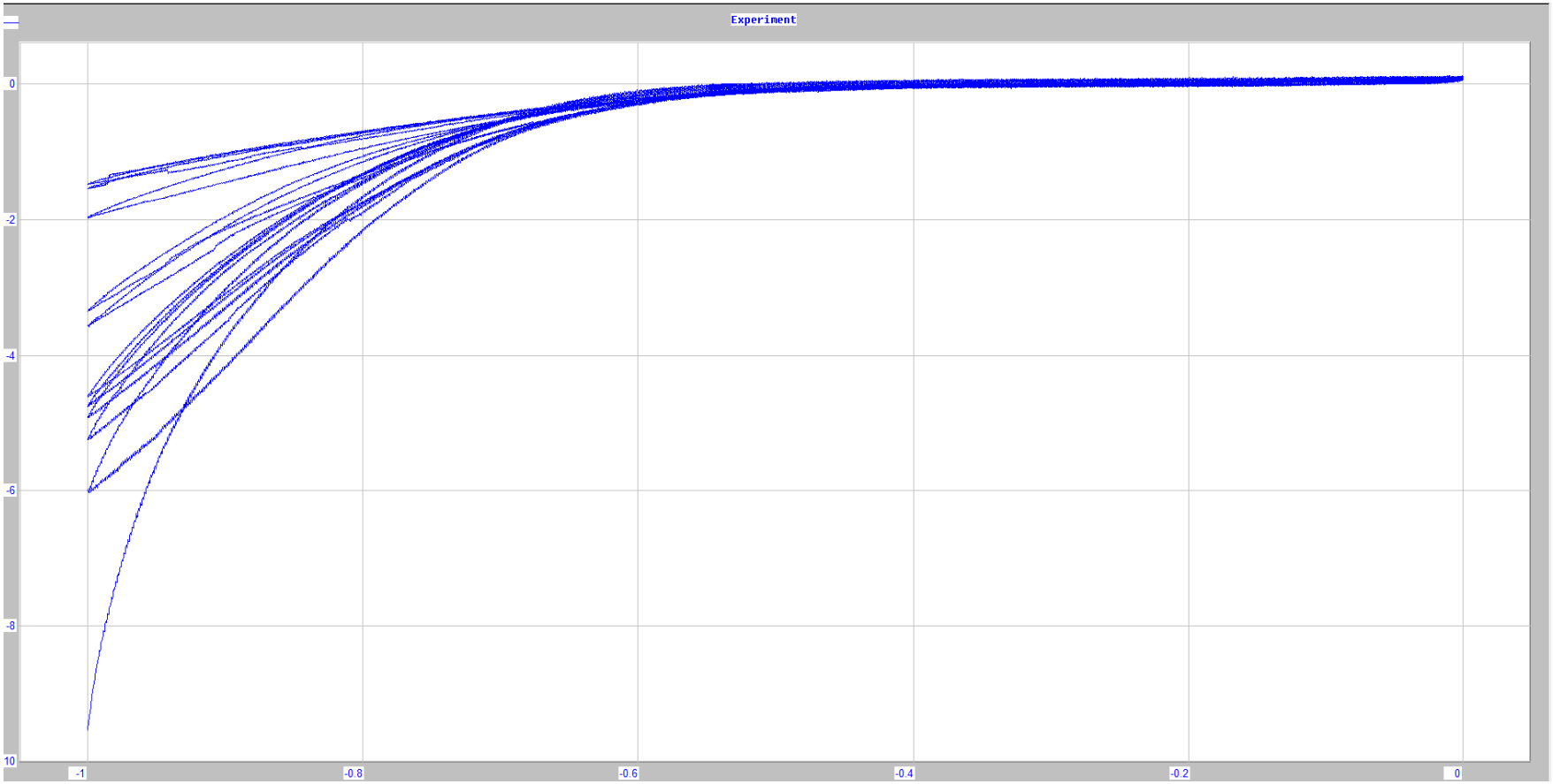
CV of Decomposed Au Plating Bath



Current Density [mA/cm^2]

Potential [V]

