LANL High Temperature Moderator update

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Work package consists of 4 main areas

- Updates to advanced moderator material handbook
- Hydrogen permeation measurements
- Neutron imaging measurements
- Cladding studies

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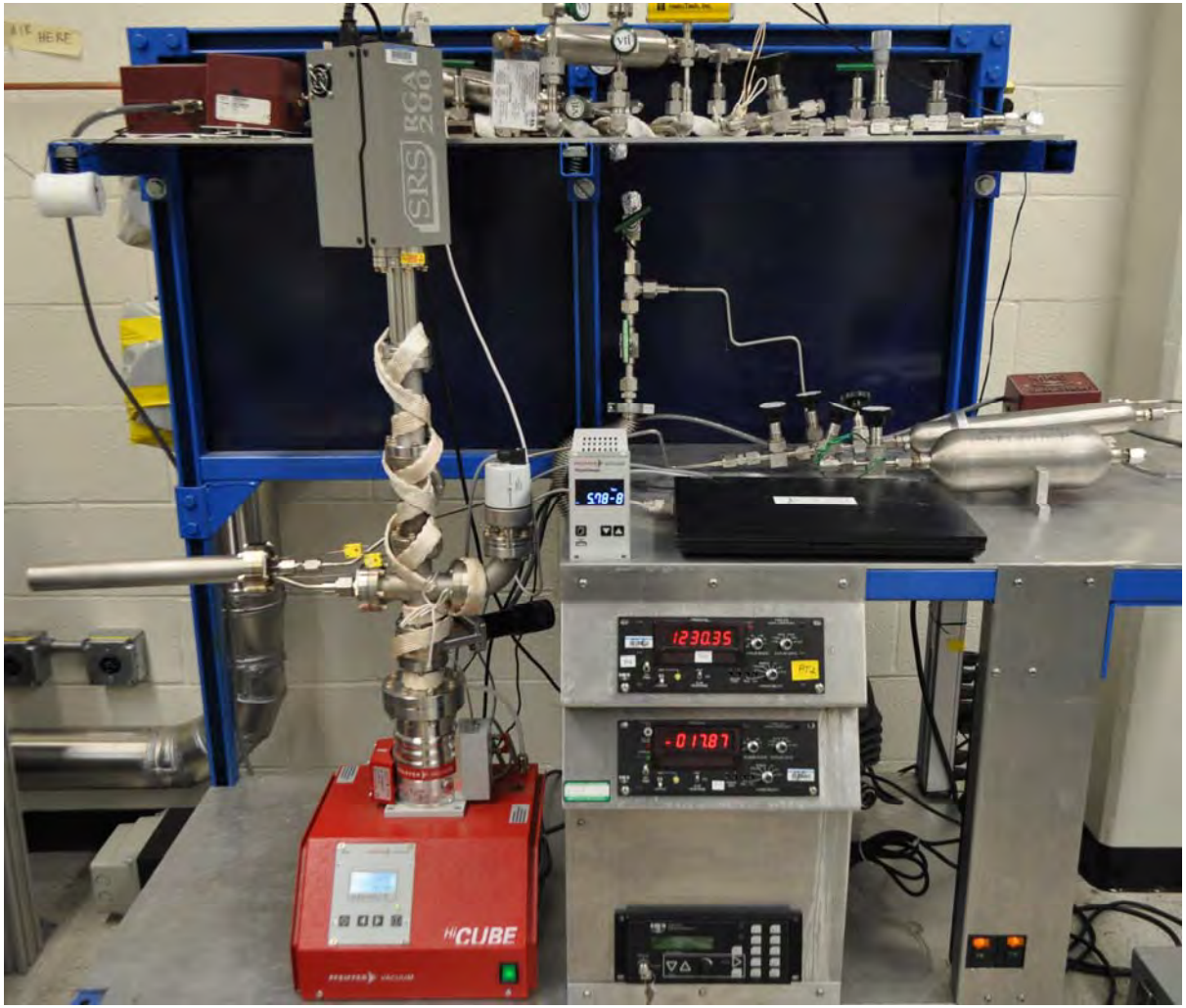
Fabrication and testing of coated cladding materials for hydrogen containment



