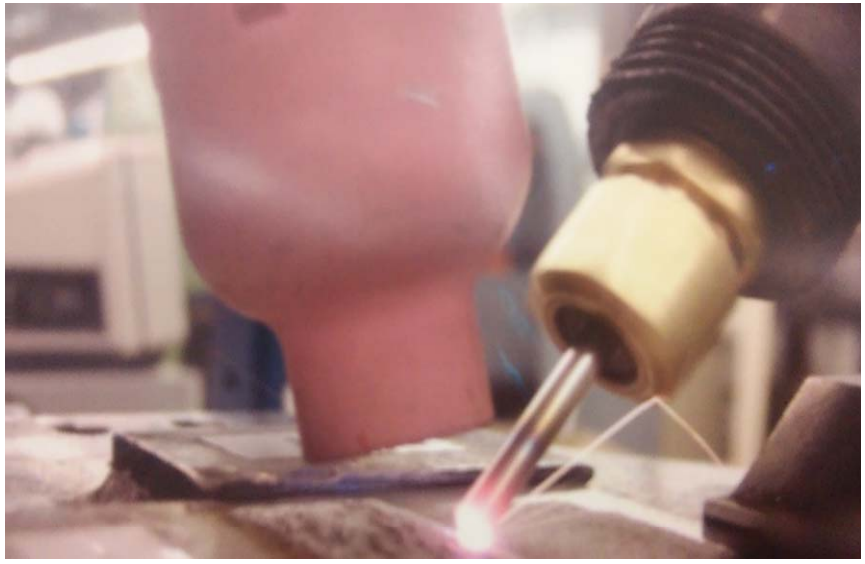
The Influence of Hydrogen-Argon Mixed Shielding Gases on Electro Spark Deposition

An Audio/Visual and Temperature recorded Deposition process followed by Microstructural analysis with SEM and EDS.

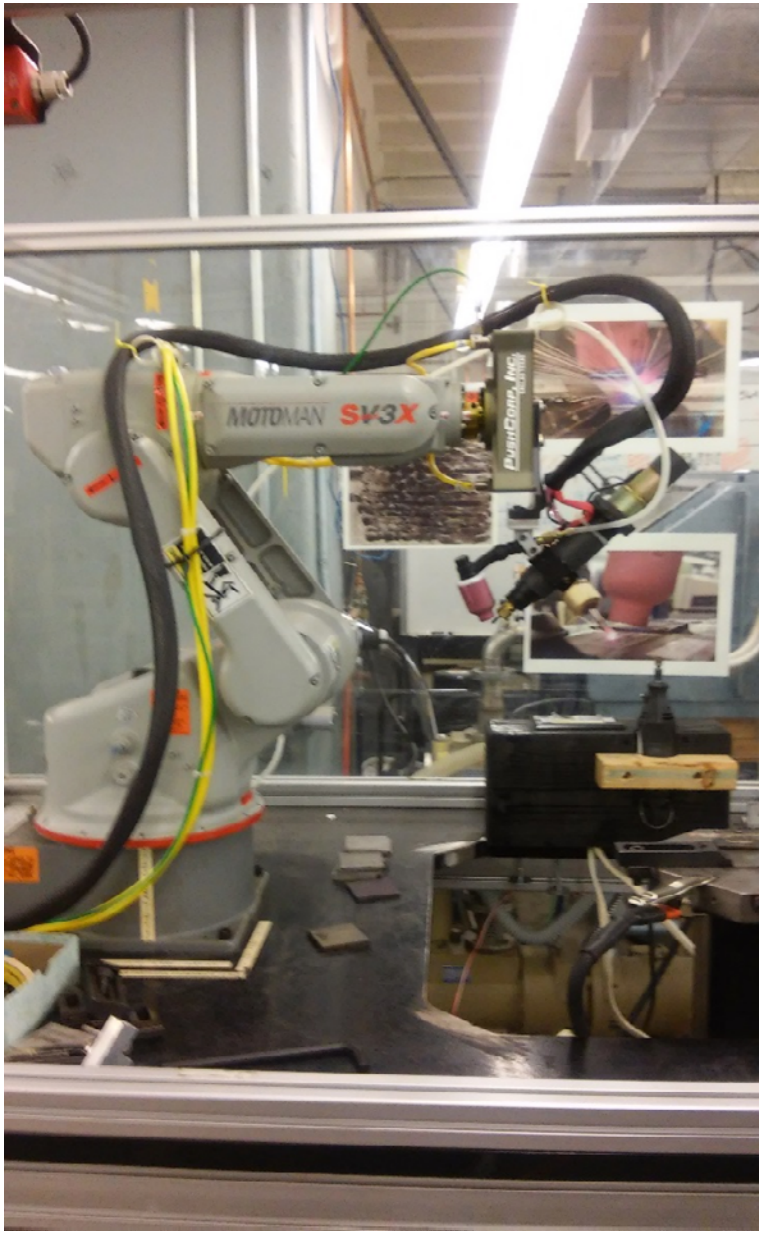
Electro-Spark Deposition

- Micro-Welding Additive Technology
- High Electrical Heat Input and Short Pulse Duration (50-75 µs) Via Capacitive Discharge
- High Cooling Rate
- Spark Hardening

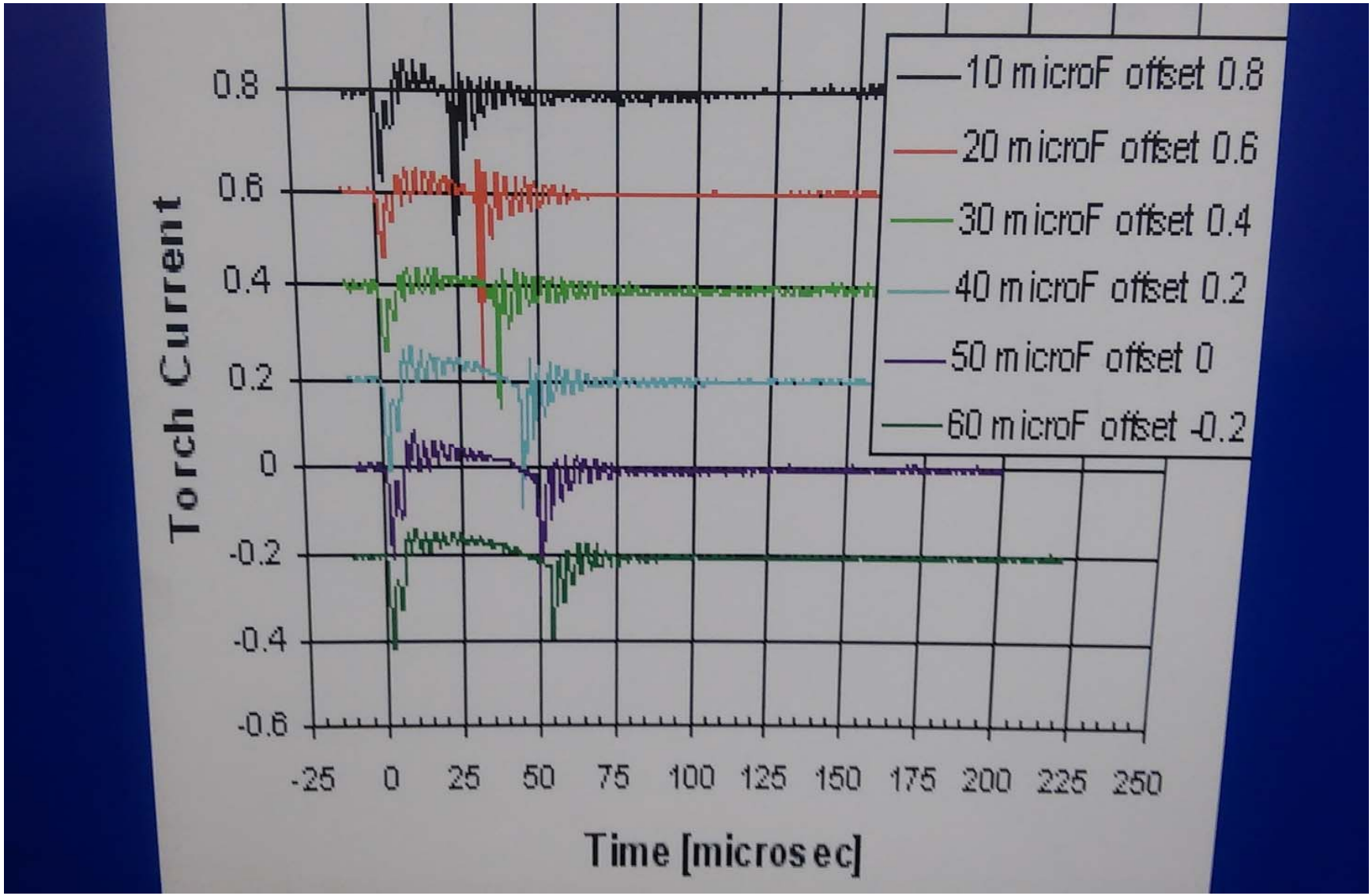
Power Source and Torch



Electrode and Shield Gas Cup



Robotic Arm with Mounted Torch



Electrical Current Behavior

Project Scope

- 95% Ar, 5% H_2 shield gas with 316L and 304 stainless steel
- Metallographic and Scanning Electron Microanalysis with EDS
- Recording of the process live
  - Video Recording
  - Frequency Spectrum Recording
  - Temperature Recording

Shielding Gases and their Influence on GMAW Welding

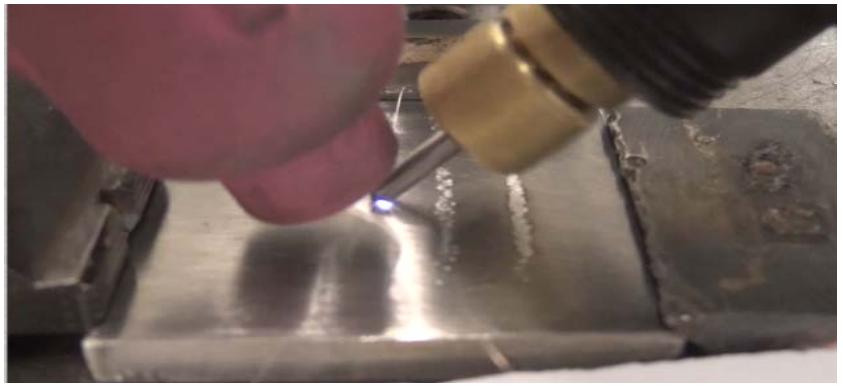
- Hydrogen-Argon
  - Hydrogen increases arc stability
  - Increases amount of material melted per discharge