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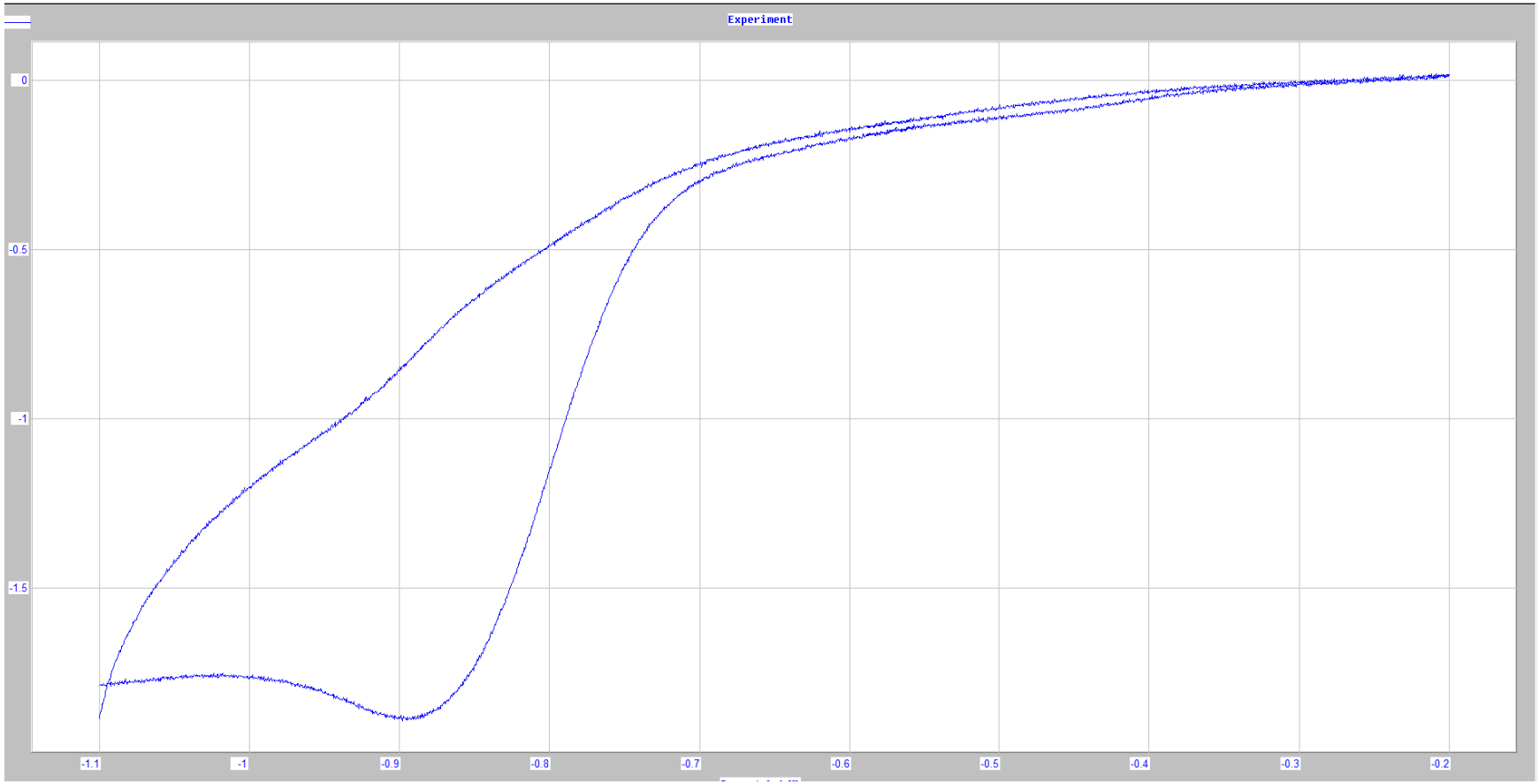
CV of New Au Plating Bath



Current Density [mA/cm^2]

Potential [V]

