

The Analytical Science Group @ GRC

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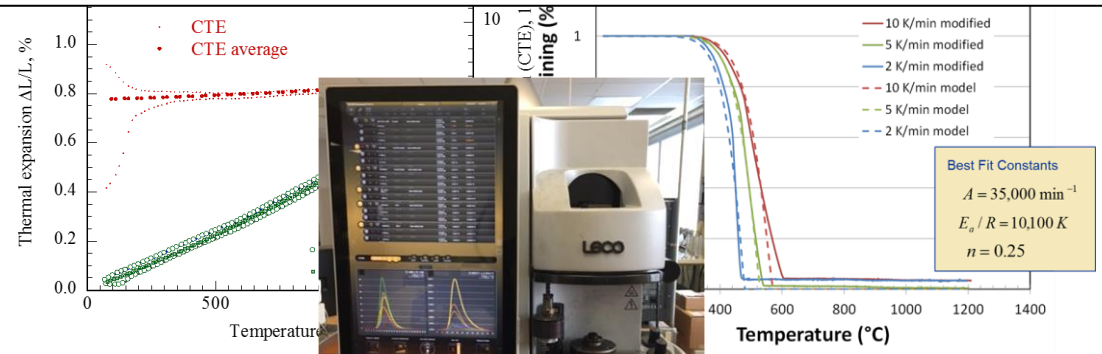
April 18-19, 2024



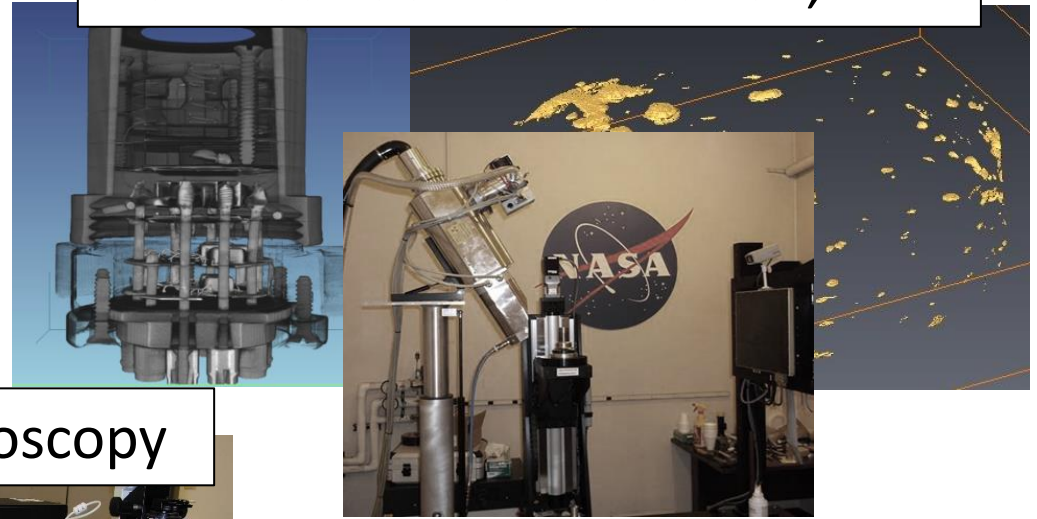
Analytical Science Group



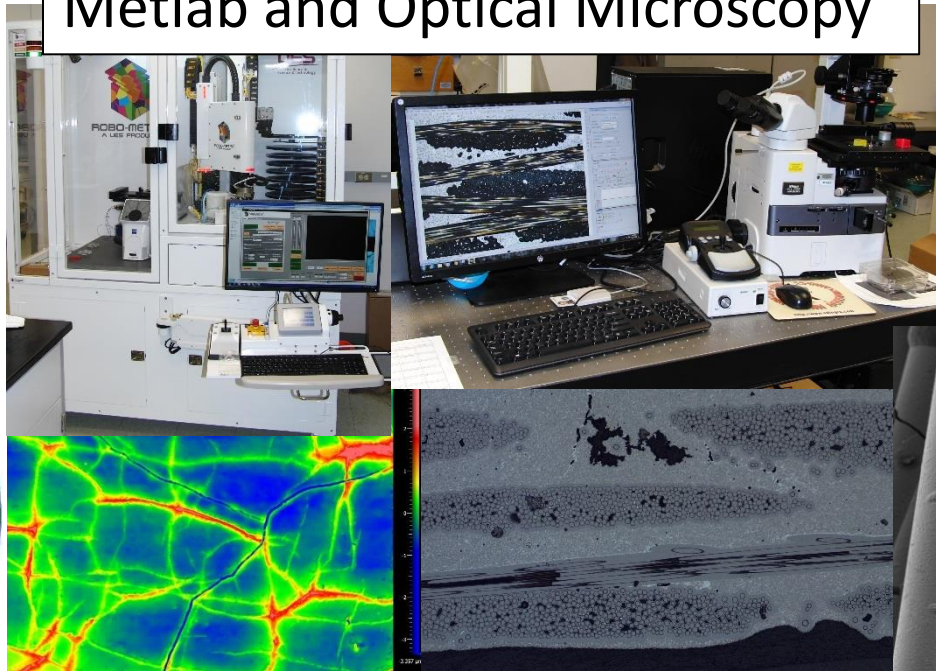
Analytical Chemistry and Thermal Analysis