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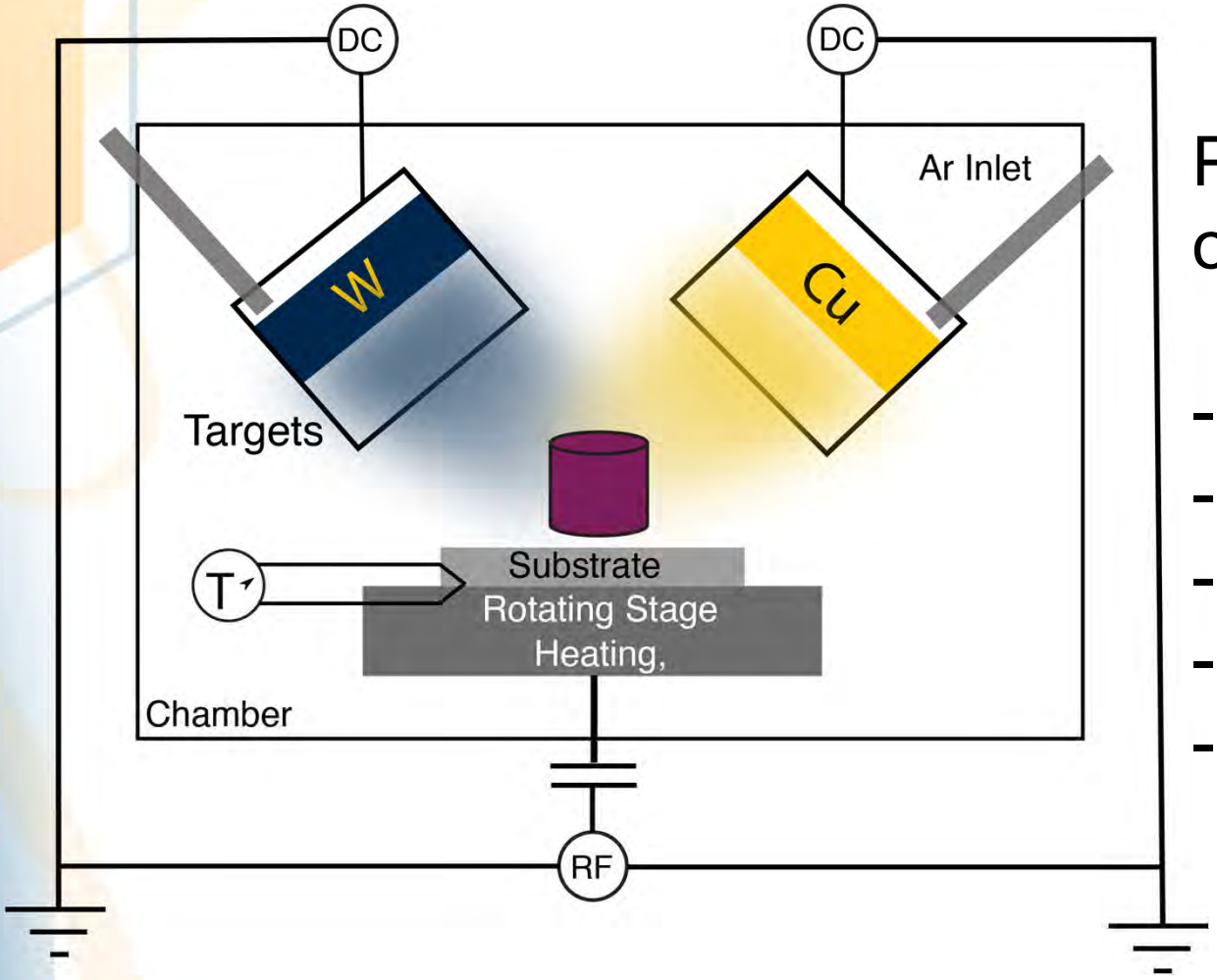
Permeability testing of moderator cladding materials



PVD allows for the control over microstructural:

- Shape
- Spacing
- Crystallography, Texture
- Defect structure
- Chemistry

Figure courtesy of B. Derby, LANL

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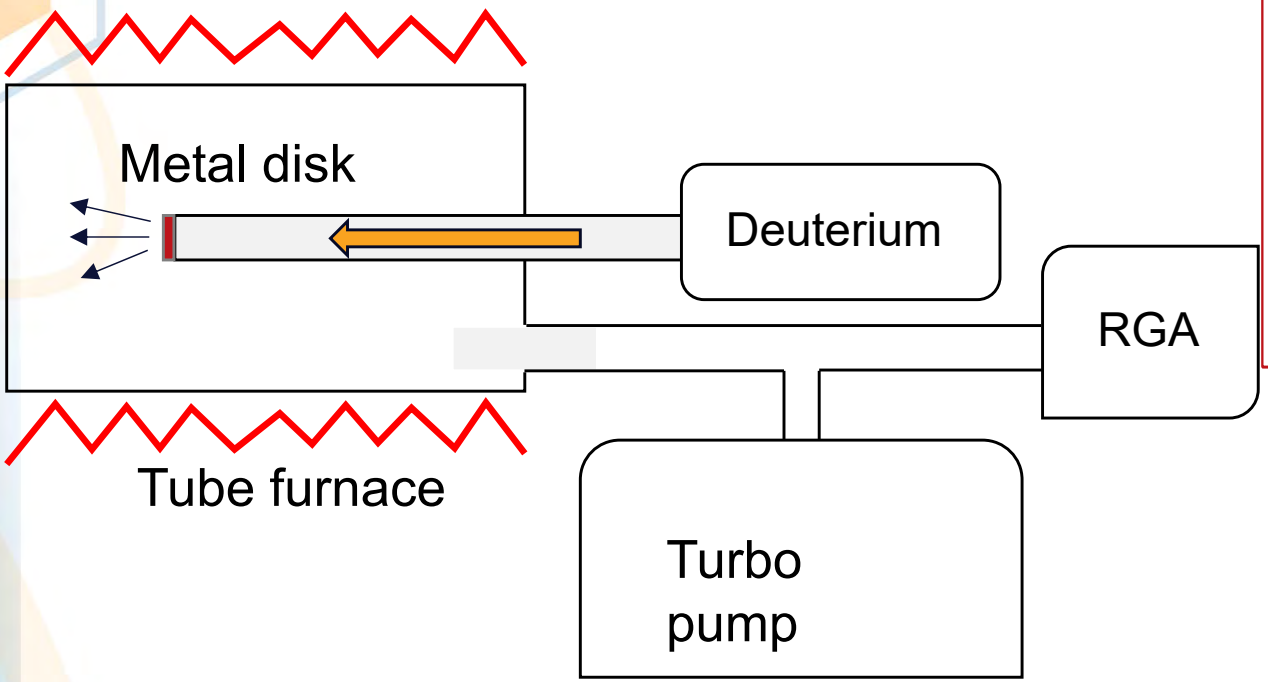
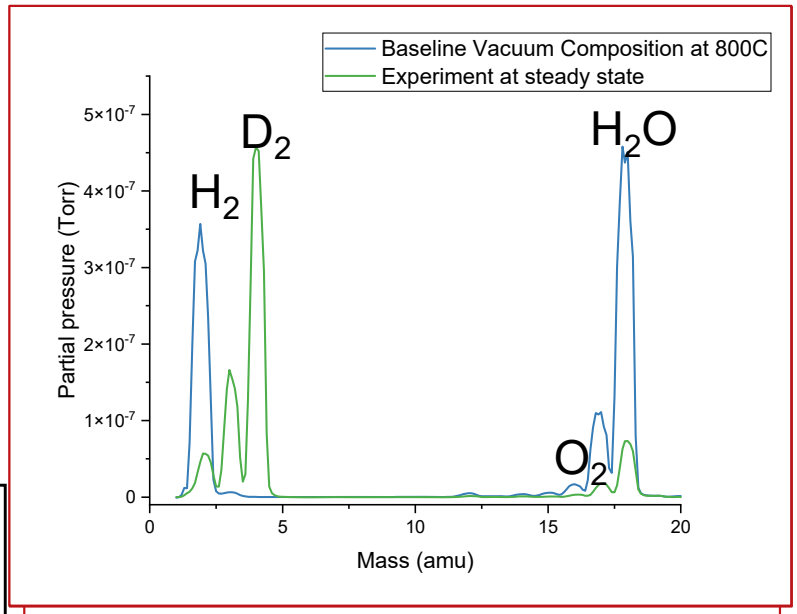
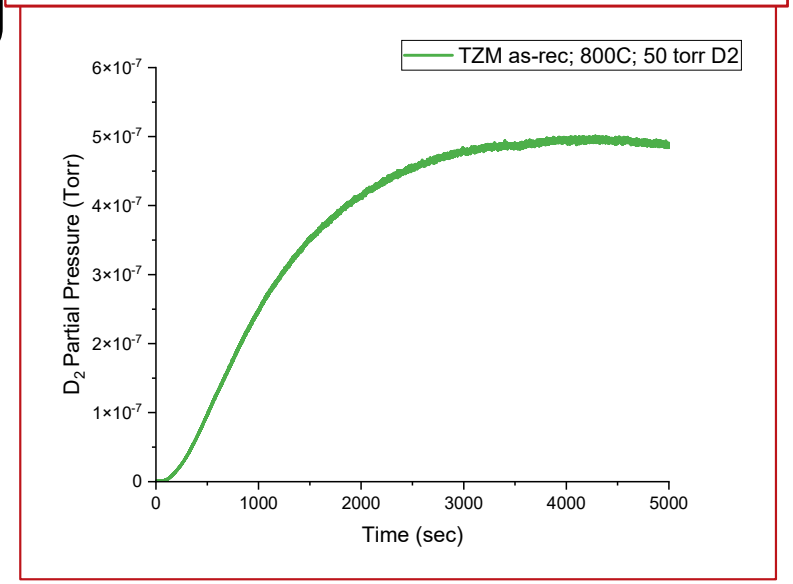
Hydrogen permeability is measured through candidate materials by measuring the D2 flux through a sample