System Setup

- Video Results
  - Air Atmosphere

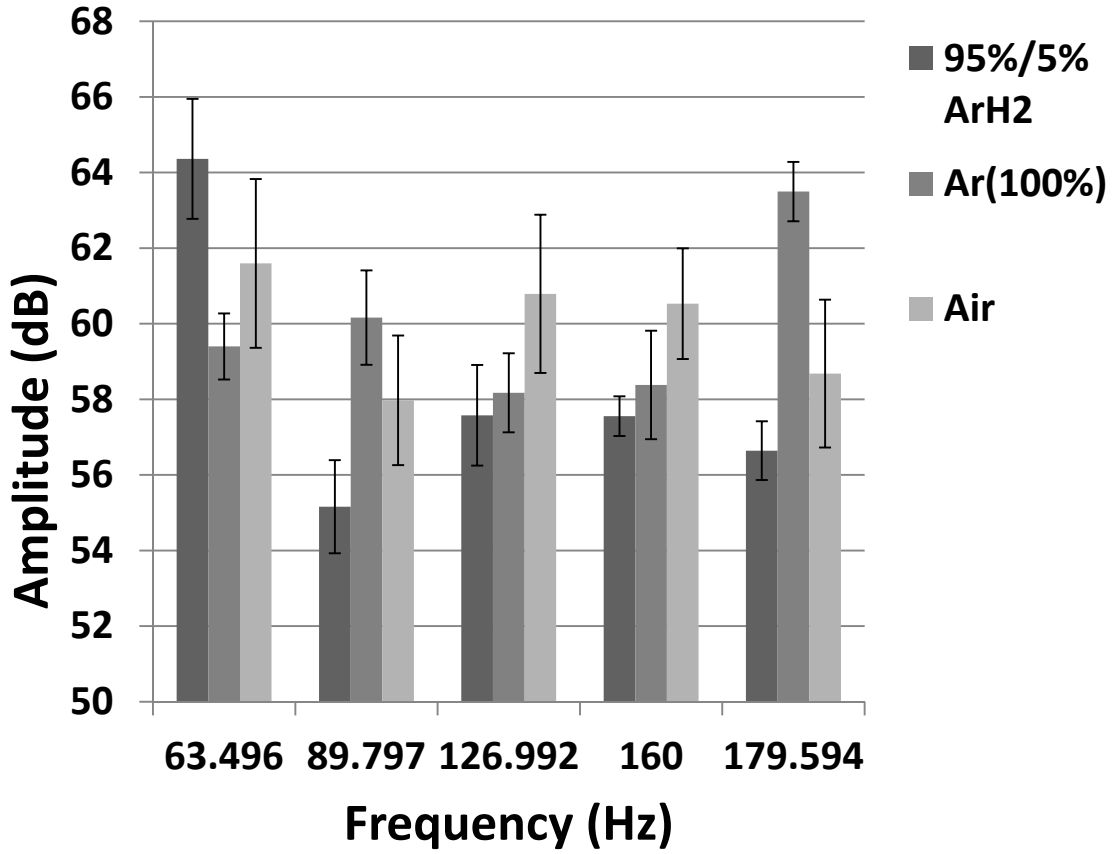
  - 100% Ar Shield Gas

  - Ar/H_2 Shield Gas



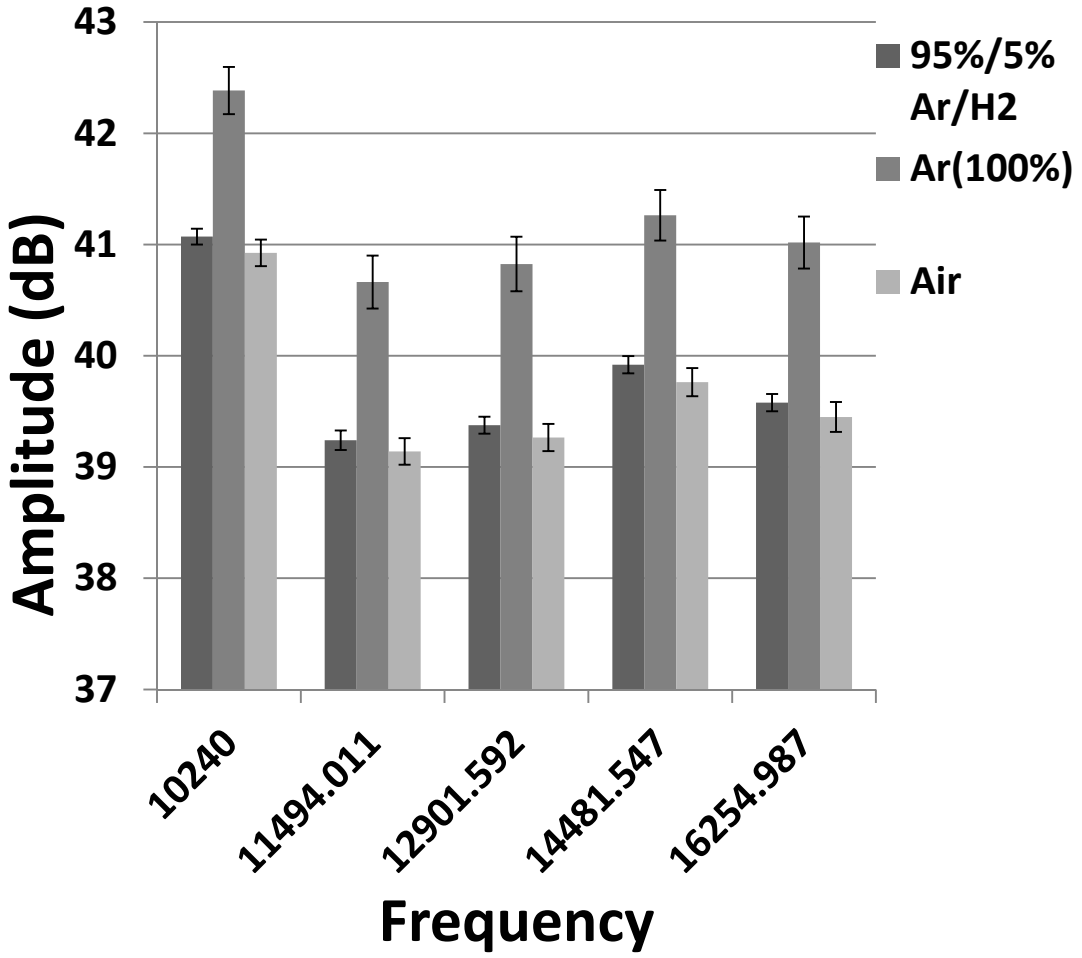
Frequency Spectrum Results

- Frequencies with large amplitude difference tended to have higher variance
- Hard to verify changes due to noise



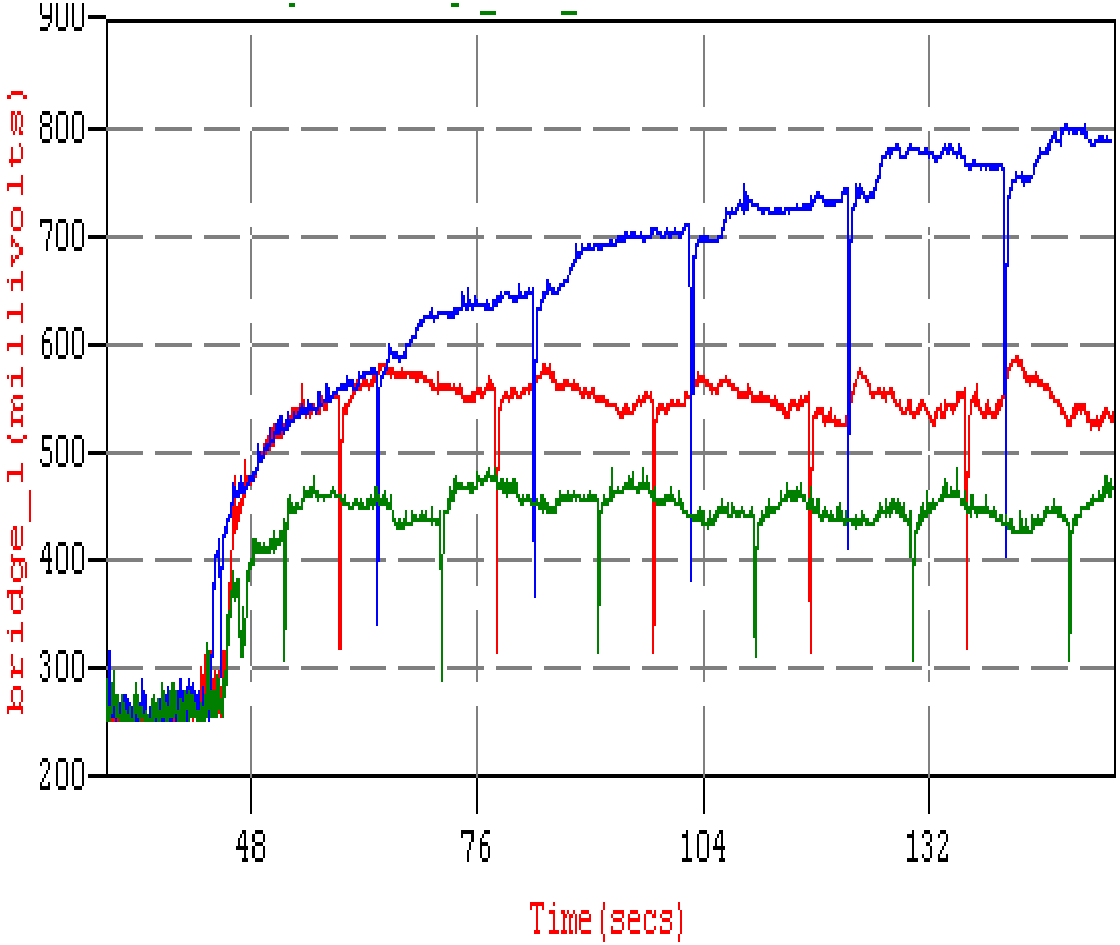
Frequency Spectrum Results

- Frequencies with less variance showed more similarity in discharge sound between Air and Ar/H_2 than with Ar