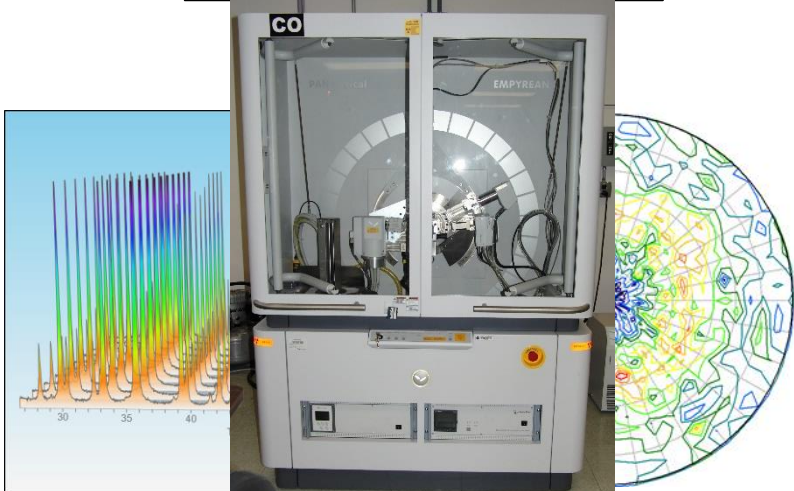
Non-Destructive Evaluation, NDE



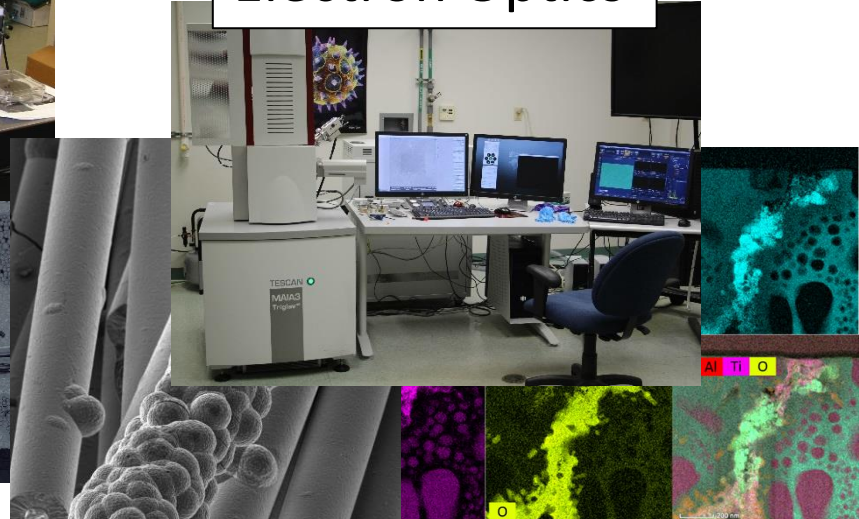
Metlab and Optical Microscopy



X-Ray Diffraction

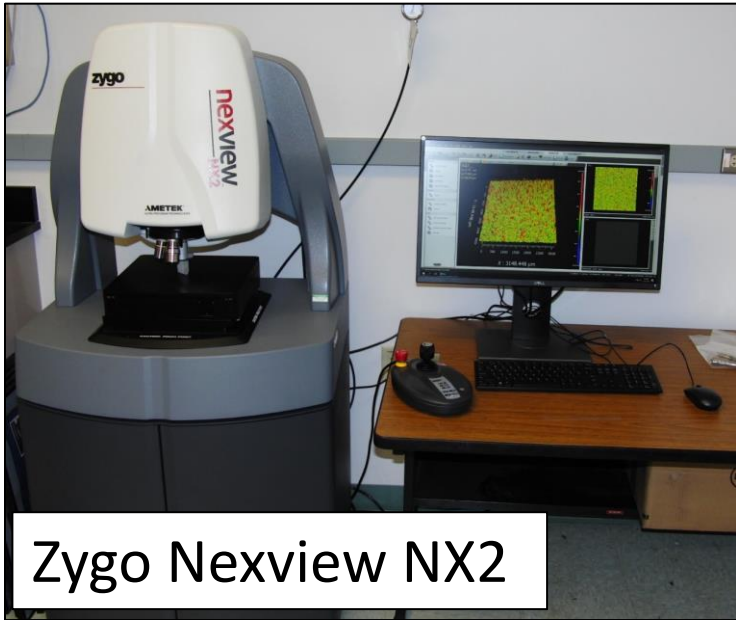


Electron Optics

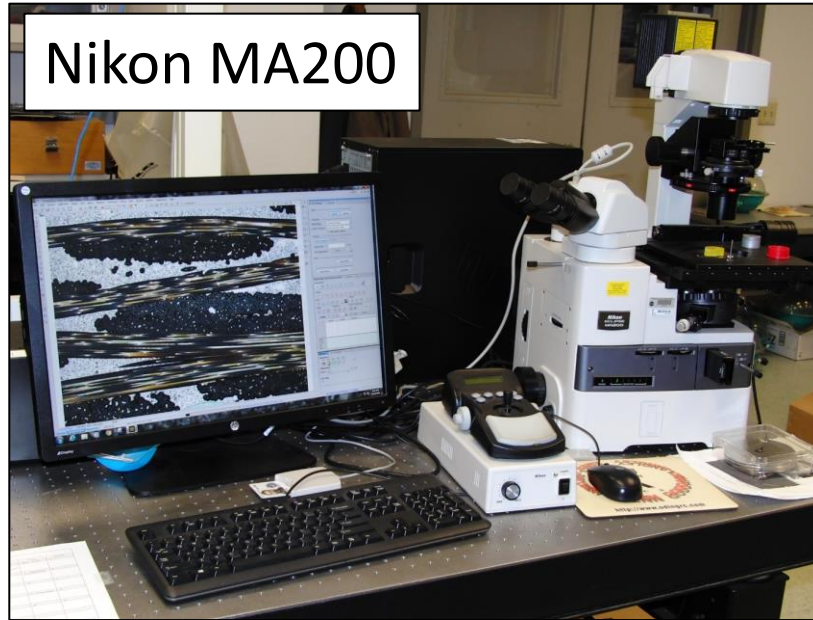




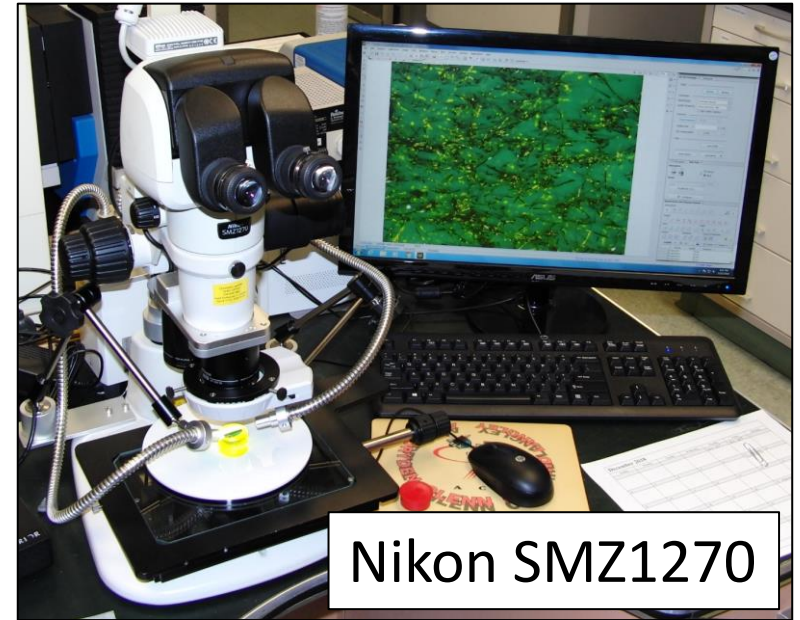
Metlab and Optical Microscopy



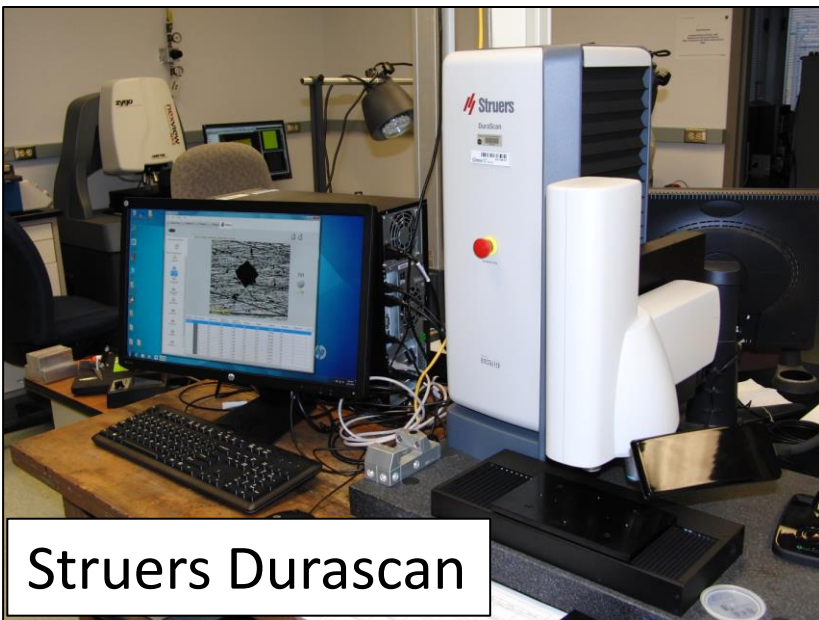
Zygo Nexview NX2



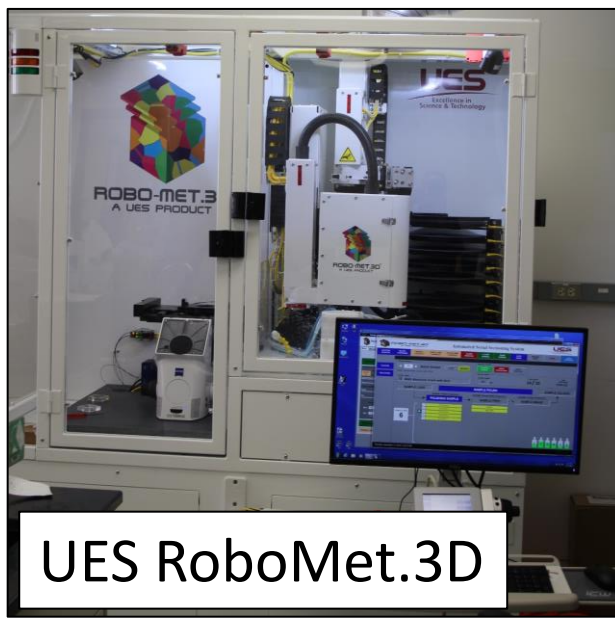
Nikon MA200



Nikon SMZ1270



Struers Durascan



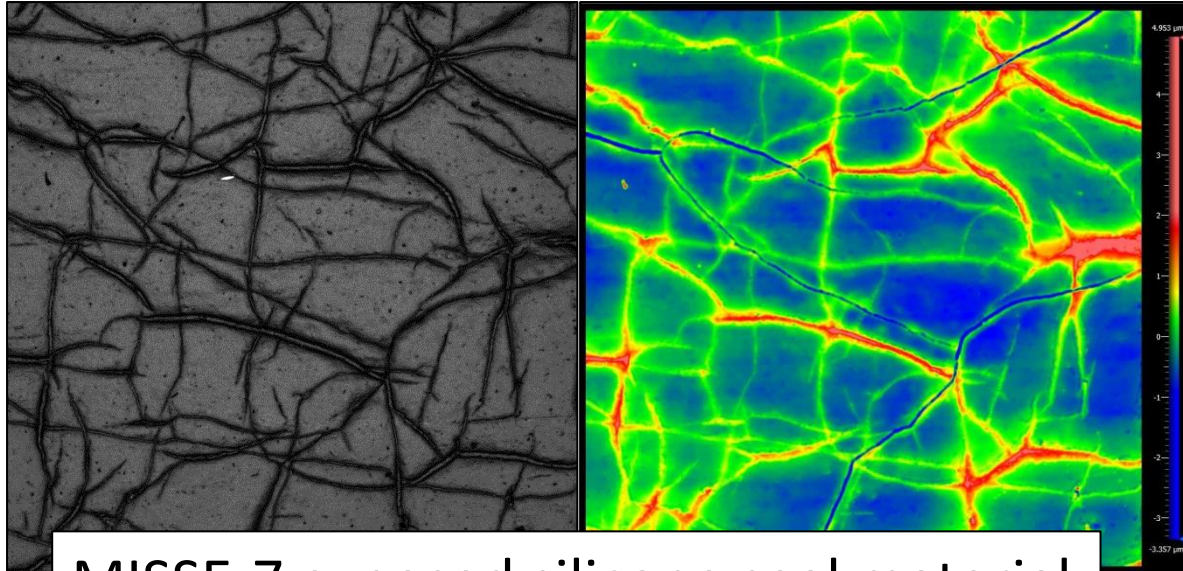
UES RoboMet.3D



Struers Abrapol-30



Metlab and Optical Microscopy

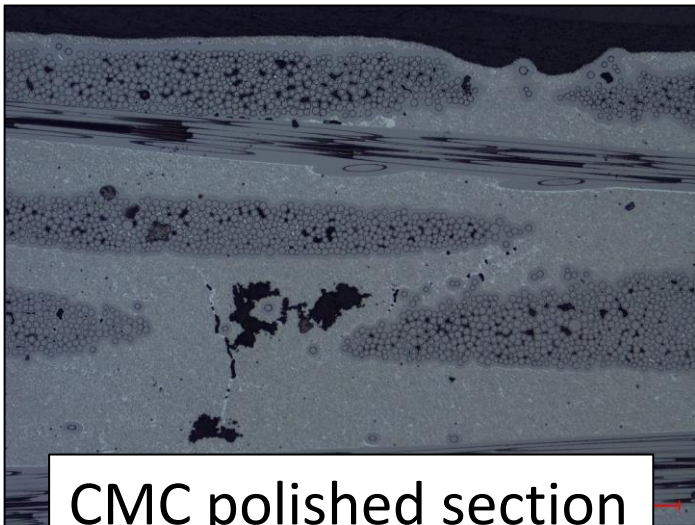
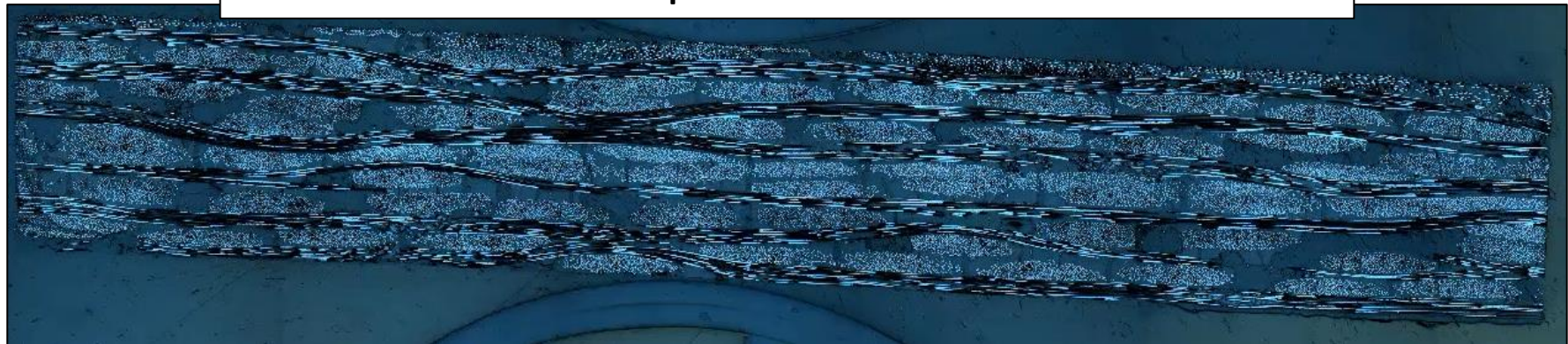