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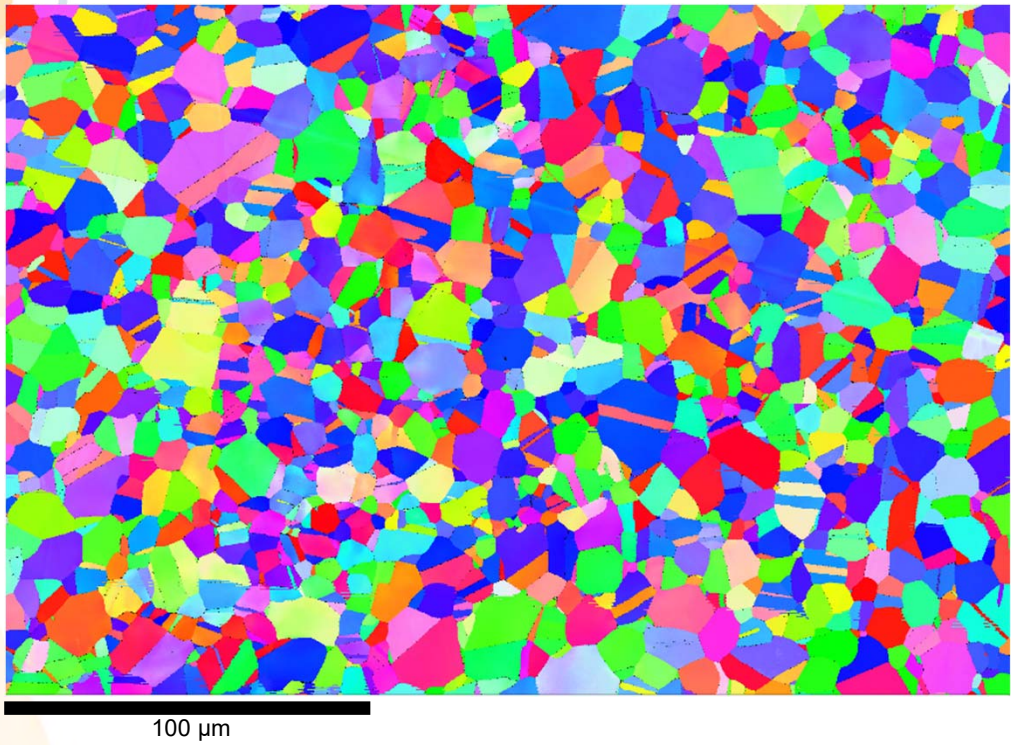
Microstructural characterization of SS316L Swagelok blind gaskets