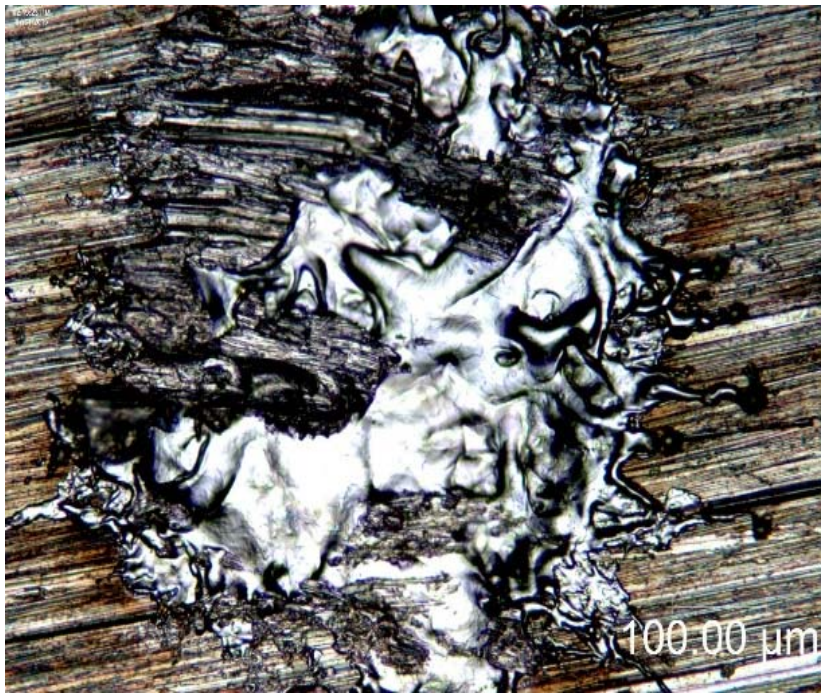


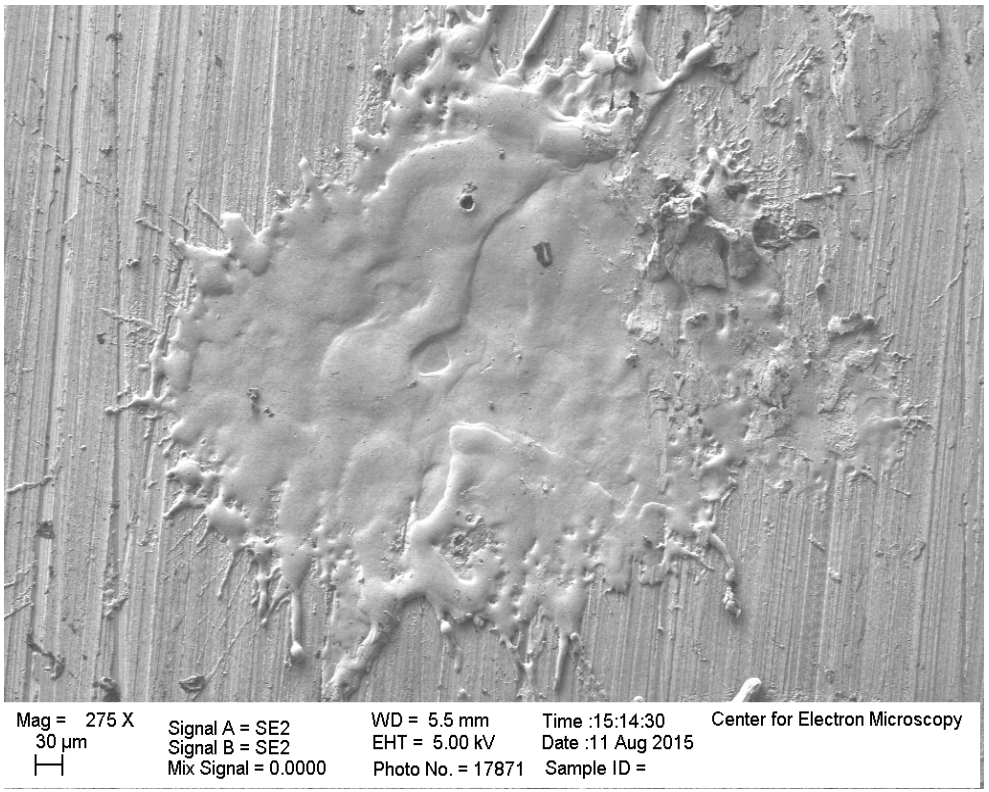
Temperature Results

- Electrode Temperature mV signal
- **Blue: Air**
- **Red: Ar**
- **Green: Ar/H_2**