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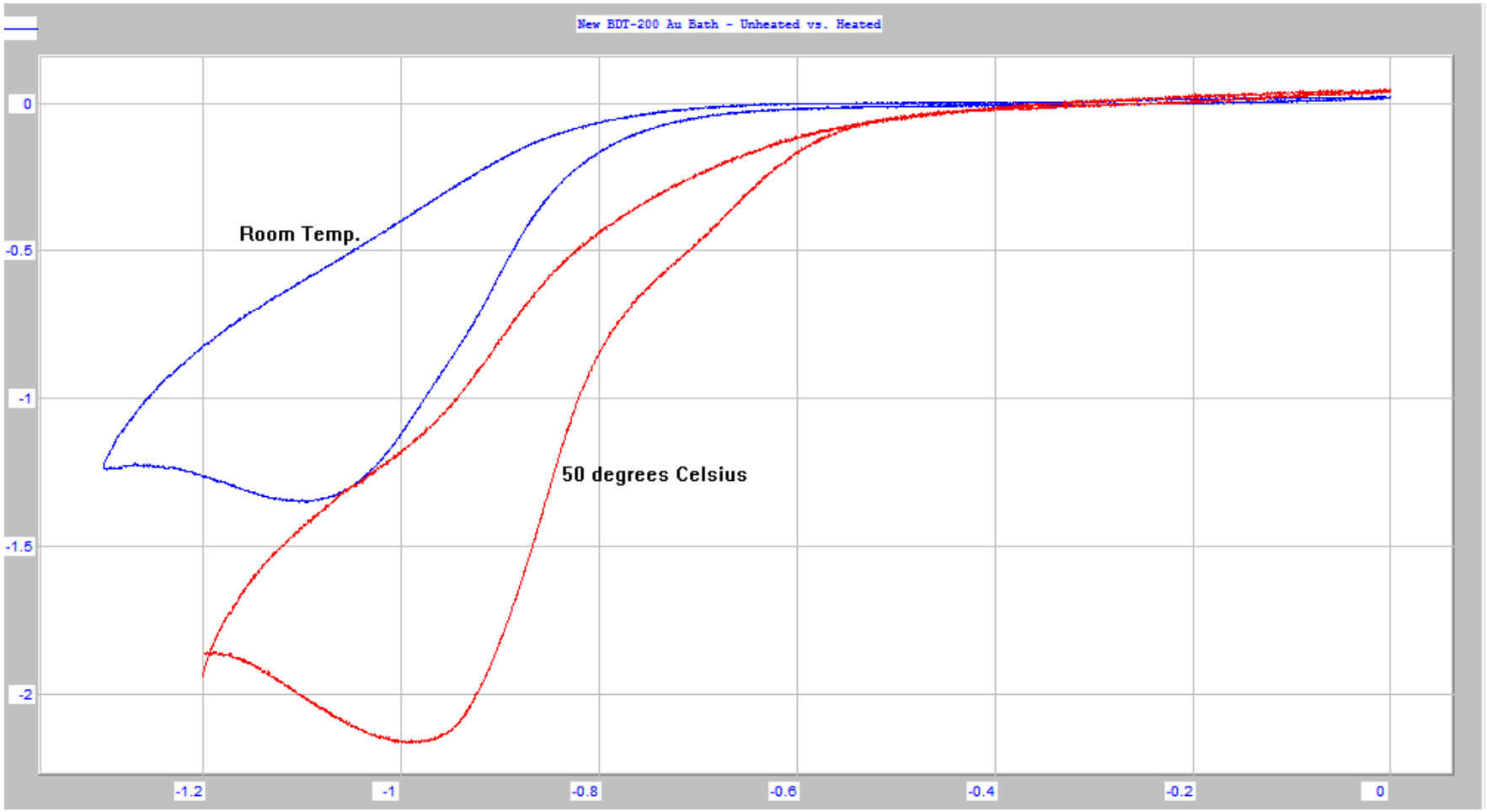
Au Plating Bath – Heated vs. Unheated