- Basic microstructural characterization of SS316L Swagelok blind gasket (cross-sec)
- Electron Backscatter Diffraction (EBSD) grain map shows equiaxed grain structure

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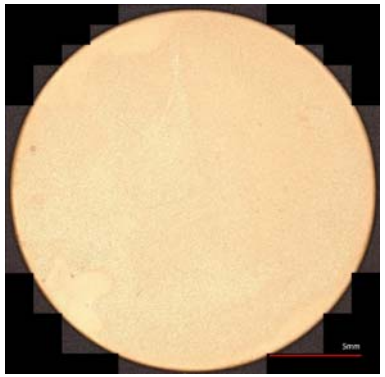
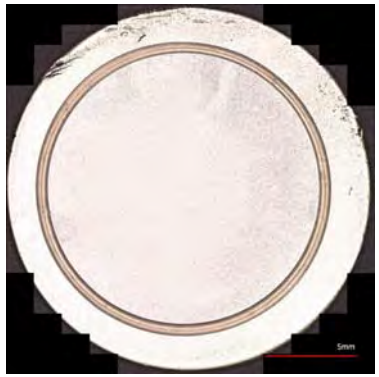
Gold electroplating appears to reduce the H permeability of 316L SS

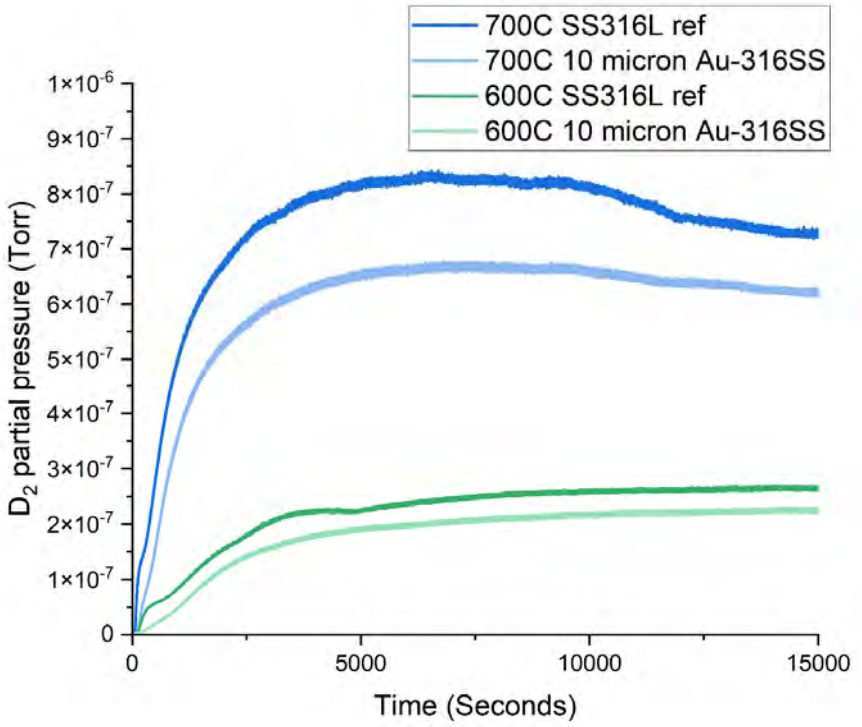
- 10 μm gold electroplated SS showed a minor improvement in performance.
  - Both sides electroplated with 10 μm gold (20 μm total).
- Gold plating changed color during measurement
  - Alloy with Ni-strike layer at elevated temperatures