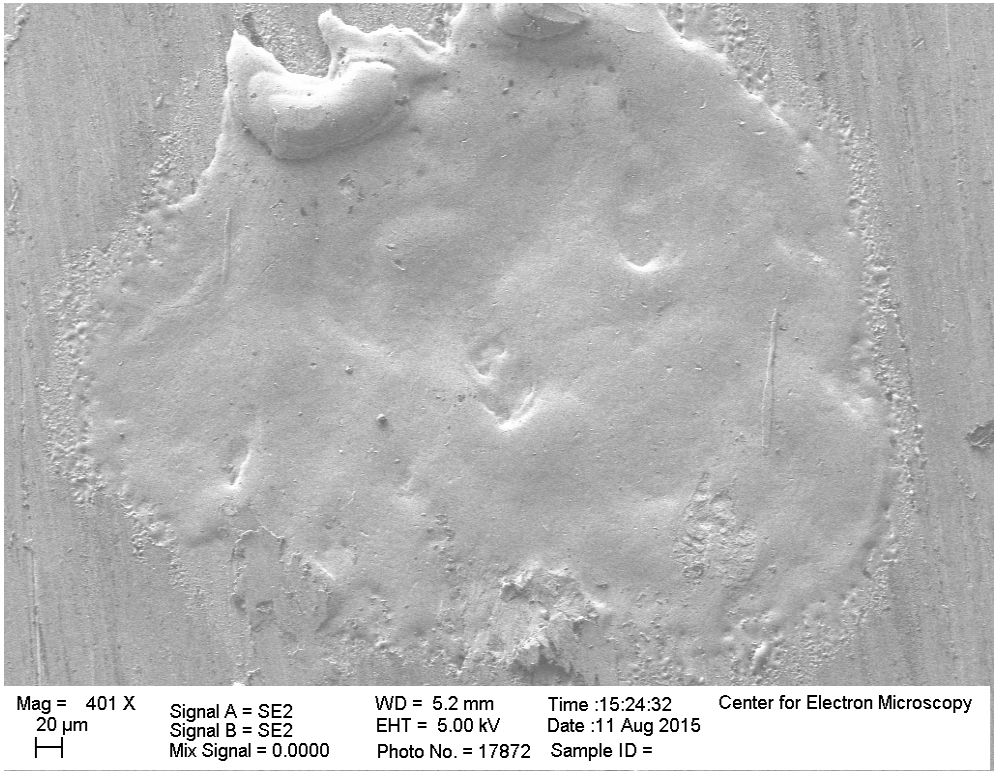


Single Splat Images






100.00 µm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20 µm
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Signal B = SE2
Mix Signal = 0.0000
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EHT = 5.00 kV
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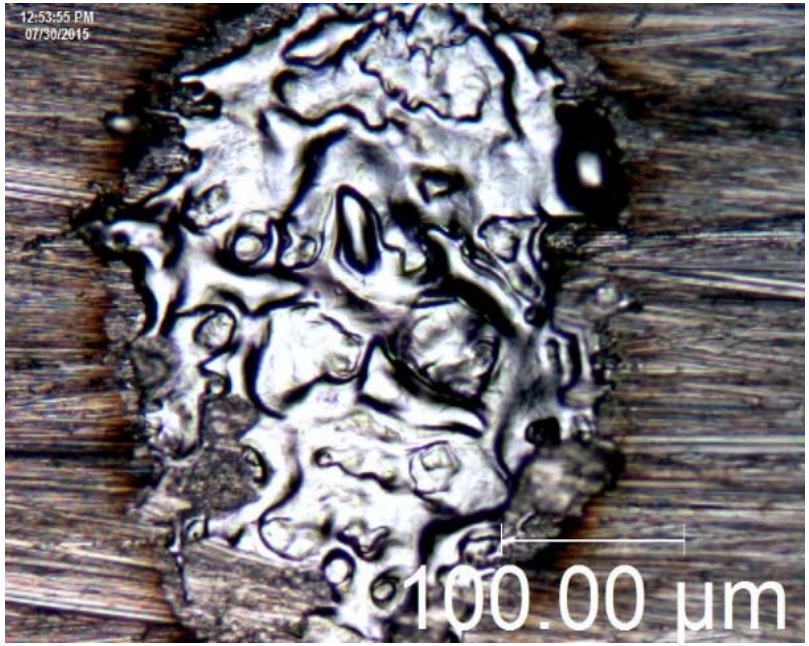
Date :11 Aug 2015
Sample ID =
Center for Electron Microscopy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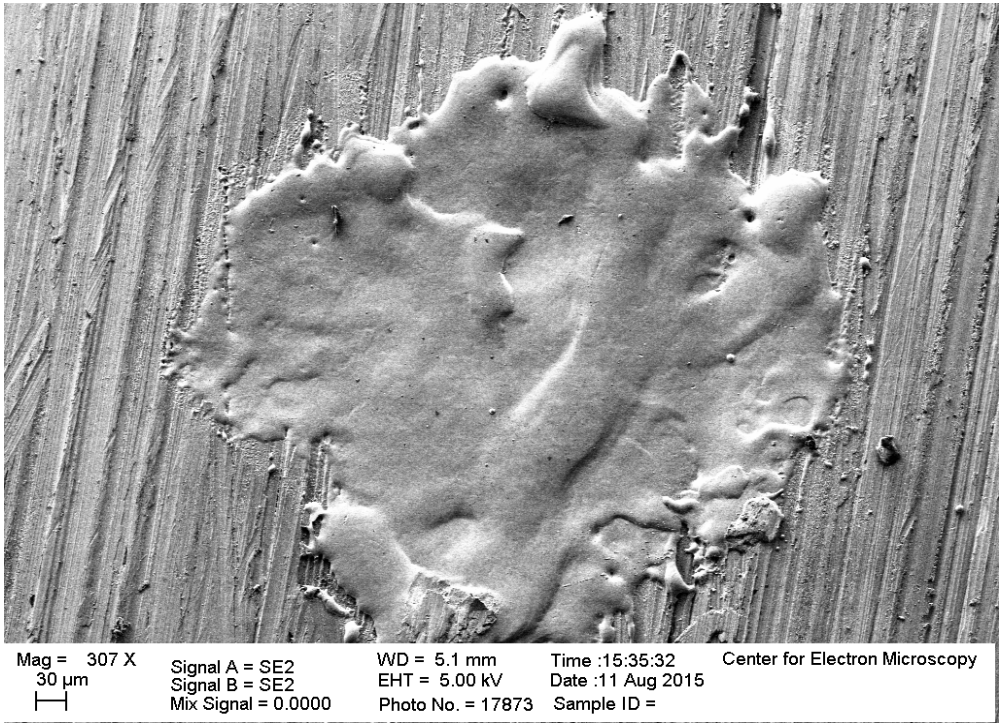
07/30/2015
100.00 µm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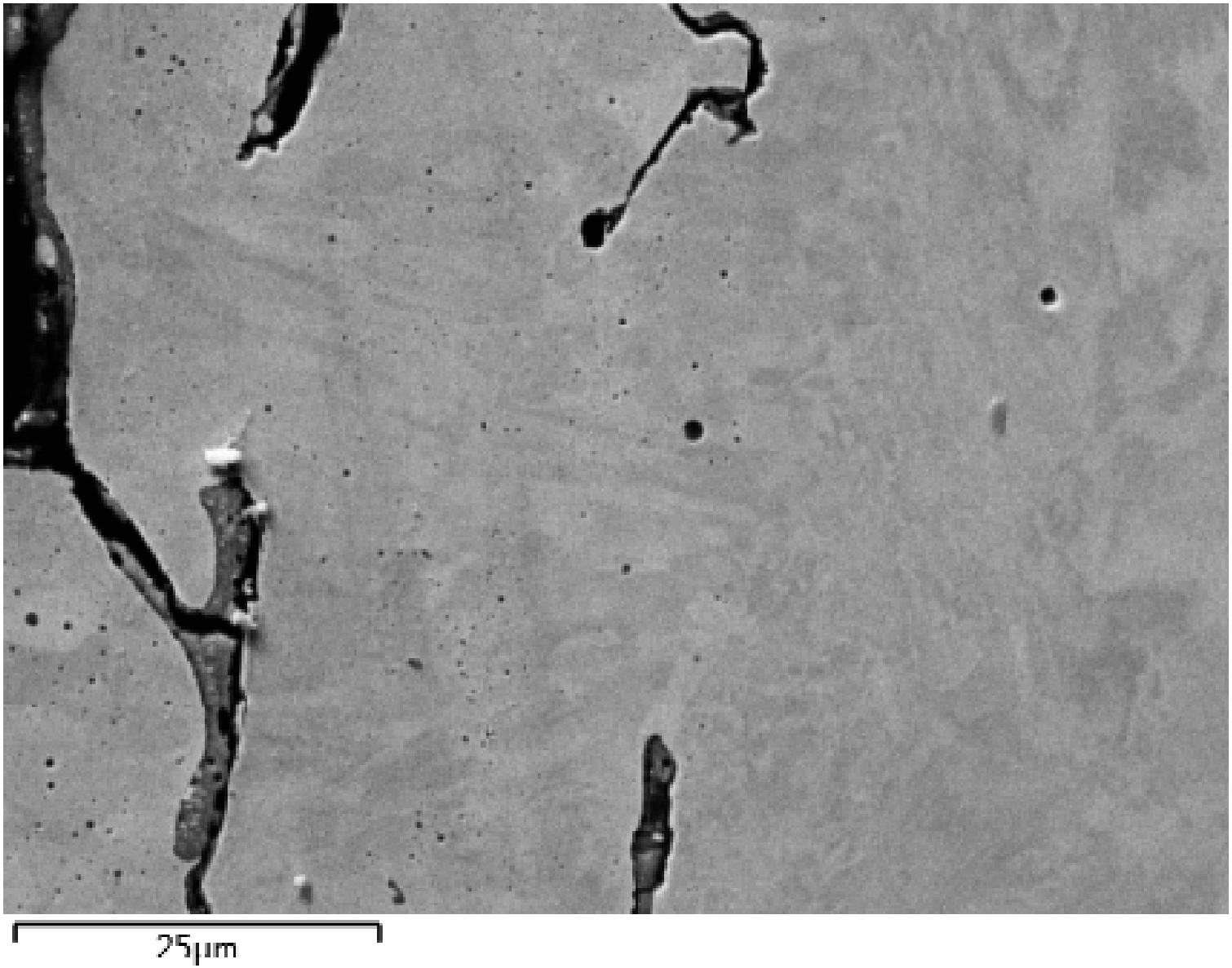
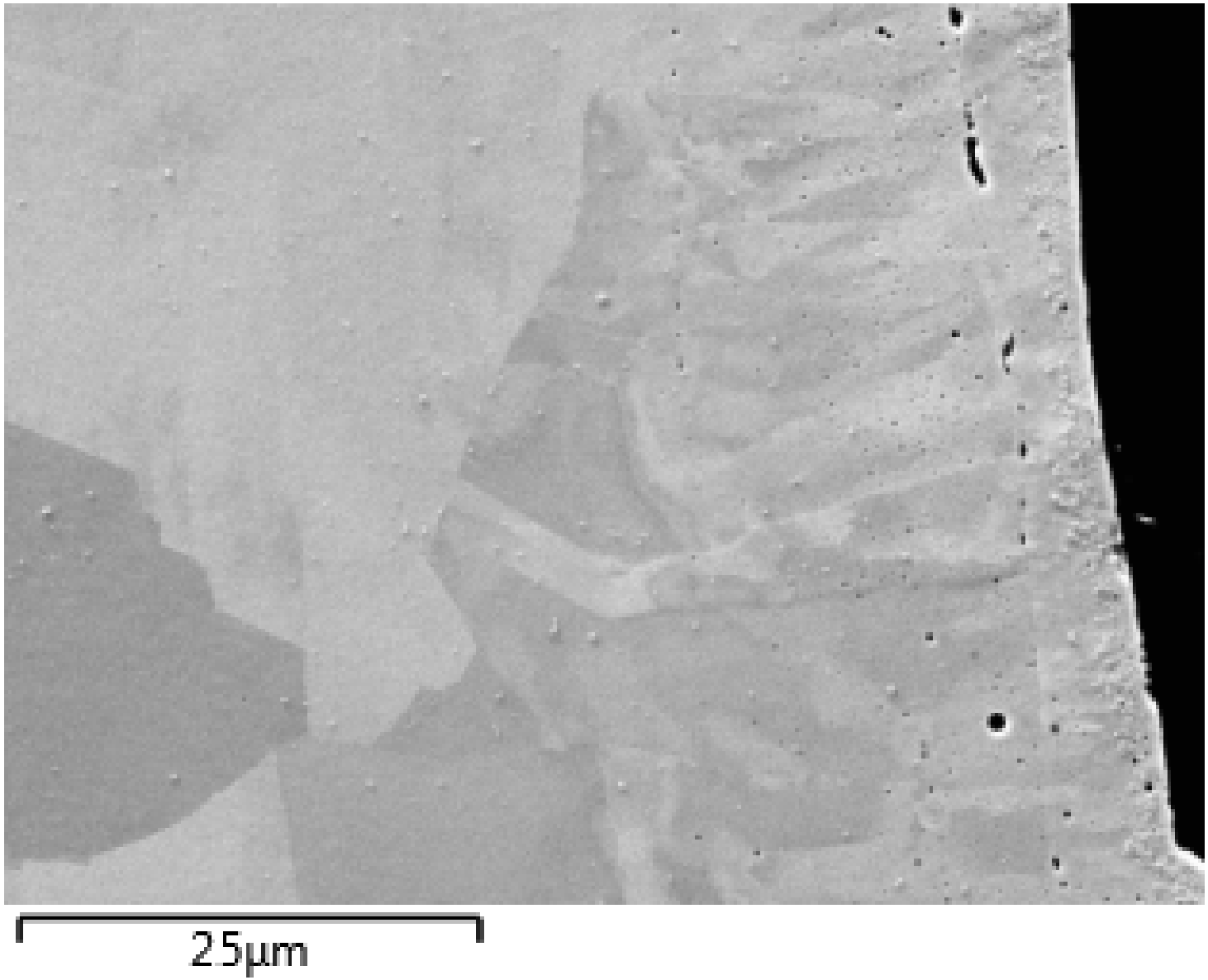
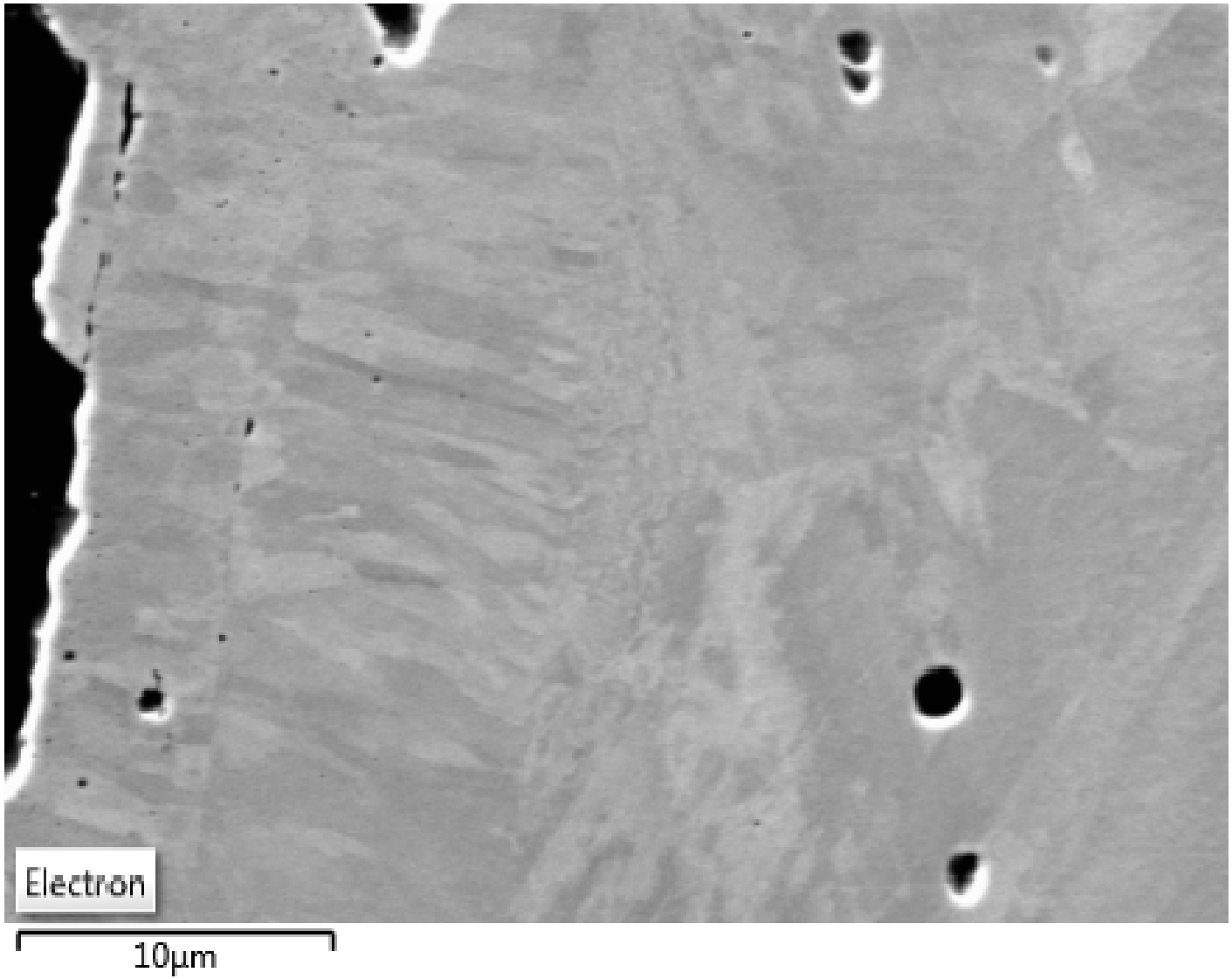
316L Deposition in Air