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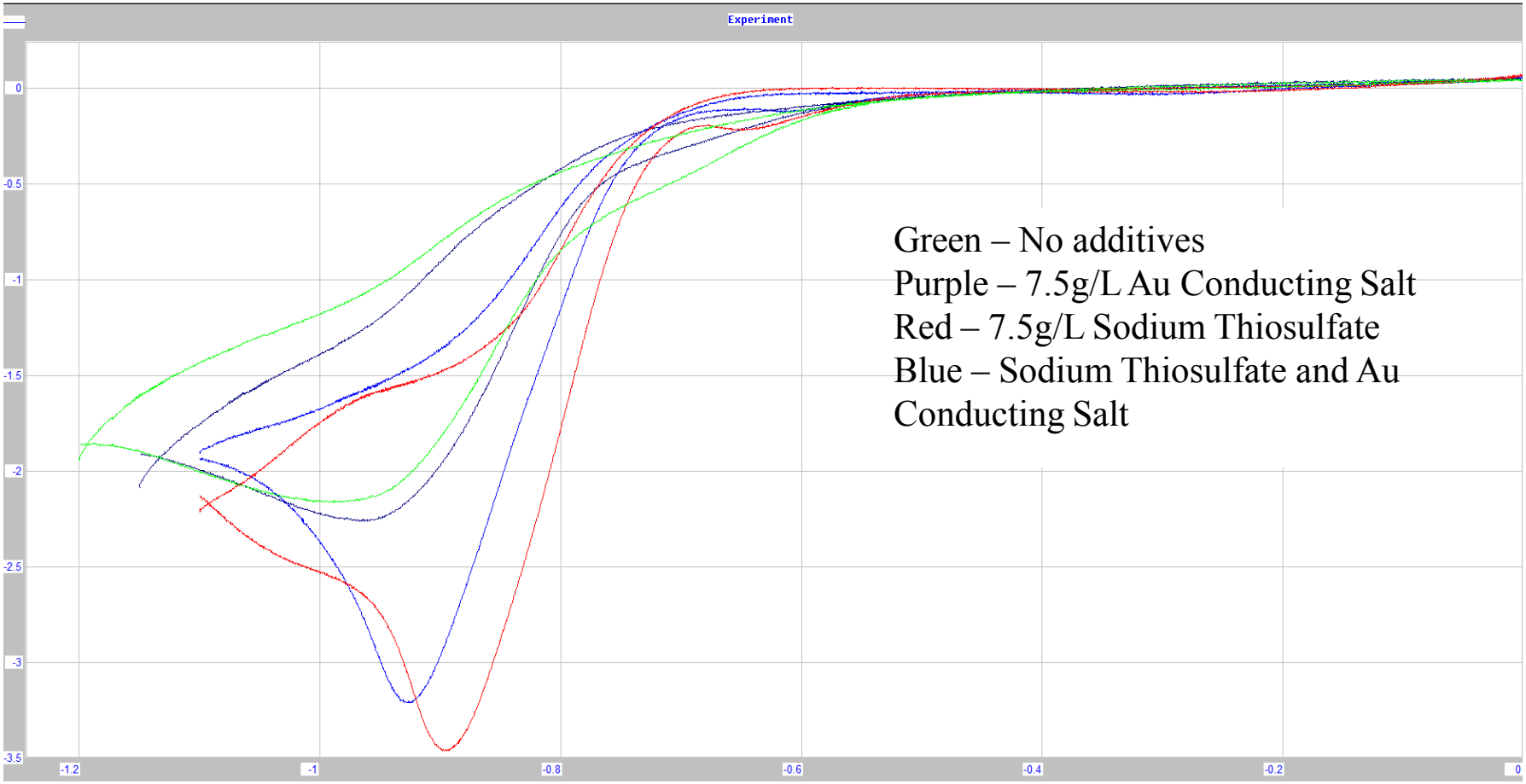
New Au Plating Bath with Constituents



Current Density [mA/cm^2]

Potential [V]