Before



After



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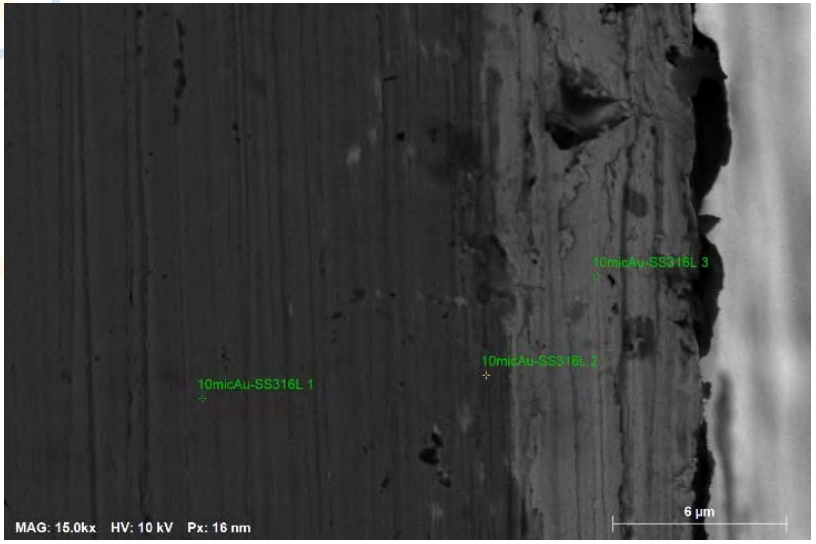
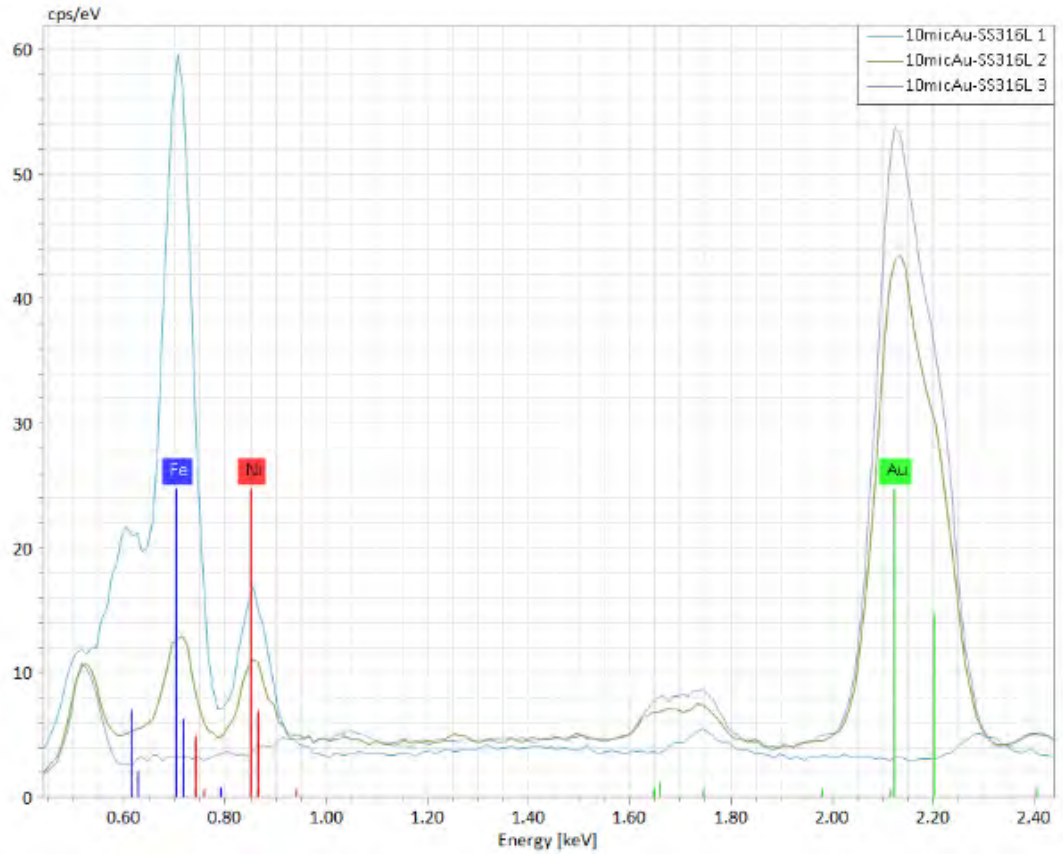
Post-mortem characterization gold electroplated SS sample showed microstructural change with permeability testing



- Gold layer thickness changed with processing



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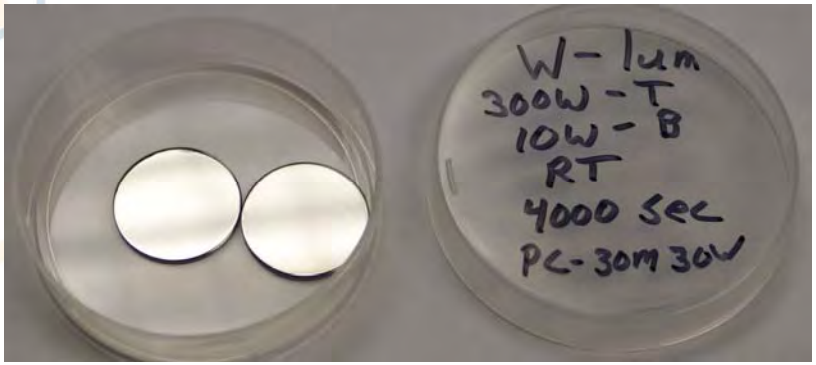
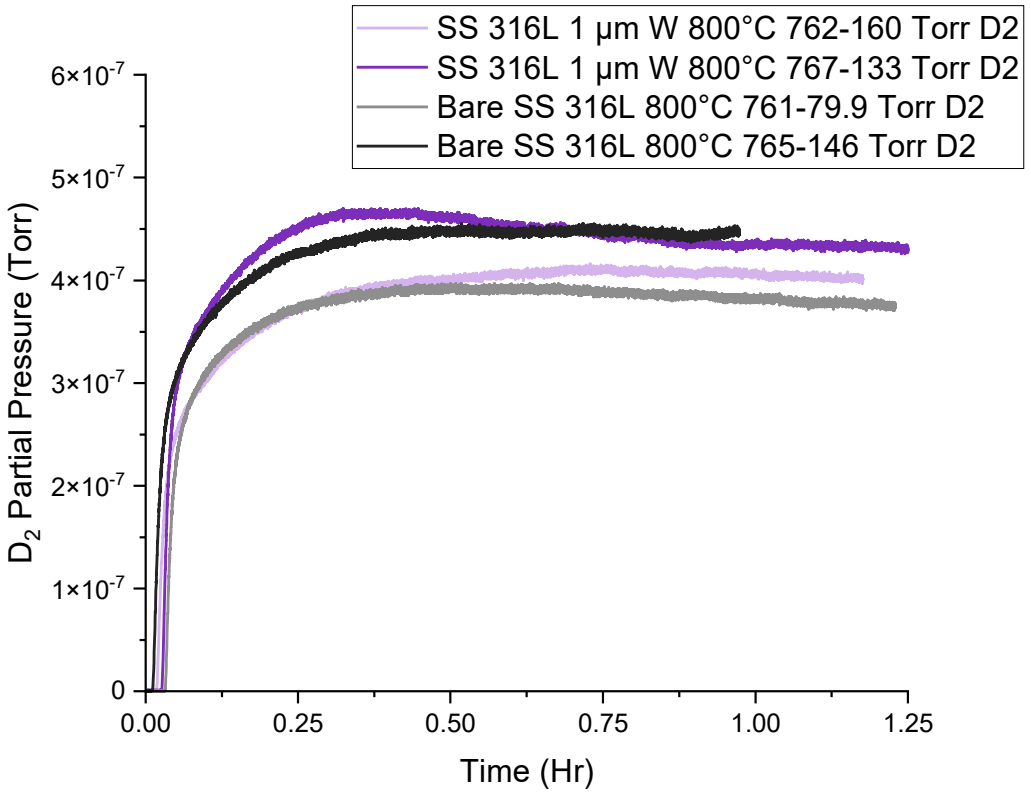
Permeability testing of W-coated (PVD) 316L showed no significant improvement over 316L