316L Deposition in Ar



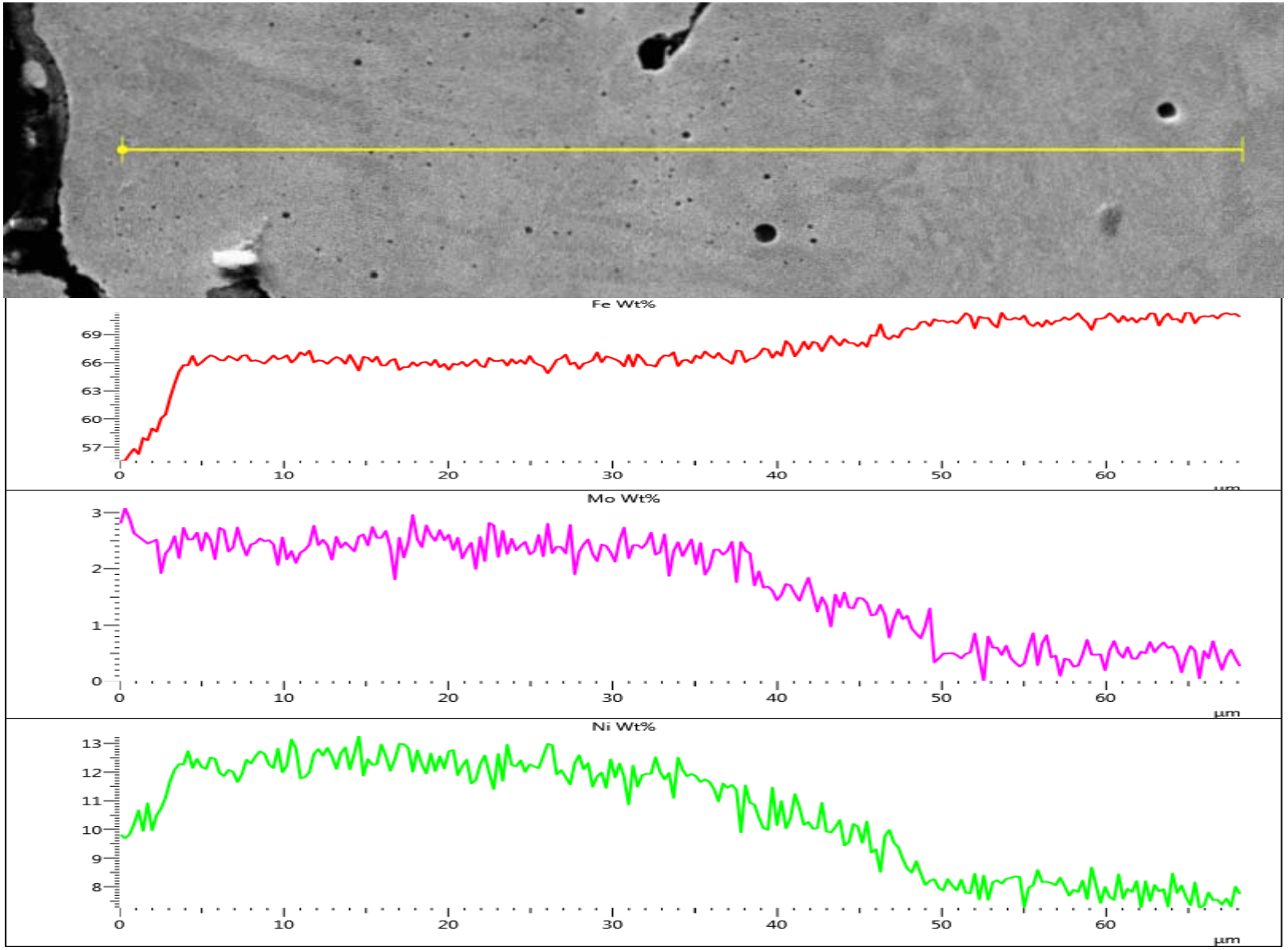
316L Deposition in Ar/H_2



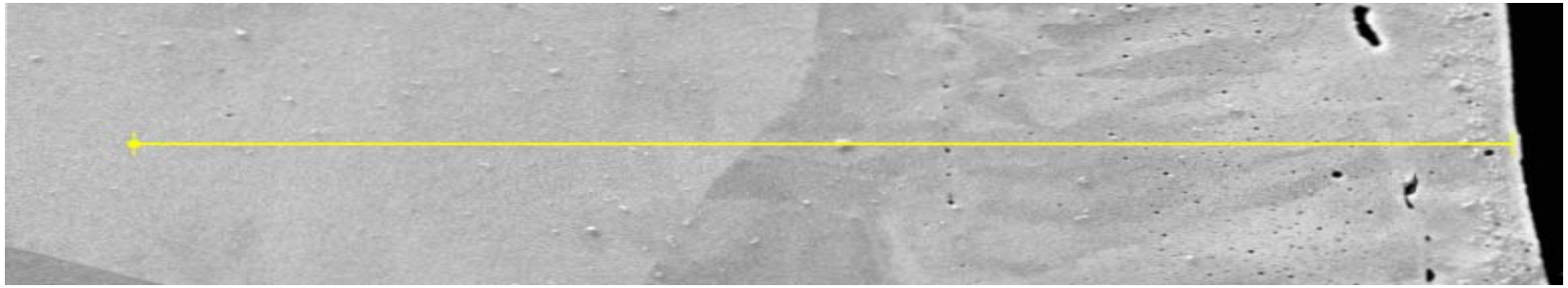
Line Scans

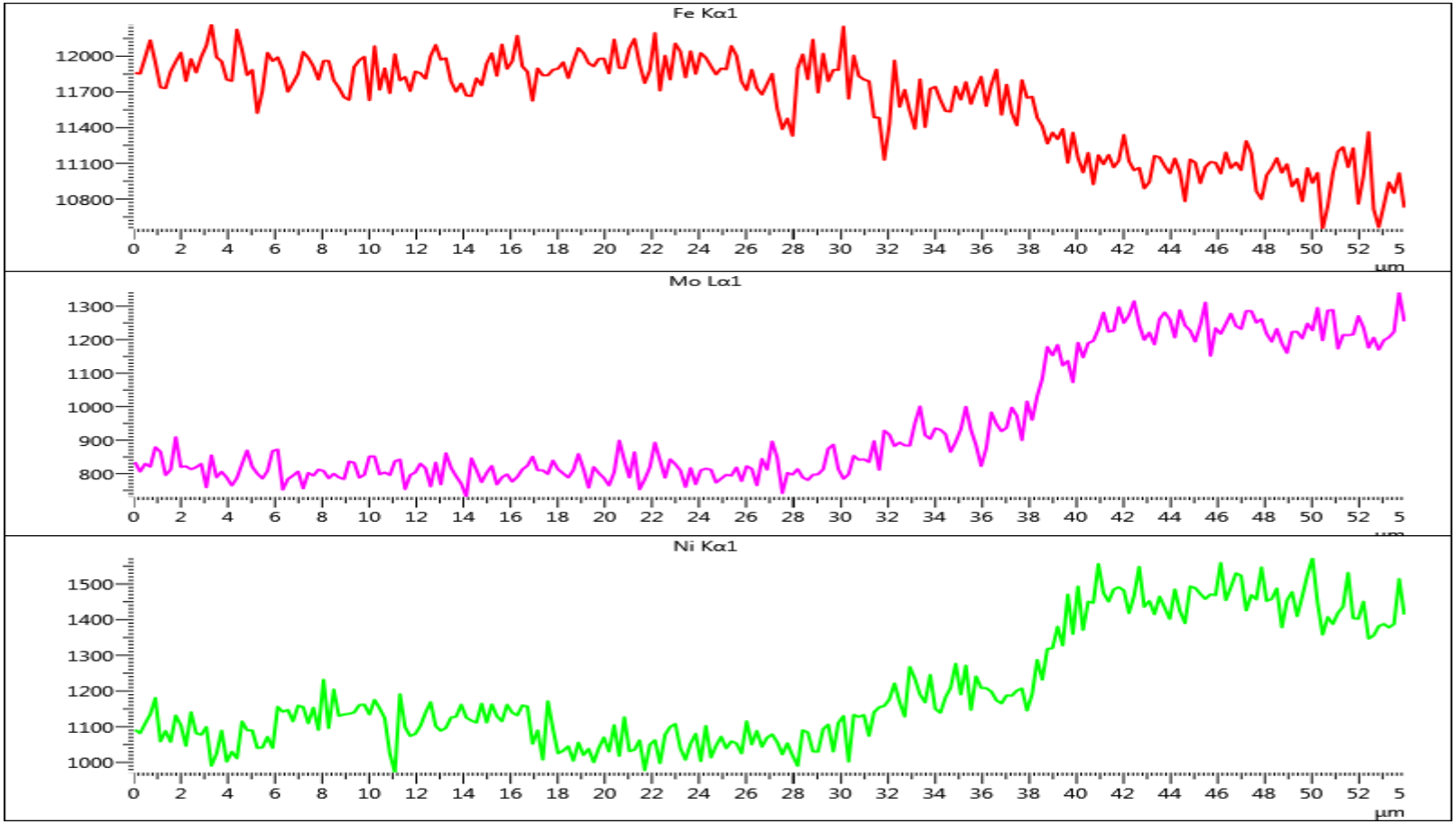
- Red: Iron
- Pink: Molybdenum
- Green: Nickle