MISSE-7 exposed silicone seal material

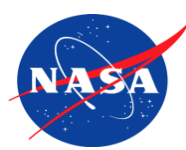
Polished and etched Ni base superalloy



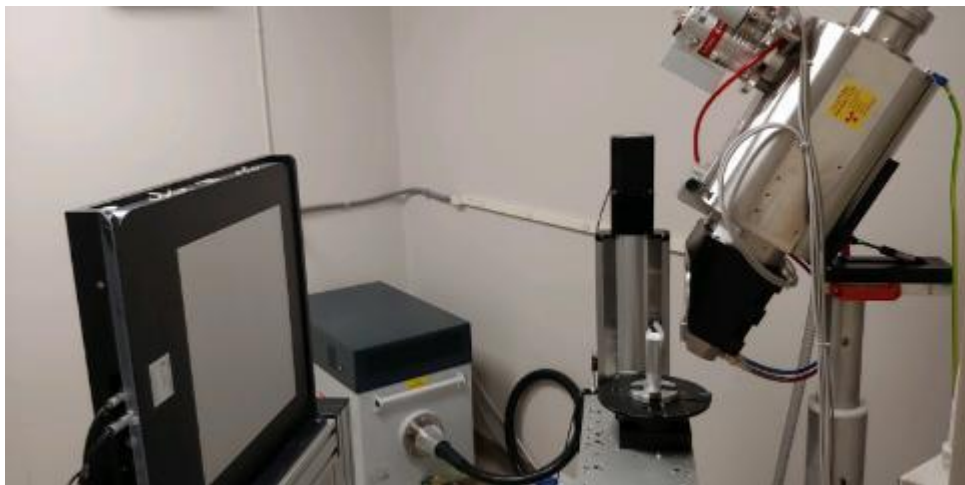
Woven CMC serial polished on the RoboMet.3D



CMC polished section



NDE, Microfocus X-Ray CT Capabilities



300kV Microfocus CT



225kV Microfocus CT

Two Systems Available

- 225kV microfocus reflection and nanofocus transmission tube
- 300kV microfocus tube
- North Star Imaging acquisition and reconstruction software

Applications

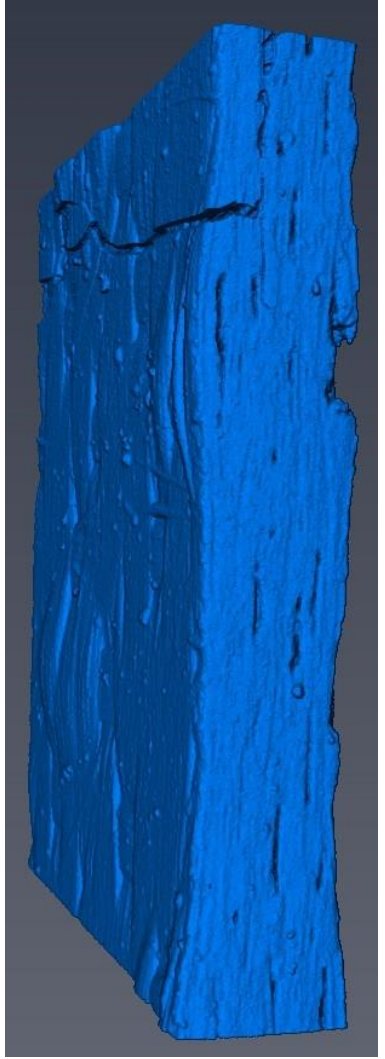
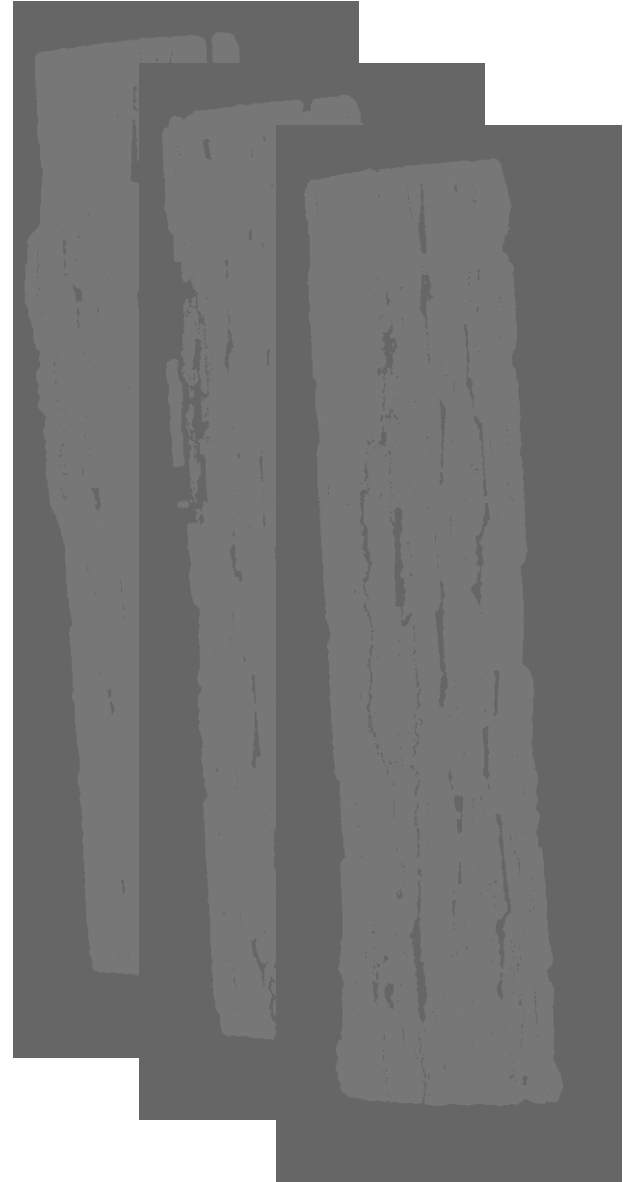
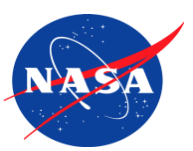
- Damage detection
- Manufacturing related issues
- Input to material models
- Component inspection