1-µm W coating on 316L



H2 permeation test of coated and uncoated 316L



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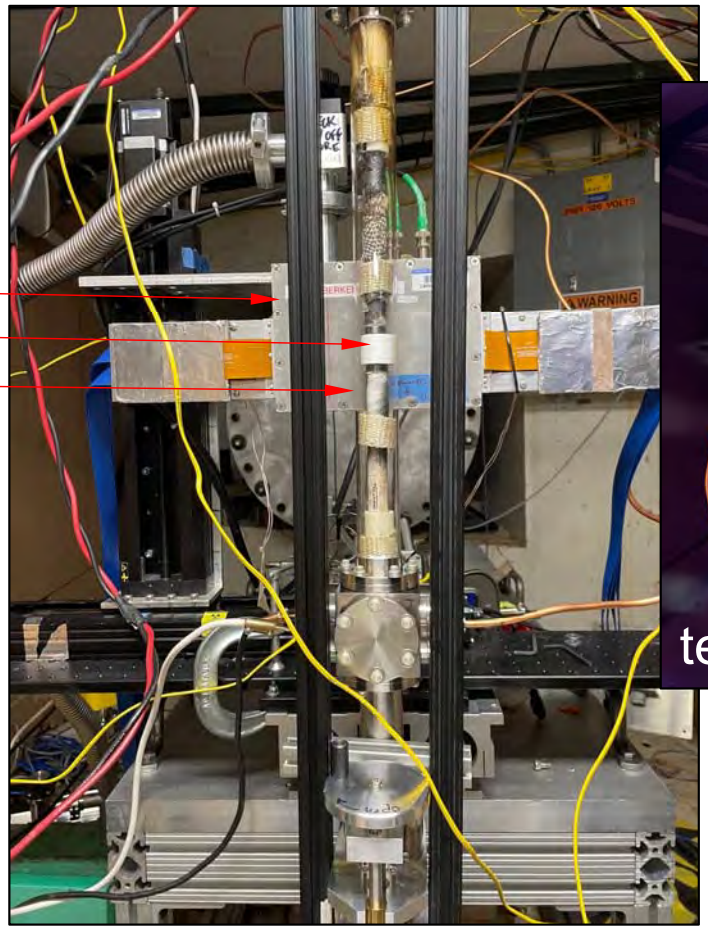
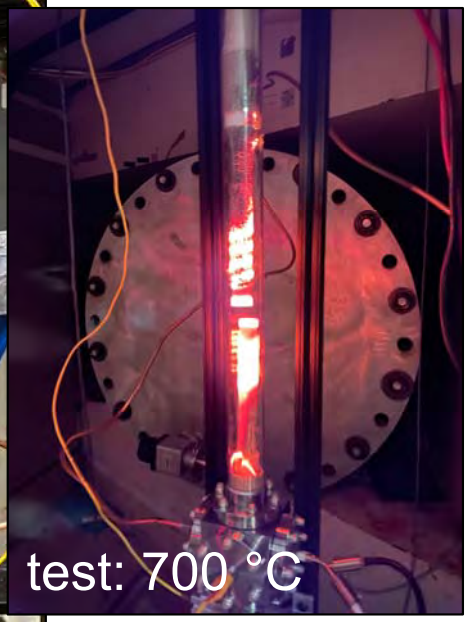
Neutron imaging: furnace and setup at Los Alamos Neutron SCience Center (LANSCE) flight path 5 (FP-5)

- Assembled the *upgraded* compact dual-zone furnace at FP-5 thermal imaging beamline…
  - MCP/Timepix detector
  - Sample (in insulation)
  - Quartz tube (on furnace)
- Upgrades:
  - S-bond ® quartz-to-metal tube seal, plus…
  - ConFlat seals → leak tight
  - Linear motion device → variable sample length
  - Modular design (gas, thermometry, etc.)
- Performed gas flow and heating tests.