Line Scans (Air)

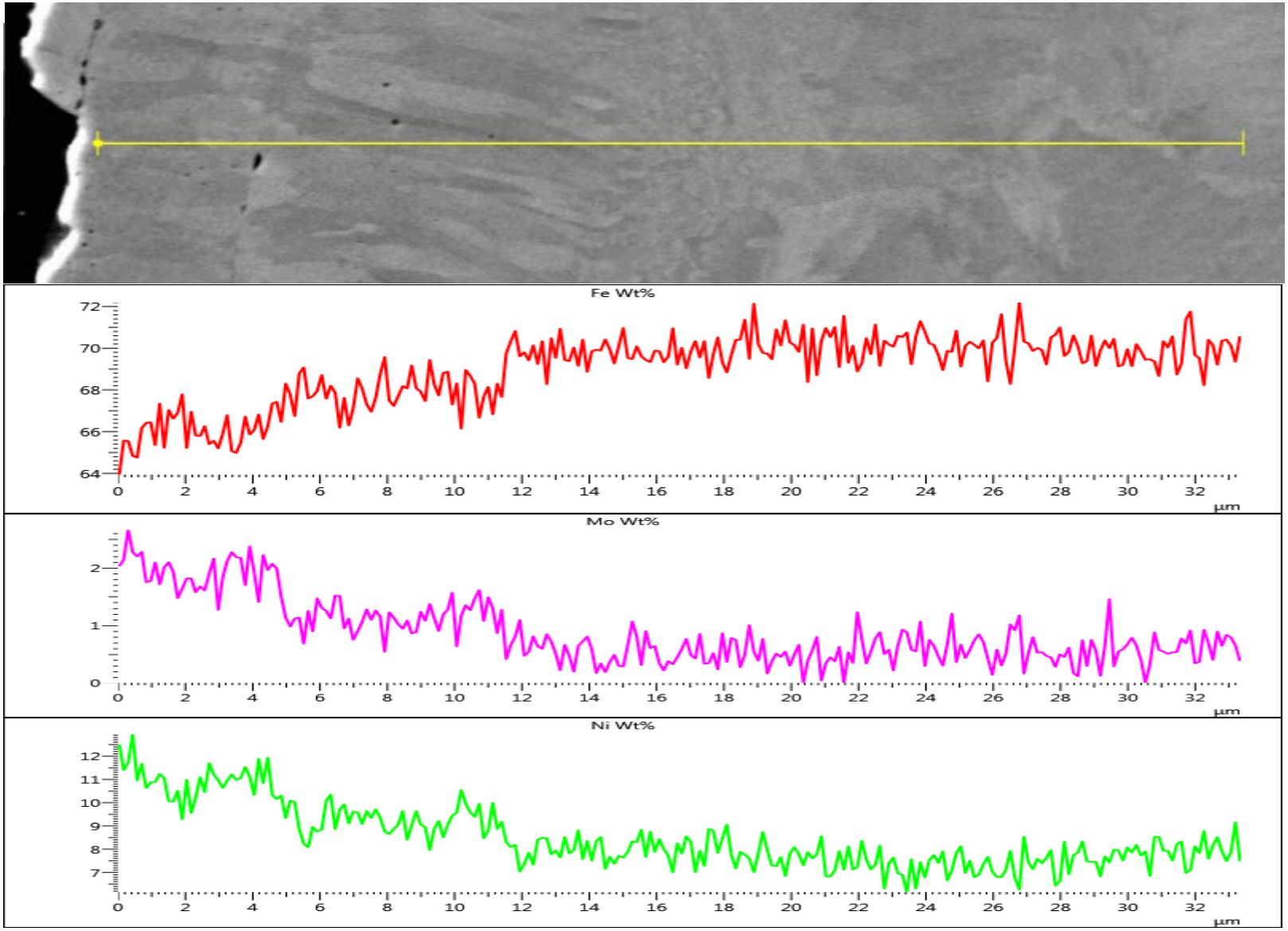


Line Scans (Ar)

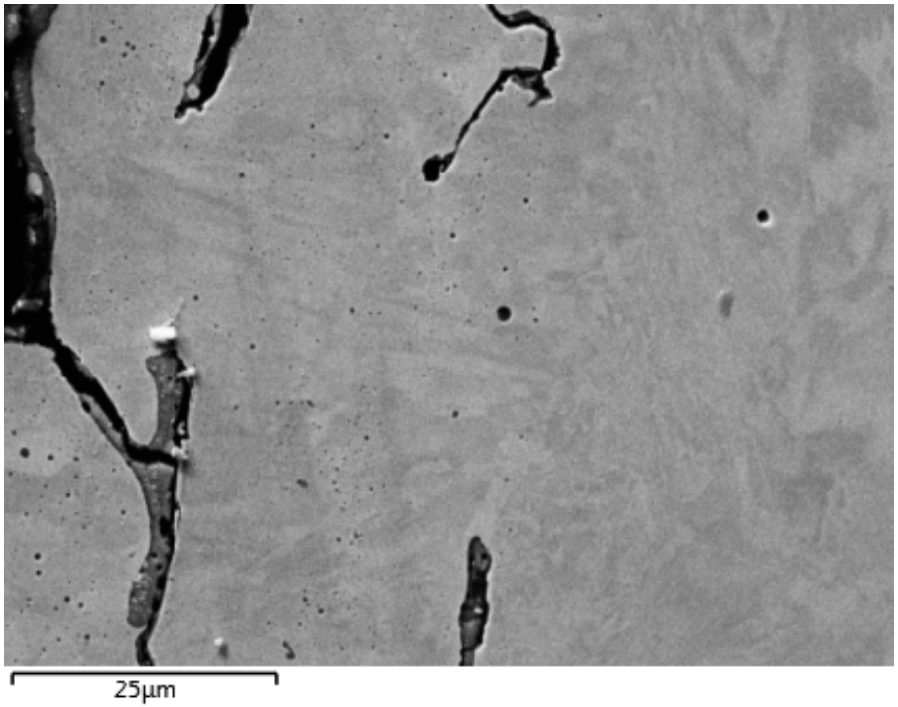


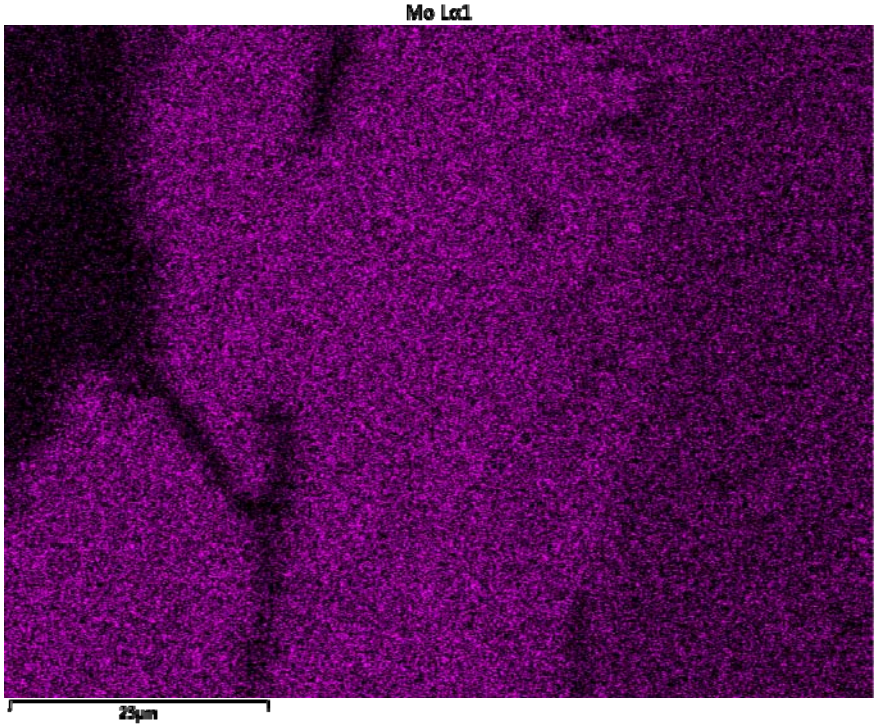


Line Scans (Ar/H_2)