Materials

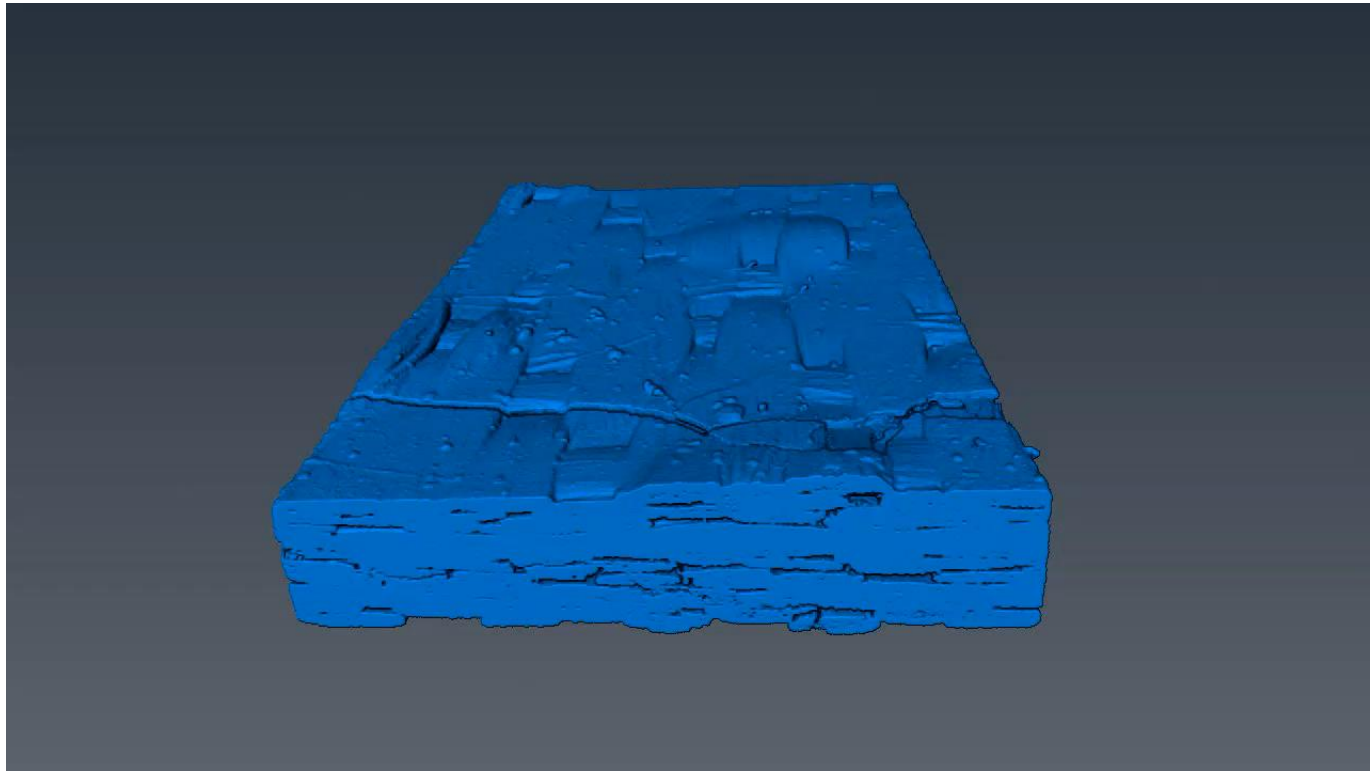
- Polymer and Ceramic Composites
- Metallic Components (traditional and AM)
- EBC/TBC coatings

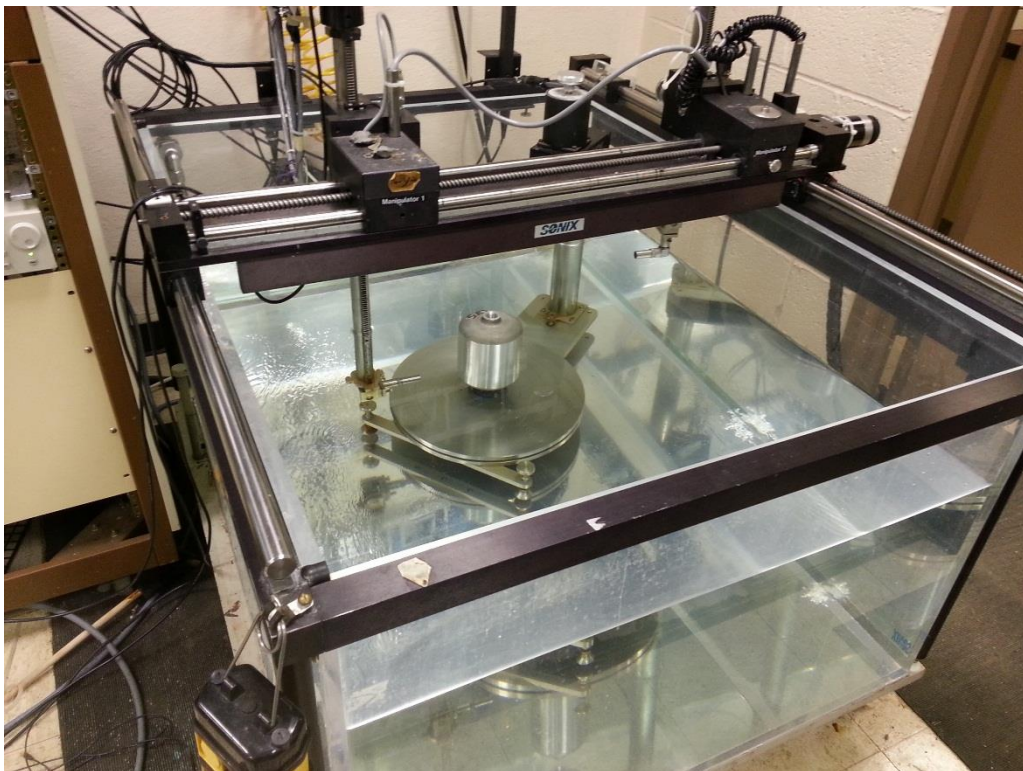


NDE, X-Ray Microfocus Computed Tomography



CT scan of a Failed CMC Test Specimen





Immersion Ultrasonic System.

Components

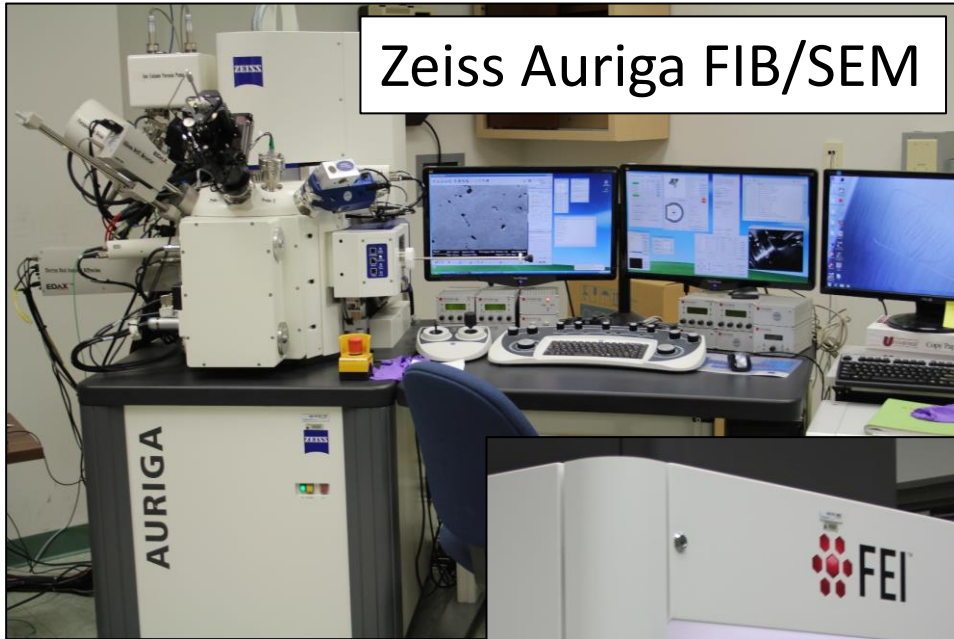
- Immersion tank for sample.
- 9-axis transducer/sample manipulation system.
- Ultrasonic pulser/receiver.
- Data acquisition card for collecting ultrasonic signals
- Software for signal processing and display

Method

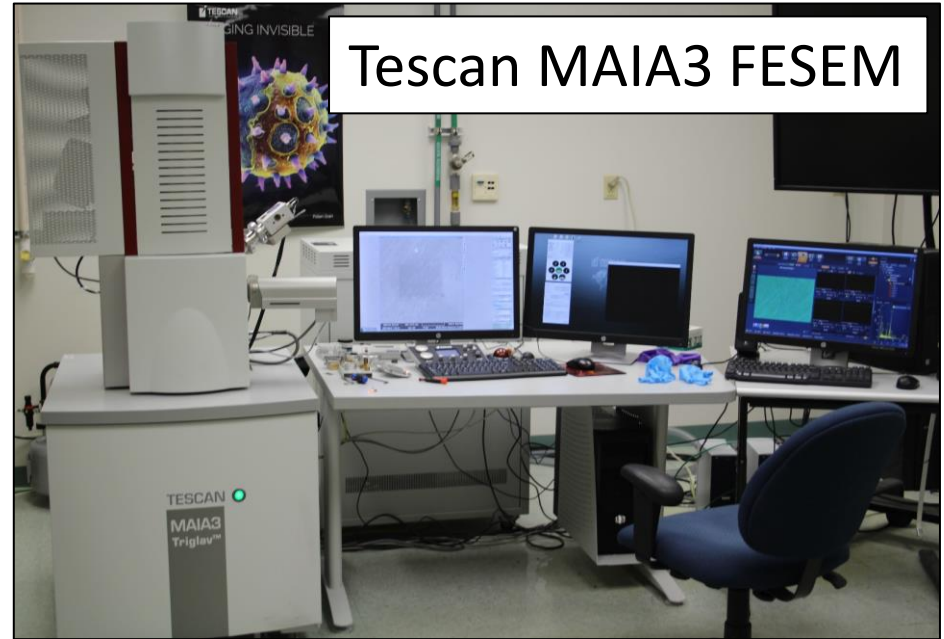
- Ultrasonic signals (500kHz – 100MHz) are sent into sample.
- Water in tank acts as a sound couplant.
- Signals are either received by the same transducer (pulse-echo) or by a second transducer on opposite side of sample (through transmission).
- Amplitude, frequency, and time of arrival of the received signals are used to identify flaws and material thickness.