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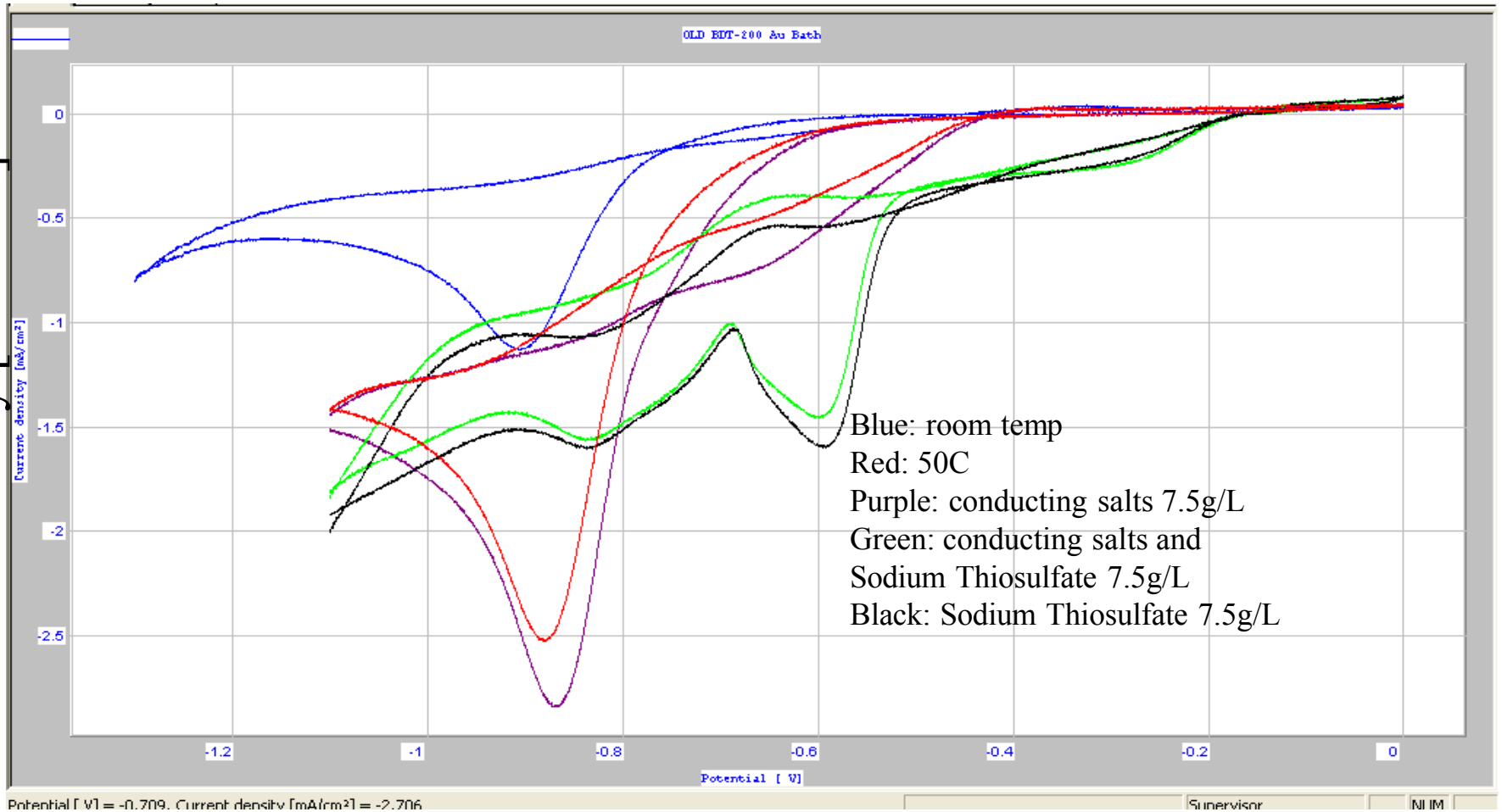
Old Au Plating Bath with Constituents



Current Density [mA/cm^2]

Potential [V]