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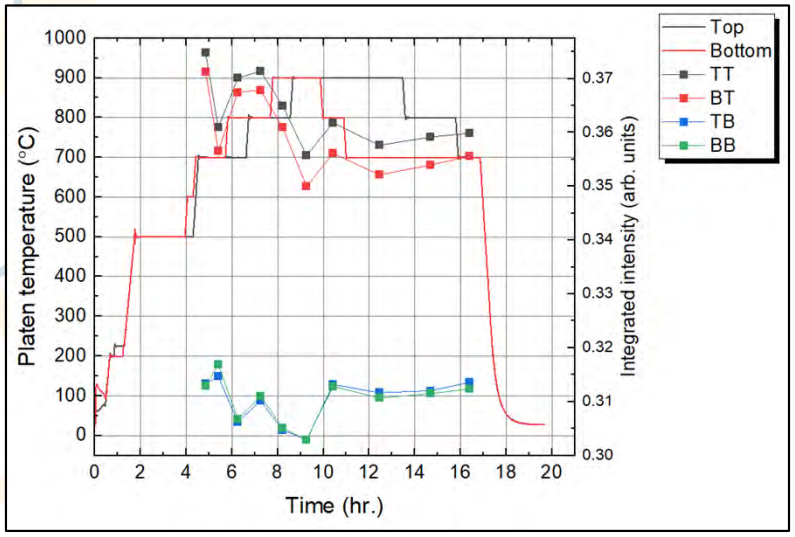
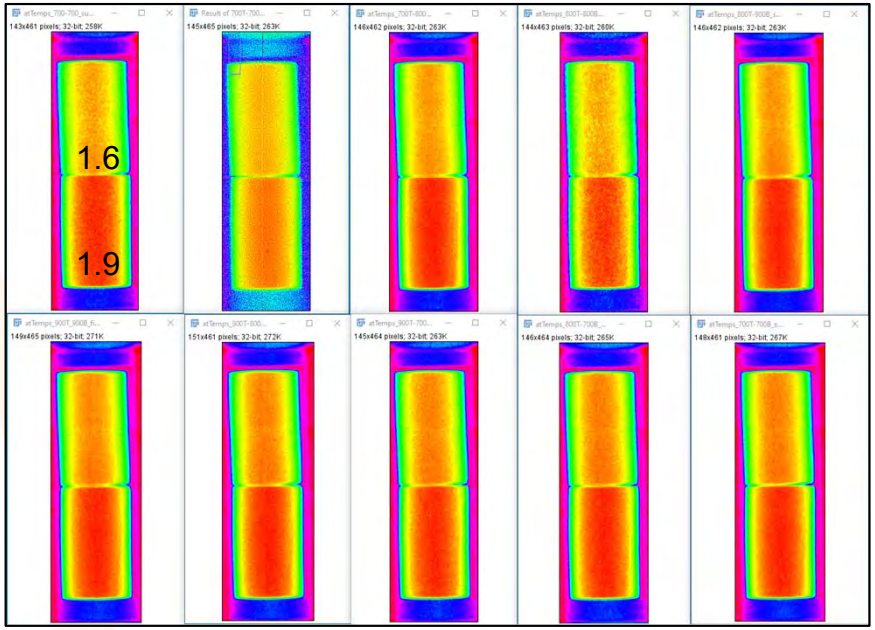
Neutron imaging: day 1 - YH_x stack





Red → High H neutron attenuation
Blue → Low H neutron attenuation

- A stack of two YH_x samples (x = 1.6 and 1.9) in a TZM can.
- Apply various temperatures, both isothermally (e.g., 700 top and 700 bottom) or with a gradient (e.g., 700 top and 800 bottom).
  - Gradients between 100 and 200 °C (controlled)
- Image corrections need to be applied
- Analysis is ongoing

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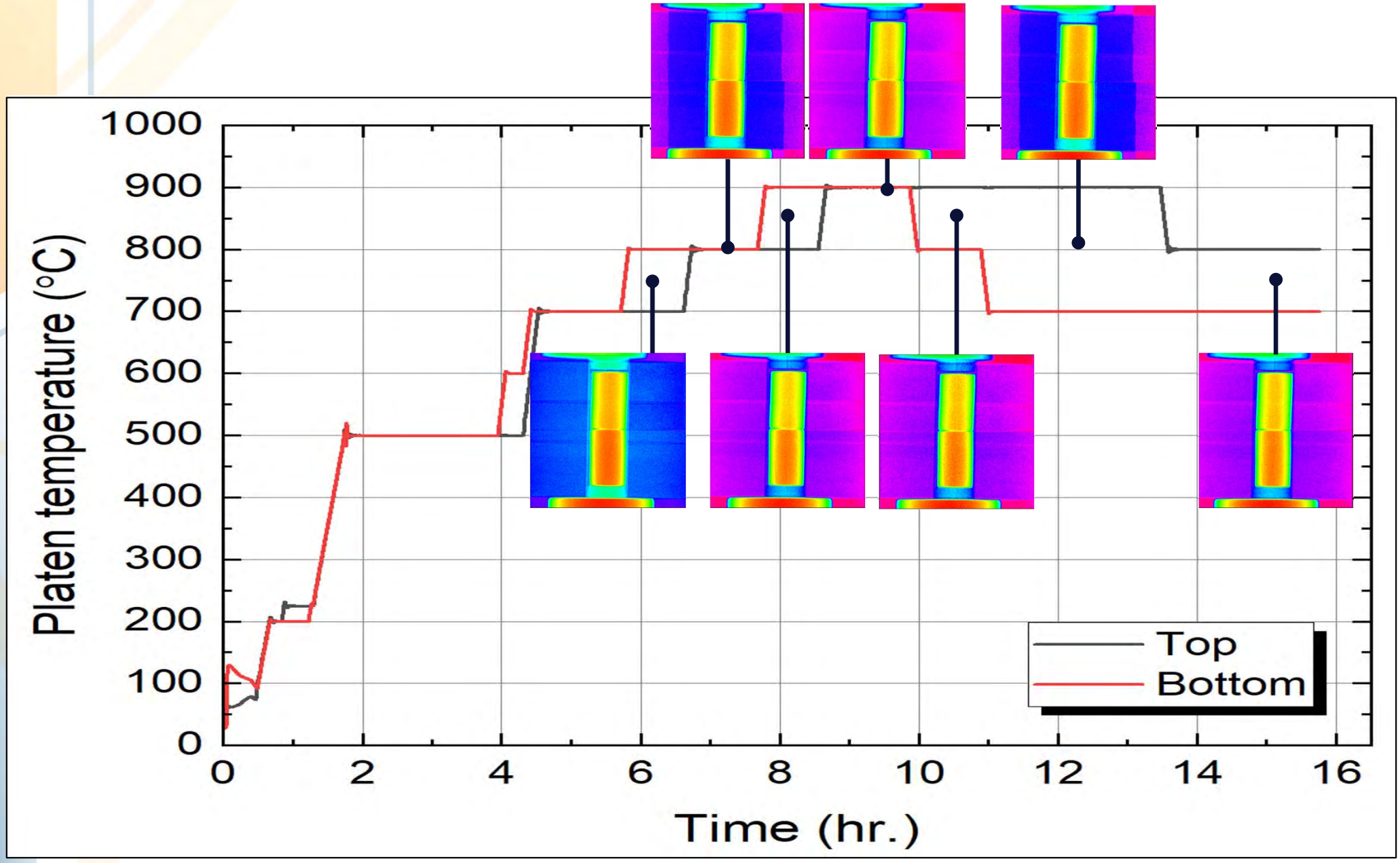

