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Sandia National Laboratories

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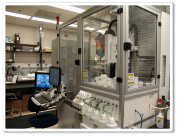
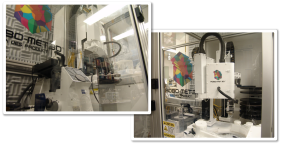


RoboMET.3D™ @ Sandia National Laboratories
A Unique System, A Unique Capability



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OVERVIEW

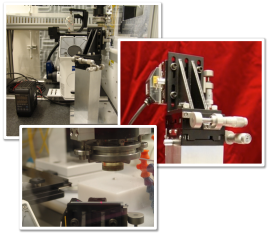
The RoboMET.3D™ is one of the many characterization tools located within Sandia National Laboratories, Albuquerque NM (SNL-NM). and provides automated mechanical serial-sectioning at the microstructural level. In itself, the RoboMET.3D™ is a rather rare instrument as there are only 15 units deployed world-wide. The SNL-NM RoboMET.3D is even more distinctive based on the customized modifications incorporated specifically for SNL customer needs. Here, system customizations are highlighted and select collected datasets are presented.

MOTIVATION

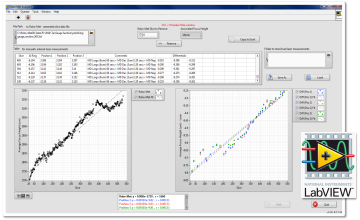
In order to relate material performance variance to microstructural variability, a full three-dimensional understanding of microstructure is often paramount to an accurate description. Data collection of typical and atypical microstructures has been pursued for the purposes of general characterization and to demonstrate the ability to produce full three-dimensional understandings through 3D reconstructions obtained by mechanical serial-sectioning. Materials examined have included 304L stainless steel, pure bcc tantalum and ceramic particles suspended in epoxy.

CONTACTLESS REMOVAL RATE MEASURE

A KEYENCE laser interferometer system using a LKH057 sensor head was incorporated into the RoboMET.3D enclosure via a custom three-axis, micron-resolution stand to provide a secondary measure of removal rate. The measurement is based on the differential between an unchanging reference height and the height of the sample throughout the serial-sectioning experiment. The method requires no physical contact with the specimen and is repeatable to within a few microns. The sensor head itself has a measurement range of 50 ± 10 mm.



REAL-TIME DATA ANALYSIS



SNL technologists have also created and developed an interactive LabView data analytics interface that receives RoboMET.3D generated data files and plots removal rate, slice number and laser measurement data all in real-time as the data is collected during the experiment. This provides opportunity to adjust the experiment in-situ should anomalies occur during sectioning.

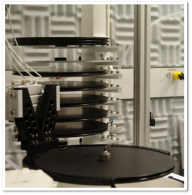
SYSTEM CUSTOMIZATIONS

DUAL MONITORS

Dual monitors have also been added to the system to allow users to view real-time data collection while system is in operation.

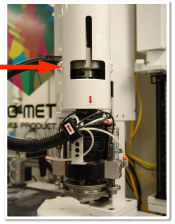
MULTI-PLATEN

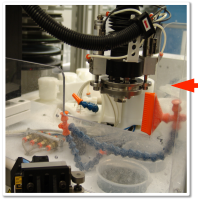
An add-on automated robotic multi-platen exchange system has been integrated into the system to allow for multi-step polishing. This allows a greater variety of choice in sectioning thicknesses, sample preparation and cycle time.



VIEW PORT

A view port was machined into the robot arm to allow for in-situ verification of the polishing load.





AIR BRUSH

The addition of an "air brush" blows compressed air across the sample pass-through window keeping the laser, inverted microscope and associated electronics free of water droplets from the neighboring ultra-sonic cleaning station.

PLATEN SENSOR BRACE

Due to the short working distance of the platen sensor, a screw-actuated locking adjustor was fabricated and added to the system. This enables the sensor to better maintain precise positioning thereby drastically decreasing system pauses from false-negative reads. Overall, the primary result are longer un-interrupted runs.

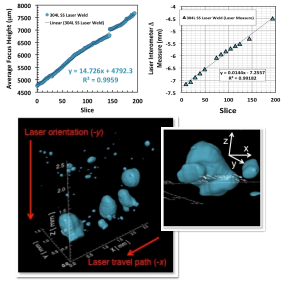
REMOTE ACCESS

Operators internal to SNL can log in to the system to begin, operate or check on the progress of an extended run remotely. This customization enhances the ability of the system to run un-manned for significant periods of time while still allowing remote monitoring and evaluation of the quality and integrity of the data being collected.

EXAMPLE DATASETS

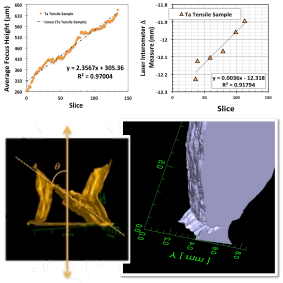
– LASER WELD POROSITY IN 304L STAINLESS STEEL

- 195 serial sections
- 14.7 microns per slice
- Total sectioning depth, approx. 2.8 mm
- Identified and successfully reconstructed both large-scale "root-porosity" and comparatively small-scale "micro-porosity"
- At select travel speeds, root porosity demonstrates a tendency to be very far from spherical in morphology and curvature



– TENSION INDUCED VOID CRACKING IN PURE BCC TANTALUM

- 135 serial sections
- 2.5 microns per slice
- Total sectioning depth, approx. 0.34 mm
- Revealed voids at initial cross-section quickly link to a full crack through the gauge cross-section
- Internal crack oriented at a 45° angle to the tensile direction



– PACKED CERAMIC PARTICULATES IN OPAQUE EPOXY

- 77 serial sections
- 34.2 microns per slice
- Total sectioning depth approx. 2.7mm
- Volume fraction analysis shows anisotropy of packing proximity with greater variance occurring along the *y*-direction compared to the *x*-direction