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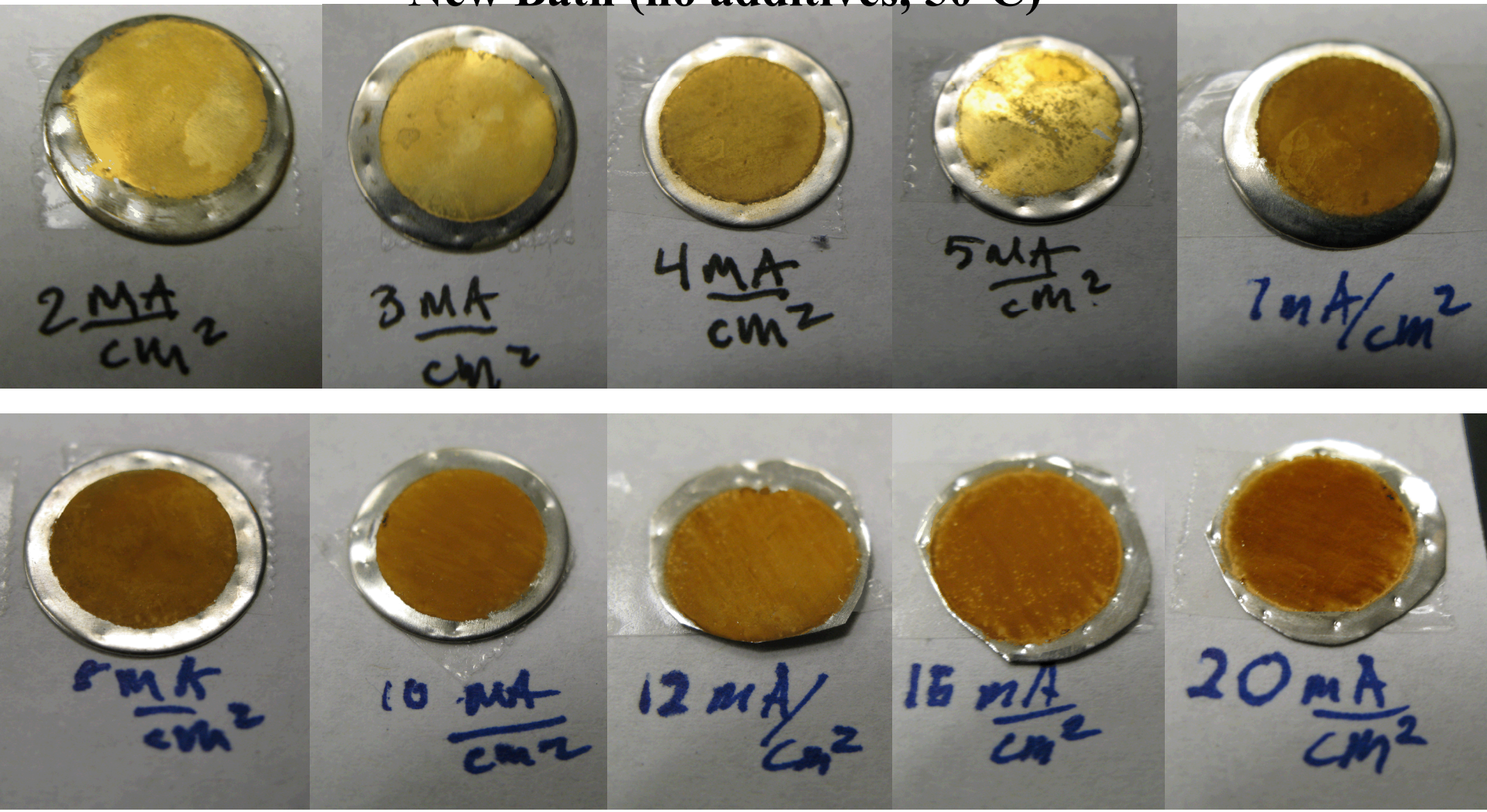
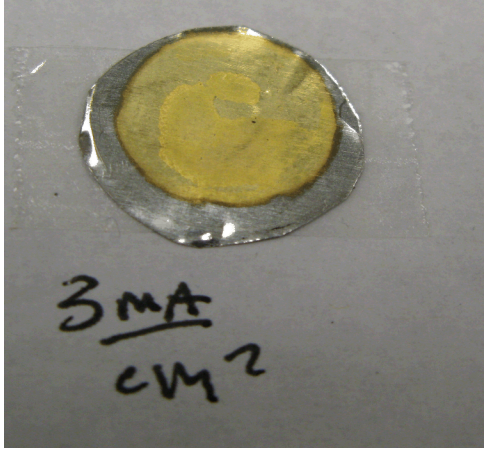
Au Plating Samples at Increasing Current Densities – New Bath (no additives, 50˚C)

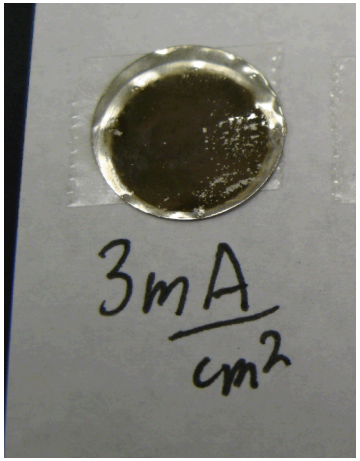


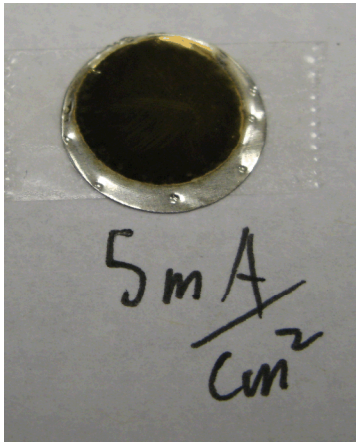
Old Au Bath (50˚C, no additives)



Old Au Bath with 7.5g/L conducting salts (50˚C)

Old Au Bath w/ 7.5g/L Sodium Thiosulfate (50˚C)





STAR Program

- Gained experience in a lab setting
- Learned new applications of chemistry, such as thermodynamics and diffusion in electroplating and redox reactions
- Exposure to actual scientific methods
- Job experience

Bibliography

- **Electrochemical Deposition of BaSO4 Coatings on Stainless Steel Substrates**
  M. Dinamani,, P. Vishnu Kamath, and, Ram Seshadri
  Chemistry of Materials 2001 *13* (11), 3981-3985

- **Basic Concepts of Electrochemistry**
  http://iweb.tntech.edu/albu/teaching/CHEM3520-S04/L040329.pdf