Red → High H neutron attenuation
Blue → Low H neutron attenuation

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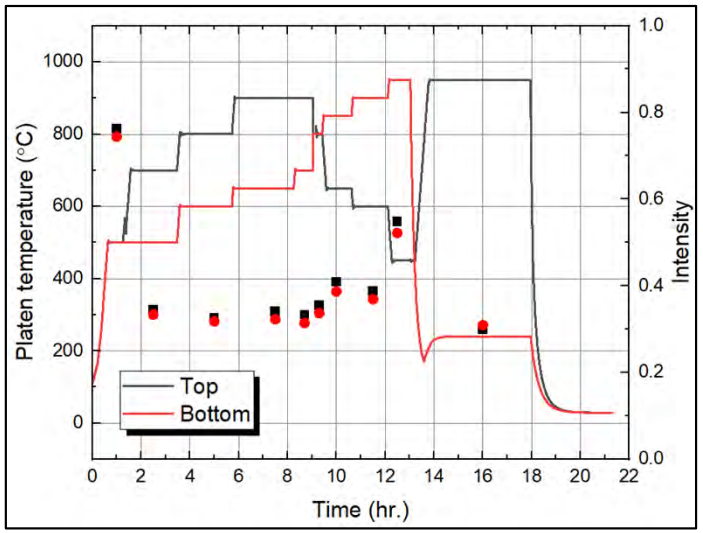
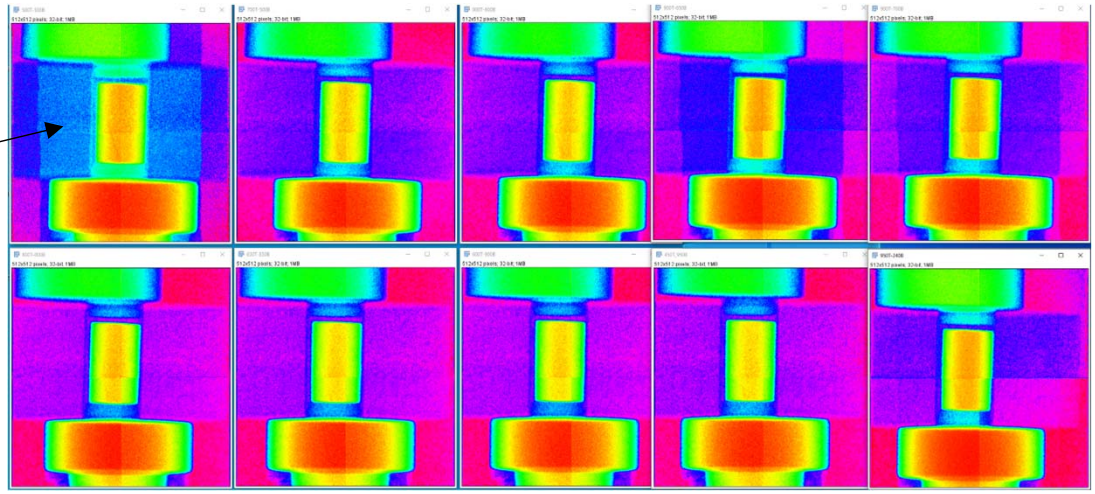
Neutron imaging: day 2 - $YH_{1.6}$

- A $YH_{1.6}$ pellet in a TZM can.
- Apply various temperatures, both isothermally or with a gradient.
  - Gradients between 50 and 500 °C (controlled)
- Image corrections need to be applied
- Analysis ongoing





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Neutron imaging current status

- Finish image analysis.
- Work with modeling expert(s) to simulate H concentration using experimental data – understand (null) results.
- Build a back-up furnace for future measurements.
- Secured beam time at ORNL to perform quasi-elastic neutron scattering measurements on YH_x powder: a capability that provides the self-diffusion coefficient of hydrogen at high temperatures.
  - Designing two different samples cells for safety and neutron transparency: quartz and TZM.
  - Beam time August 2-8, 2023.
  - Time allotted for 2 different samples, e.g., $YH_{1.6}$ and $YH_{1.9}$.
- Discussing feasibility of performing neutron imaging at the University of Missouri.
  - Back-up to Lujan.
  - Test hardware and/or technique.
  - Networking and collaboration; MURR seeks to construct an imaging station.

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FY23 milestones

1. M4AT-23LA0804031-Fabricate and test coated cladding materials for hydrogen containment of hydride moderators
   - Due March 1st, 2023 – on track
2. M4AT-23LA0804033-Measure hydrogen loss and redistribution from YH measured by neutron imaging
   - Due March 31st, 2023 – on track
3. M3AT-23LA0804032-Complete report of hydrogen mapping and dynamics in YH characterized by neutron imaging methods
   - Due end of FY
   - Impacted by loss of neutron beam time at LANSCE
   - Will pursue other neutron beamlines to complete
4. M3AT-23LA0804034-Update advanced moderator material handbook
   - Due end of FY – on track pending PIE from INL

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