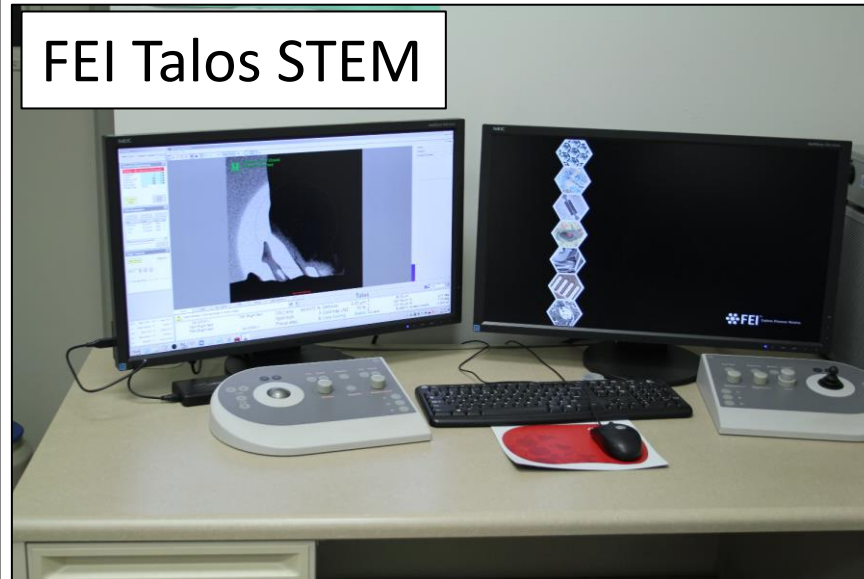
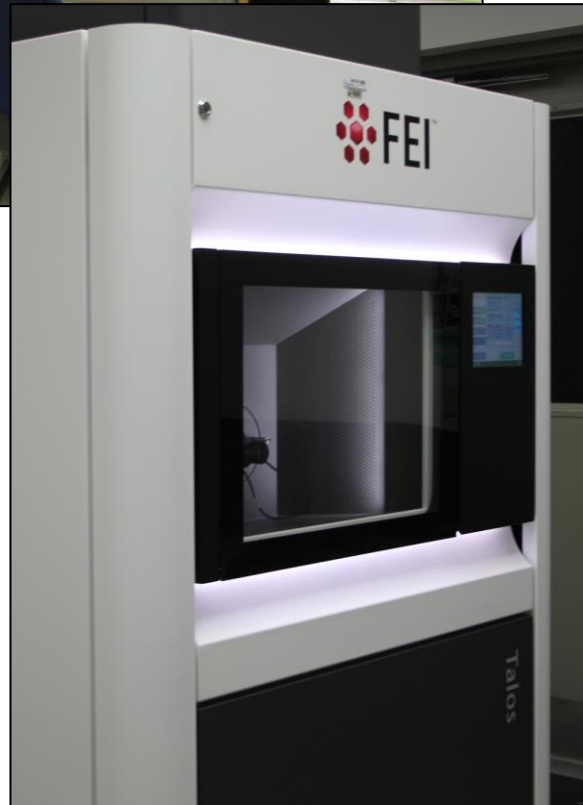
Electron Optics



Zeiss Auriga FIB/SEM



Tescan MAIA3 FESEM



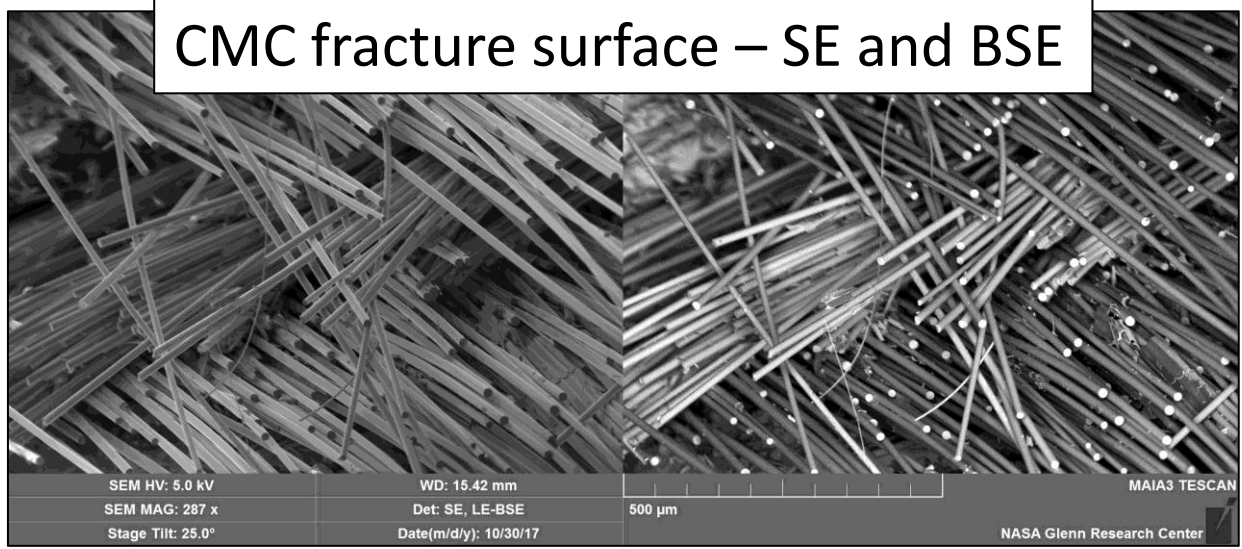
FEI Talos STEM

SEM – Scanning Electron Microscope
 FIB – Focused Ion Beam
 STEM – Scanning Transmission
 Electron Microscope
 FESEM – Field Emission SEM