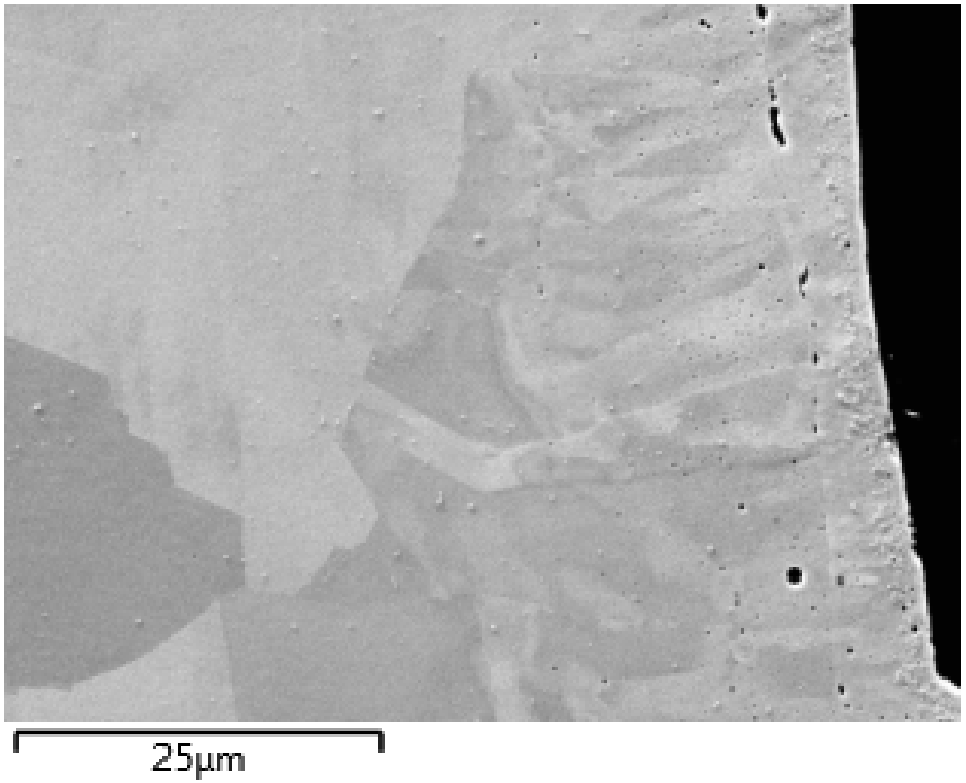


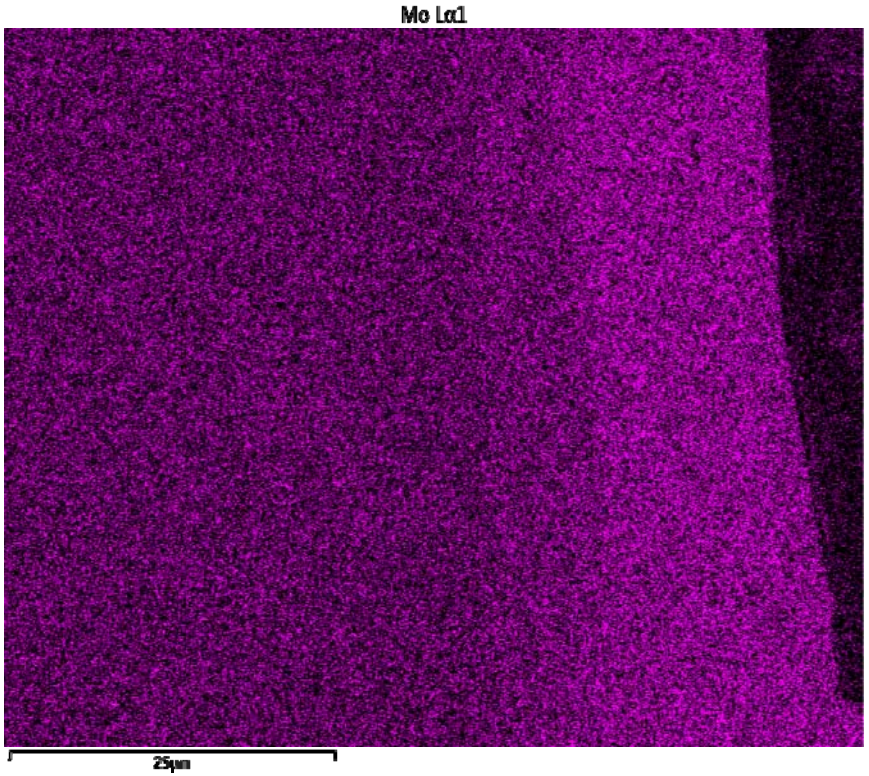
Molybdenum Mapping (Air)



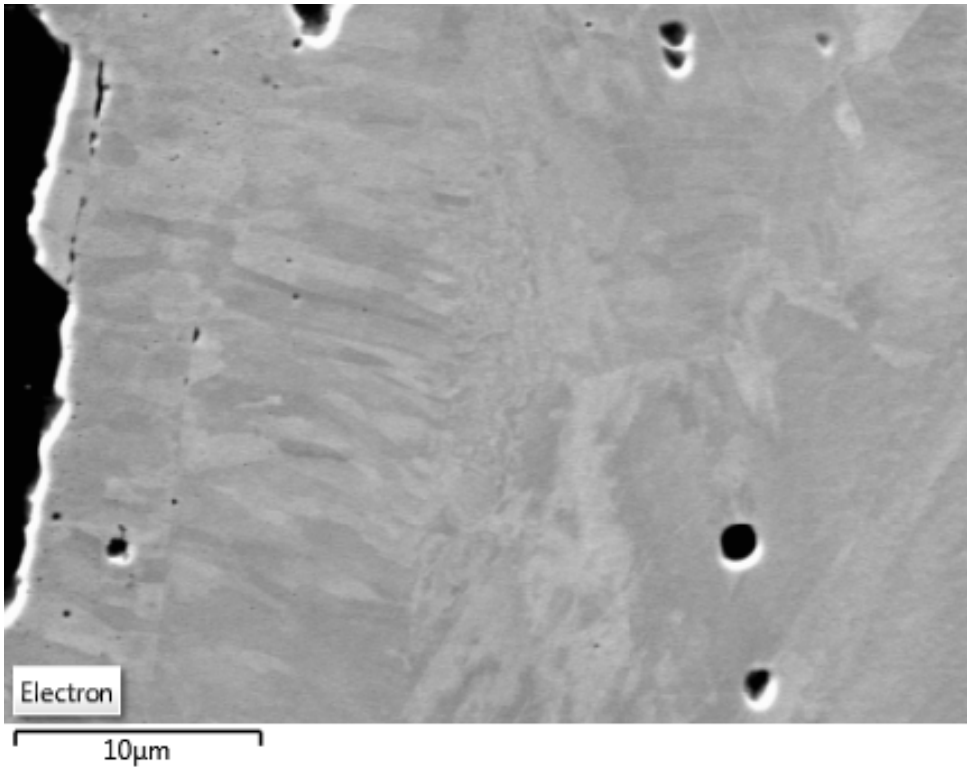


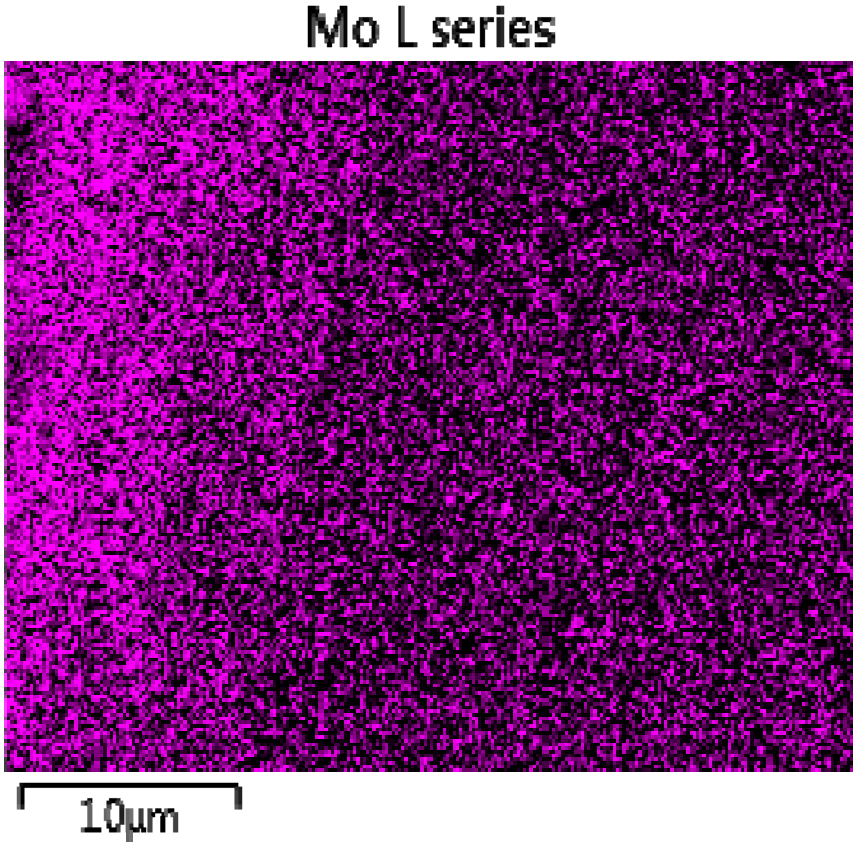
Molybdenum Mapping (Ar)