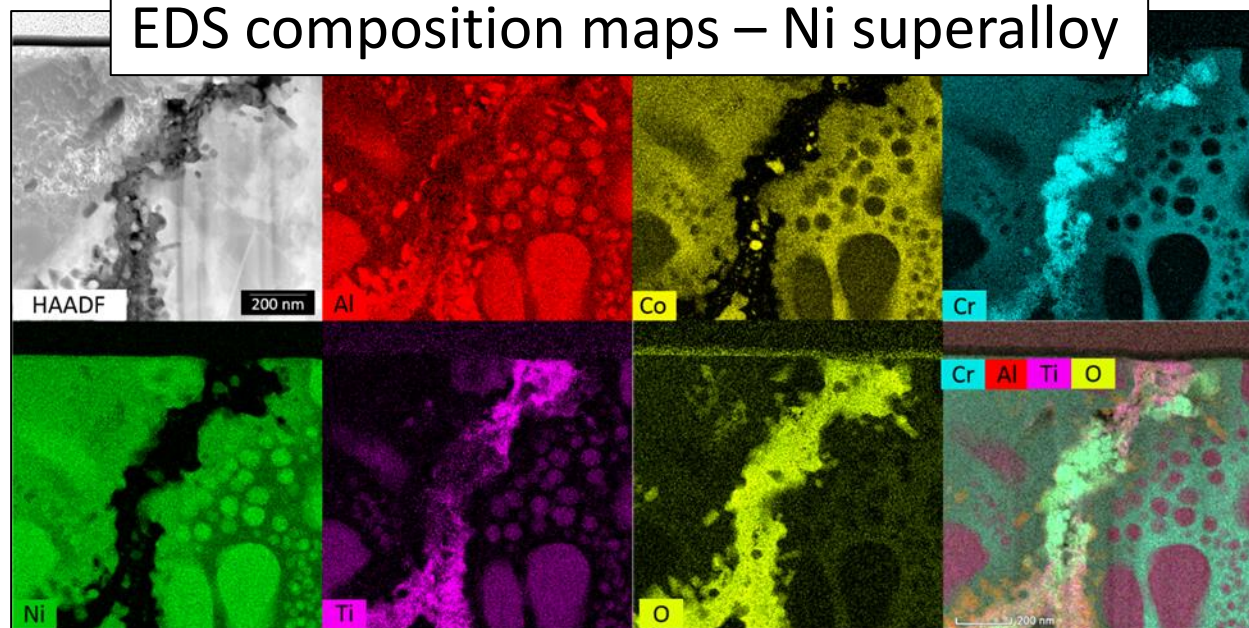
Electron Optics

CMC fracture surface – SE and BSE

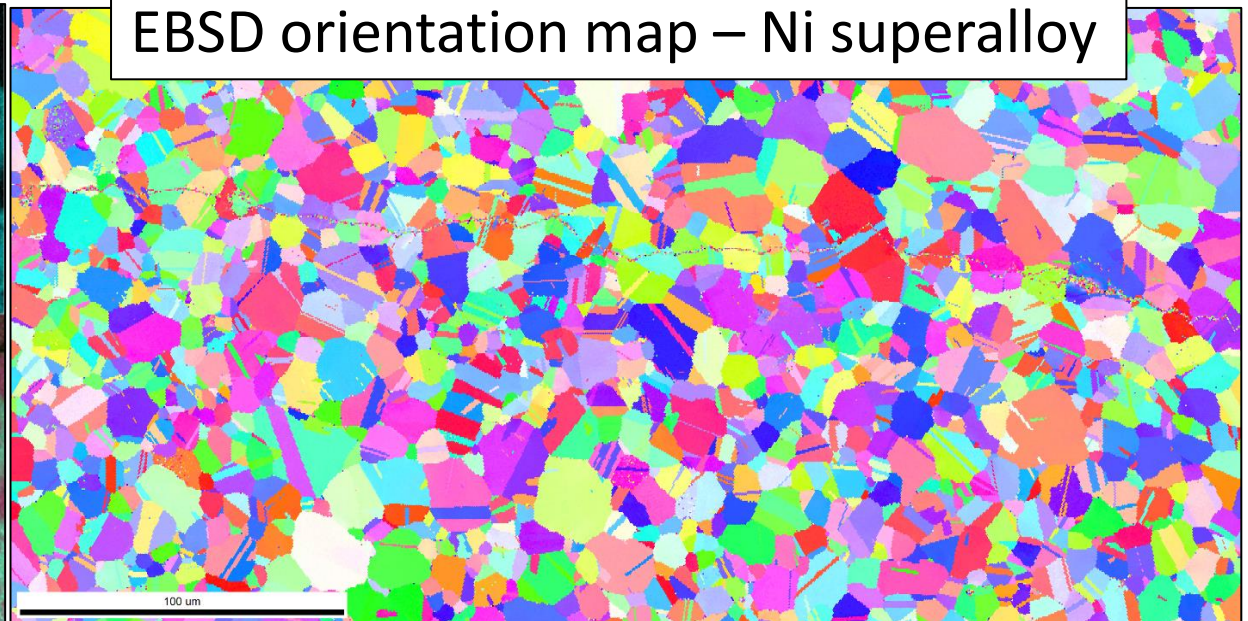


CMC – Ceramic Matrix Composite
 SE – Secondary Electron
 BSE – Back Scattered Electron
 EDS – Energy Dispersive x-ray Spectroscopy
 EBSD – Electron Back Scatter Diffraction

EDS composition maps – Ni superalloy



EBSD orientation map – Ni superalloy





Analytical Chemistry and Thermal Analysis



Oxygen/Nitrogen analyzer



Carbon/Sulfur analyzer

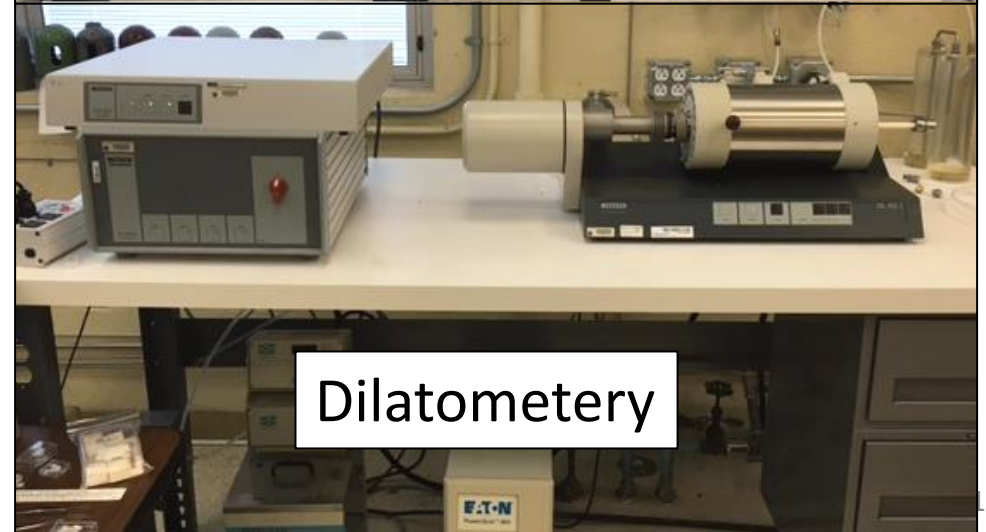


DSC – Differential Scanning Calorimetry
DTA – Differential Thermal Analysis
TGA – Thermogravimetric Analysis

DSC/DTA/TGA

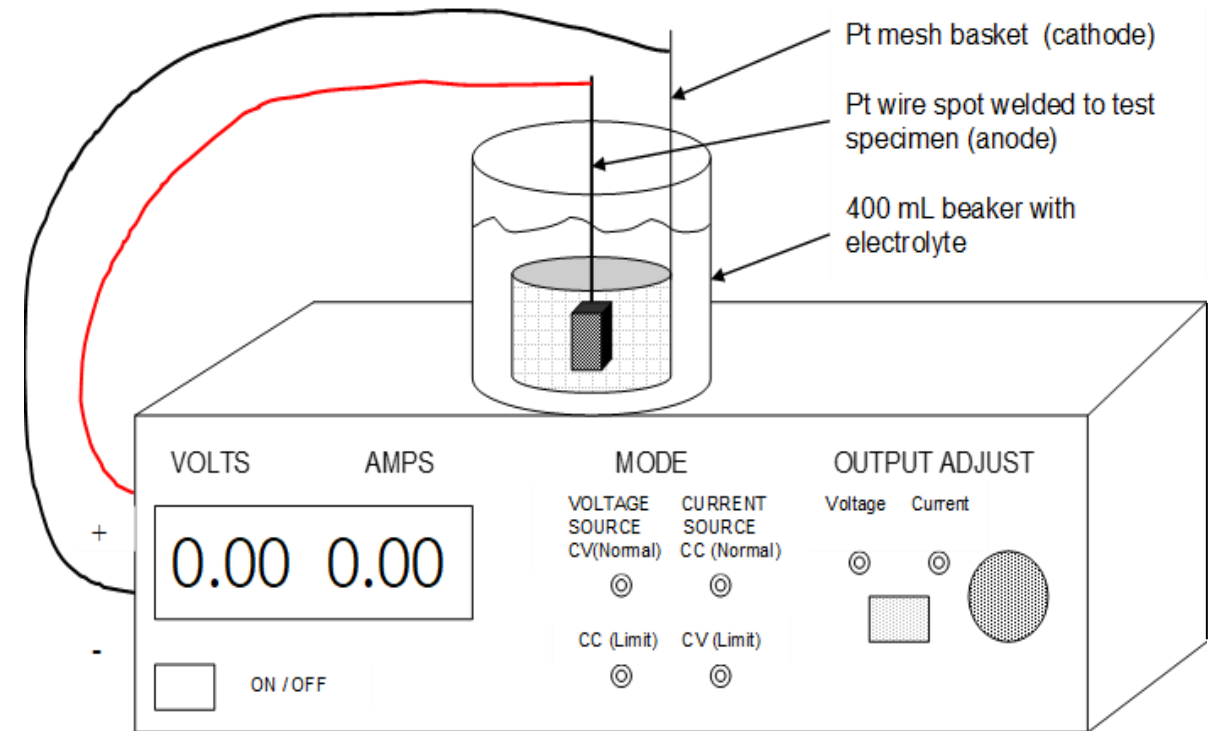


Dilatometry



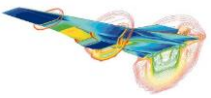


Constant current electrolytic phase extraction

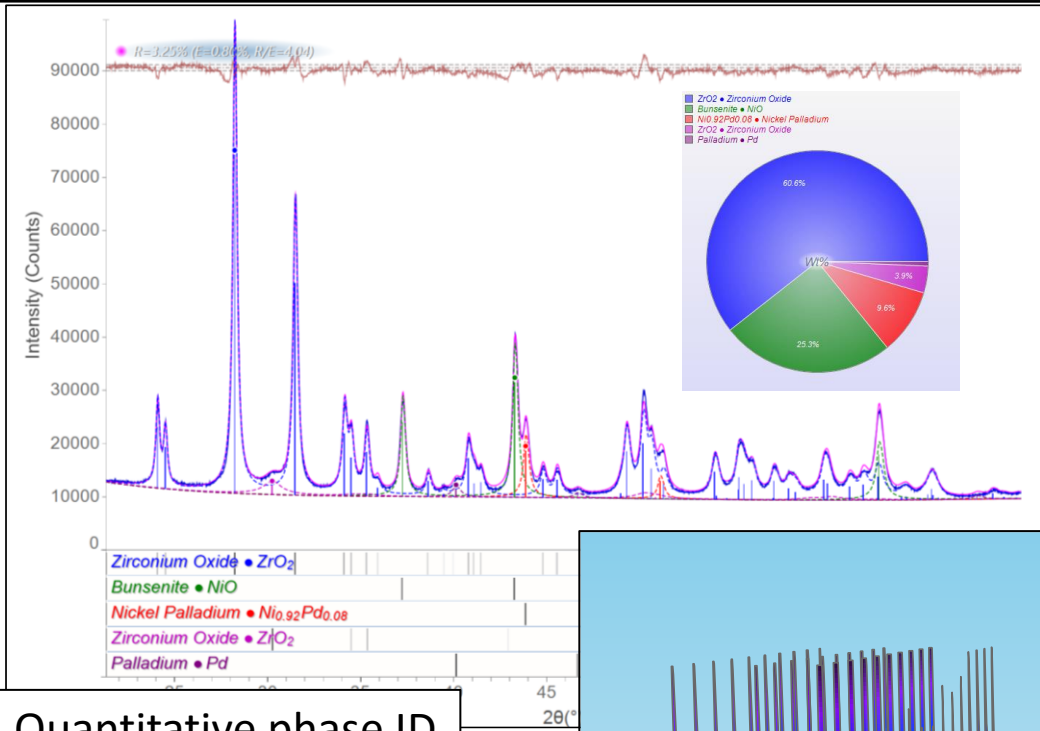


ICP – Inductively Coupled Plasma
AES – Atomic Emission Spectroscopy

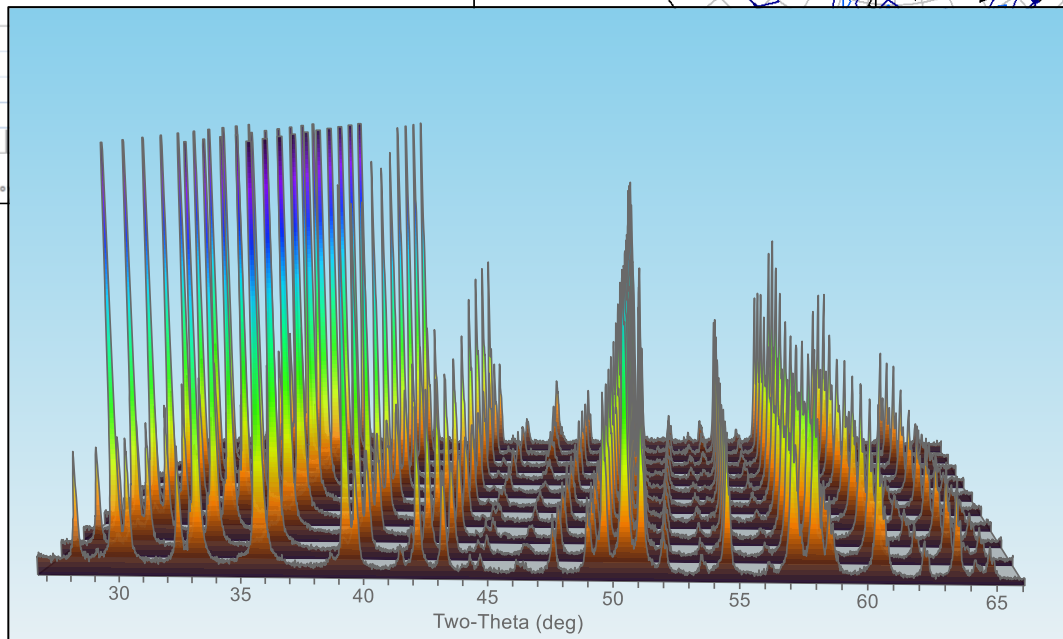
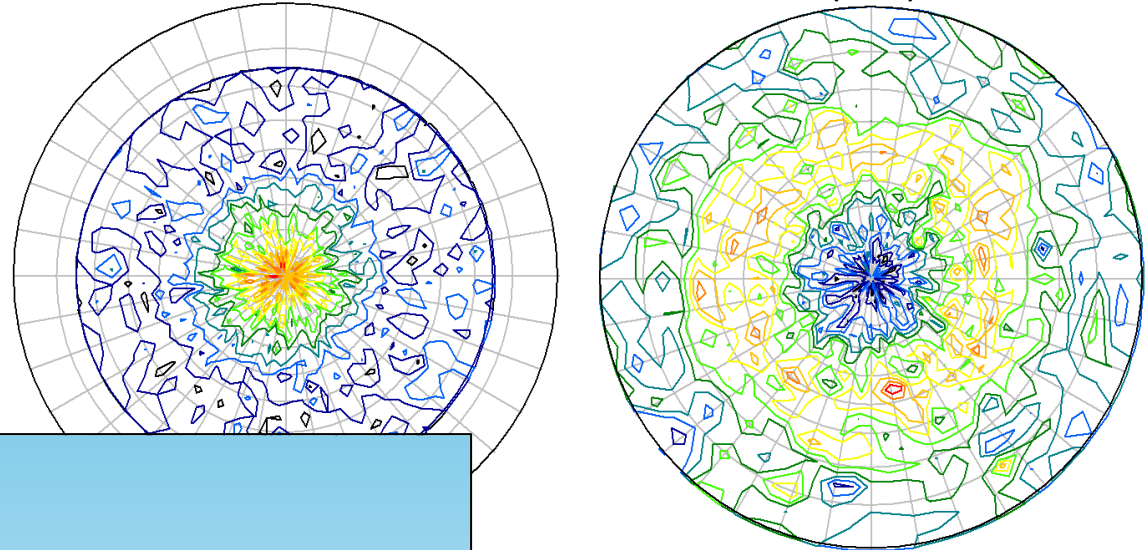
Figure 1. HP System Power Supply Electrolysis Set-up



X-Ray Diffraction (Analytical Crystallography)



Pole figures showing preferred orientation (texture)



High temperature XRD series (ambient to 1500°C)



X-Ray Diffraction (Analytical Crystallography)



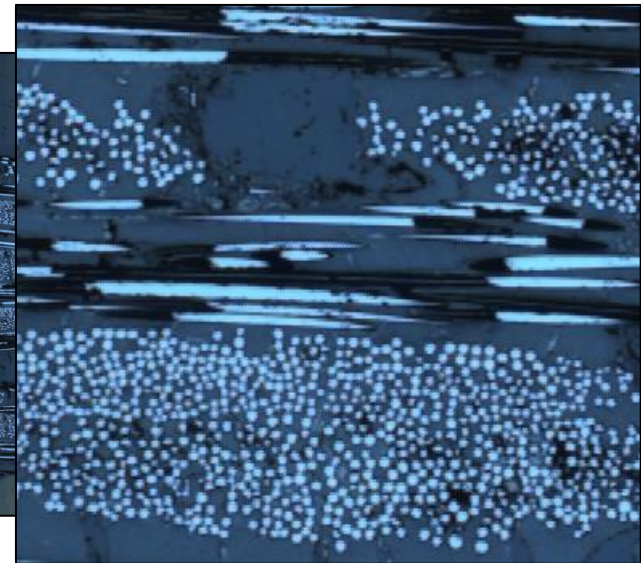
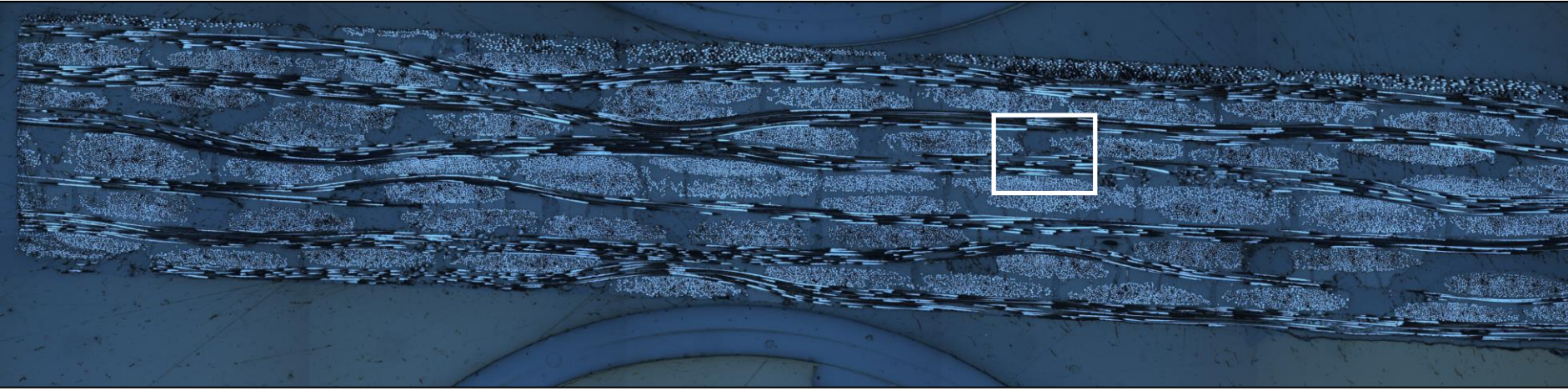
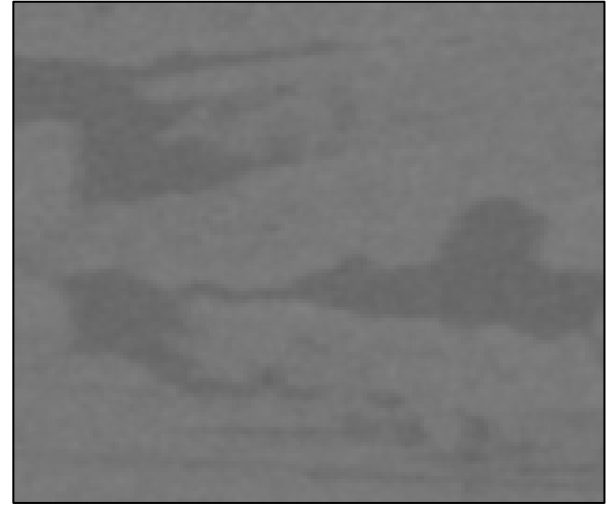
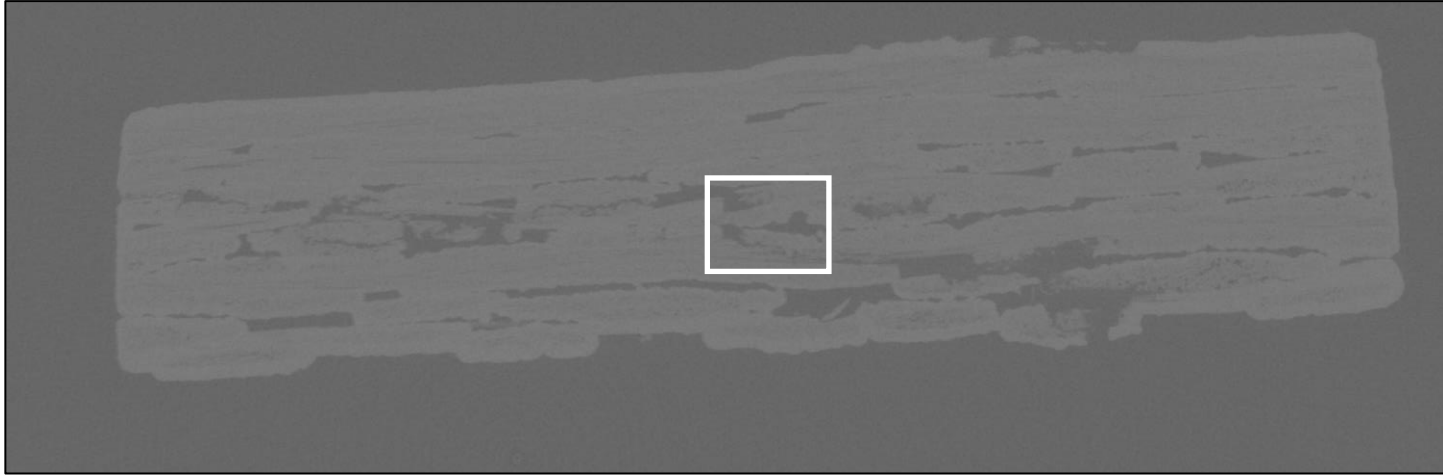
Bruker D8 Advance