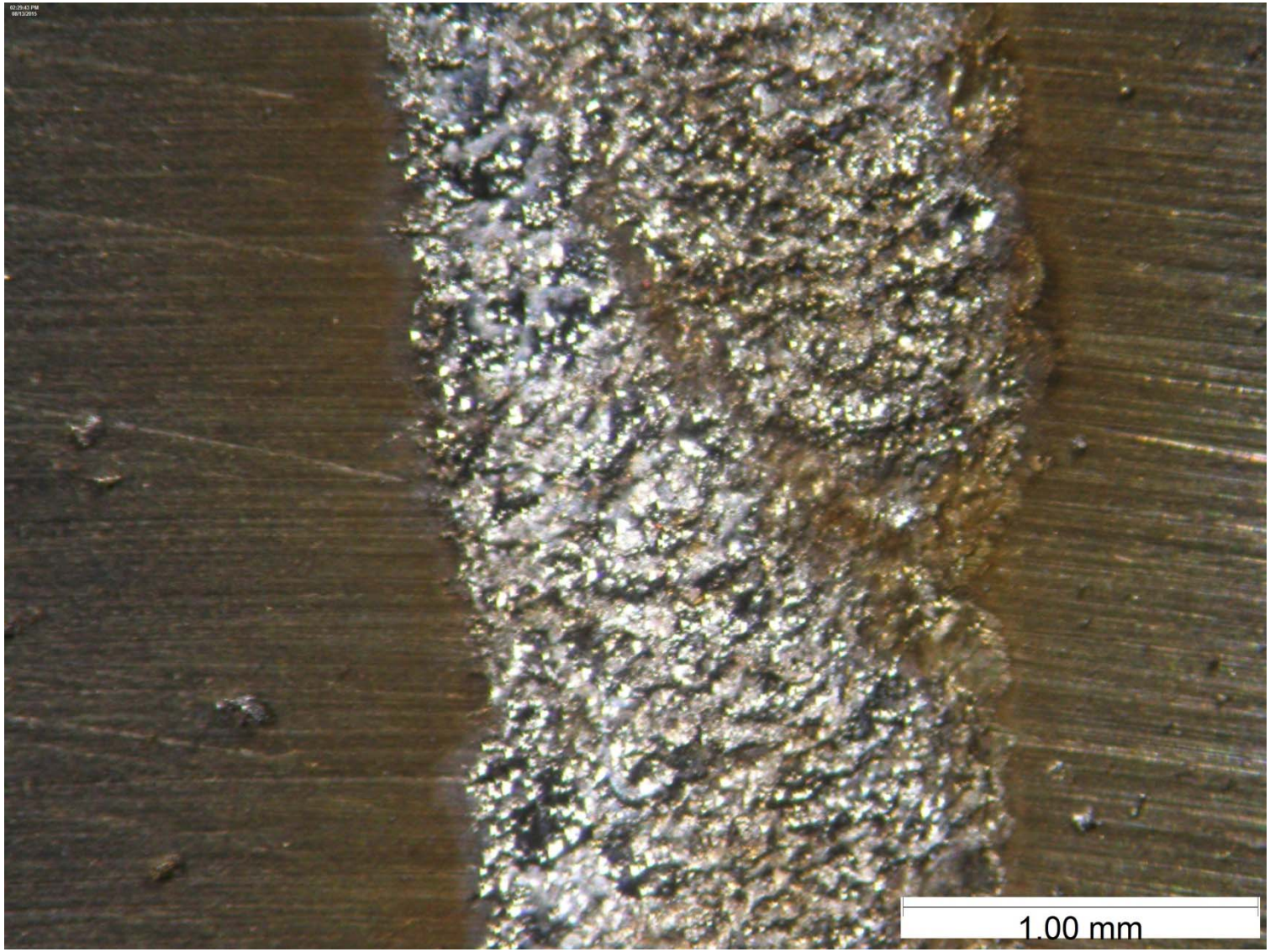


Molybdenum Mapping (Ar/H_2)

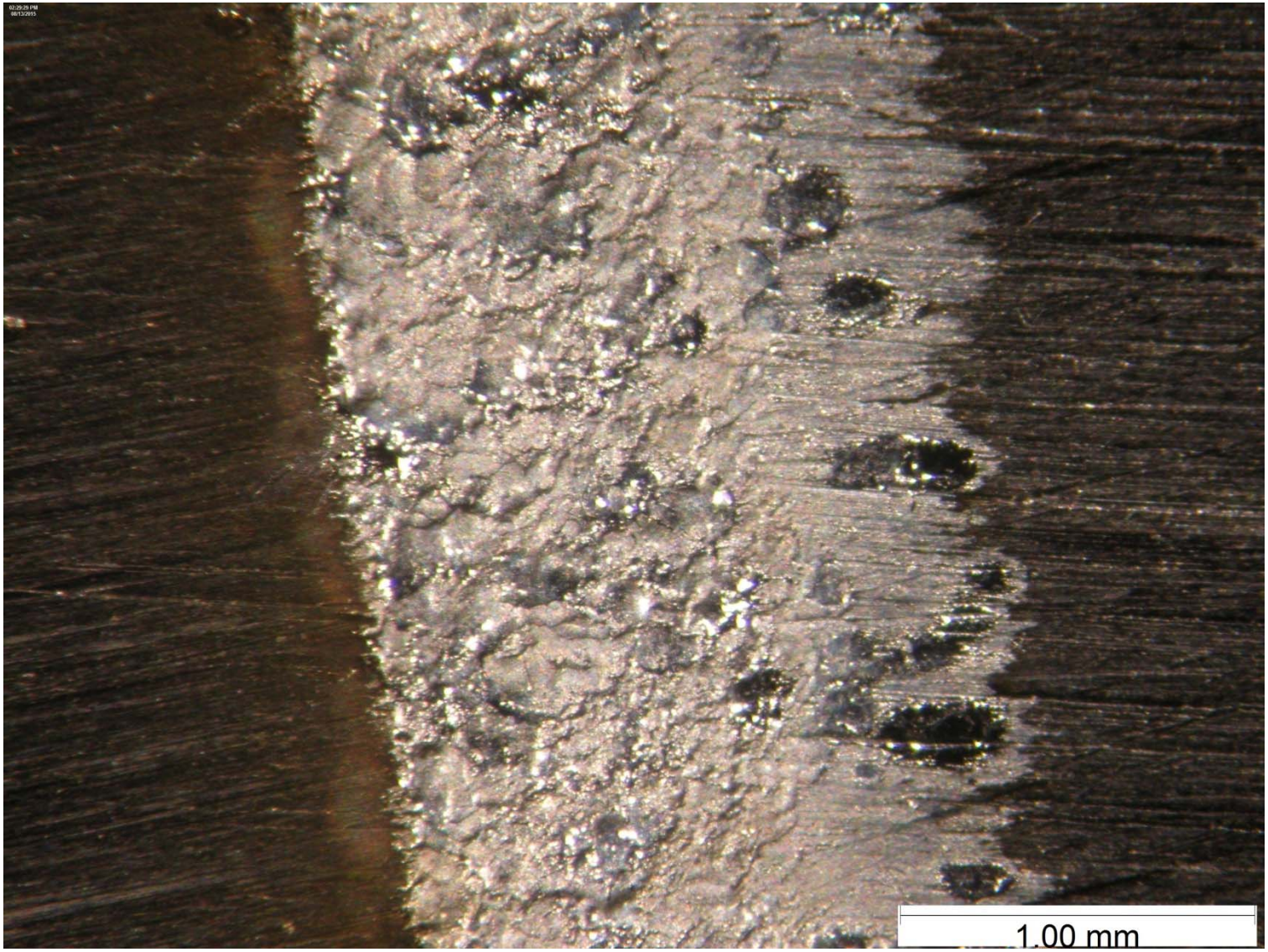




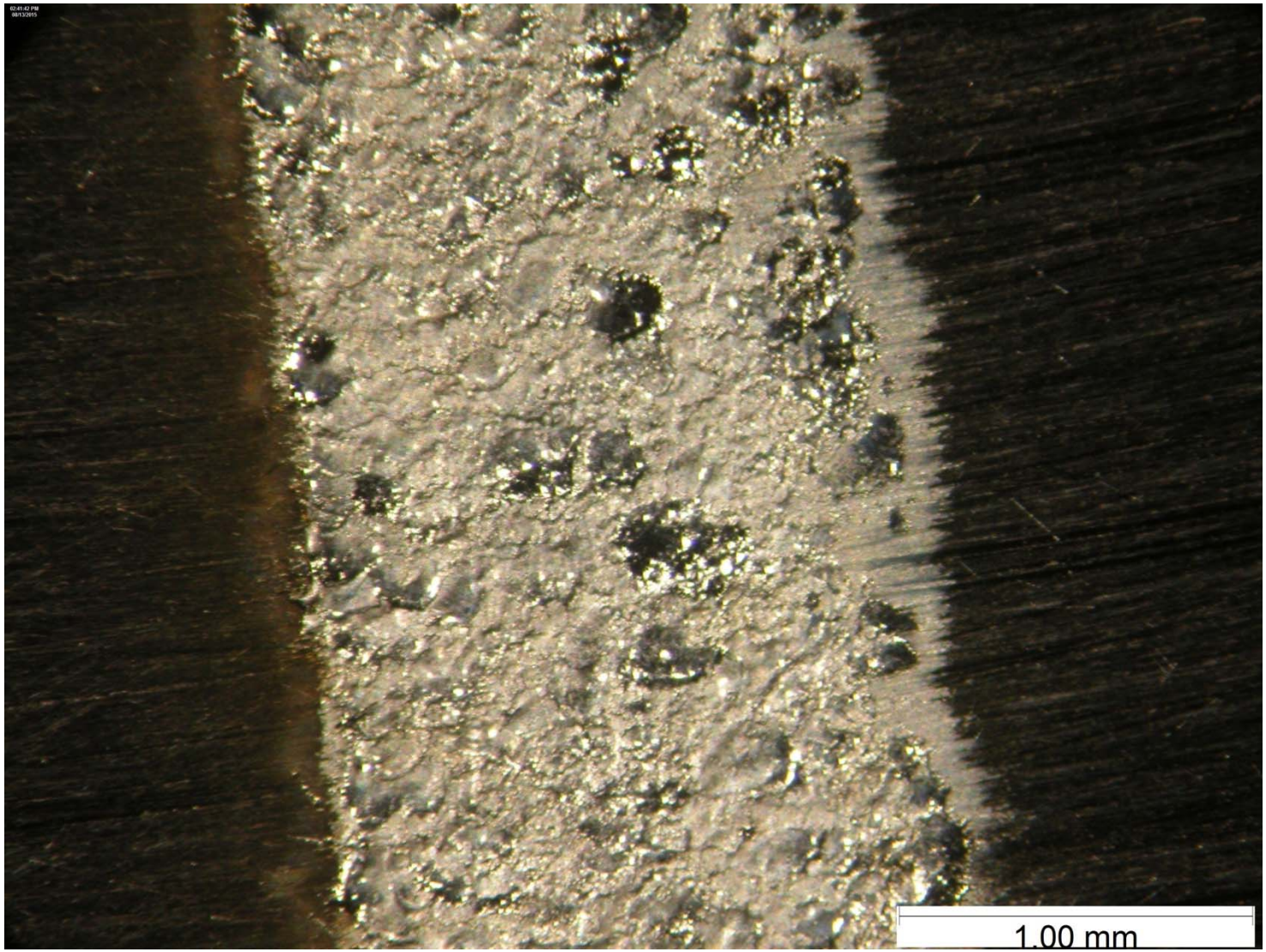
Oxides Formed in Air



Oxides Formed in Ar



Oxides Formed in Ar/H_2



Conclusion

- The effects of Hydrogen in shield gas are recordable.
- Hydrogen-Argon combines the oxidation resistance seen in Ar shield gases and, to a lesser degree, the spray transfer seen in air.
- Deposition dilution into the substrate is greater with Ar/H2 than with pure Ar and is more uniform than dilution in Air.

Further Studies

- This research is statistically unsupported.
- More Tests
- More characterization of the influence of shield gases on deposition
- Controlling more variables such as forced convection over the electrode and substrate.
- Modeling the deposition process based on an energy balance.

Thanks To:

- Help in the Lab from Bill Wood, Benjamin Adam and Neneh Switalla
- Jun Jiao, Erik Sanchez and Ellen Bradley
- PSU REU Program