Bruker D8 GADDS



PANalytical Empyrean





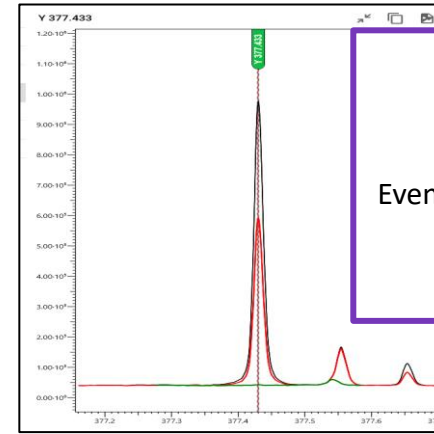
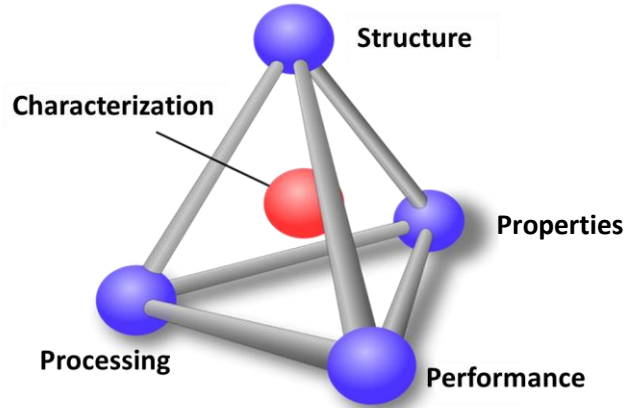
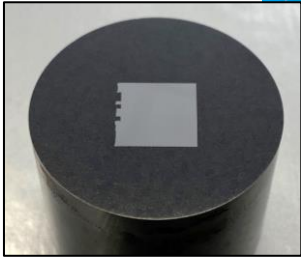
GRX-810 Analyzed by the ASG Labs



ASG aims to provide high-quality analytical results for materials characterization for Glenn Research Center

GRX-810 combustor dome

Photo taken in Optical Microscopy Lab & Sample mounted/polished in Metallography Lab, ready for analysis in other labs

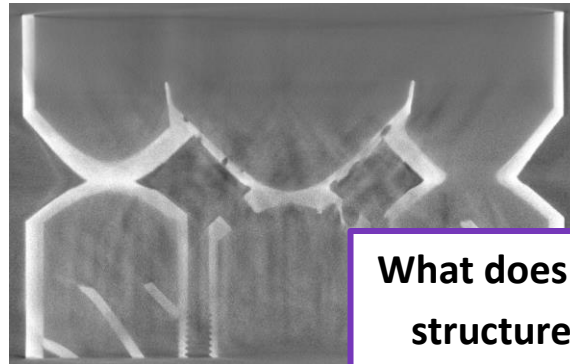
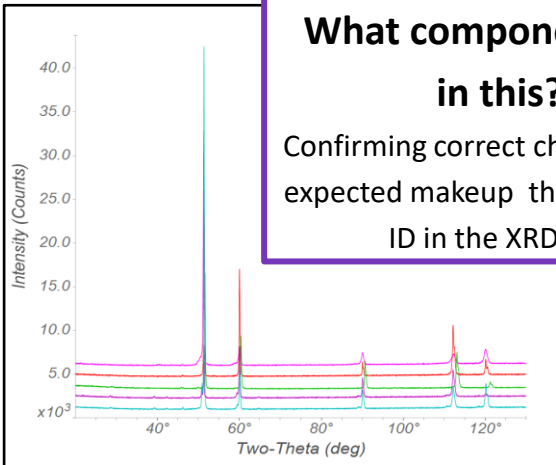


How much of the trace elements are present?

Even ppm amounts can drastically affect properties – analyzed by Phase extraction in the Chemistry Lab

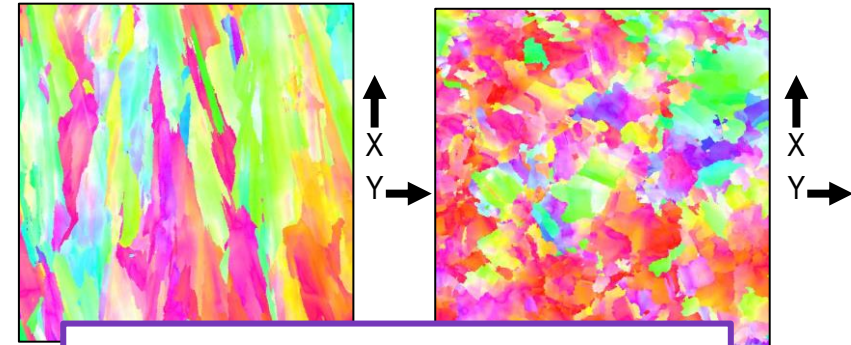
What components are in this?

Confirming correct chemistry and expected makeup through Phase ID in the XRD Lab



What does the internal structure look like?

See inside the part without cutting it with X-ray Computed Tomography in the NDE Lab



What is the microstructure?

Desired properties are tied to one microstructure vs another – measured by Electron Back Scatter Diffraction in the Electron Optics lab



- Electron Optics Lab
 - 5 electron microscopes (3 field emission)
 - Focused Ion Beam
 - Local TEM foil extraction
 - FEI Talos STEM
 - Electron Microprobe
- Metallurgical and Optical Microscopy
 - Automated serial polishing
 - Automated Microhardness Testing
 - Interferometric Surface Profiler
- Chemical and Thermal Analysis
 - Inductively Coupled Plasma
 - Nitrogen/oxygen and carbon/sulfur analyzers to detect ppm quantities to weight % levels
 - Wet Chemistry
 - Thermal analysis: DTA/TGA, dilatometry, DSC
- X-ray Diffraction
 - 4 modern instruments
 - Quantitative phase ID & lattice parameters
 - Texture & Residual Stress
- Non-Destructive Analysis
 - Micro-scale X-ray Computed Tomography (CT)
 - Down to 5 micron feature resolution
 - 3D reconstruction
 - Digital Radiography
 - Immersion and Contact Ultrasonics

- The Analytical Science Group is a comprehensive materials characterization solution.
- The ASG laboratories have advanced capabilities for characterizing the behavior, identifying the failure mechanisms, and assisting in the development of next-generation materials systems.
- The ASG staff has decades of experience dealing with the materials of interest to the hypersonics community (Ni-base superalloys, ceramic matrix composites, environmental and thermal barrier coatings, etc.)
- We welcome collaboration with other government agencies and industry in investigating, and helping to solve, your most challenging materials problems.