MRF: Scientific Equipment

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Analysis available NOW

- Basic Sample Preparation and Cutting
- Dual beam FIB
- Nanoindenter
- SEM (with EDX, EBSD, TKD)
- Thermal Desorption Spectroscopy

Coming soon after MRF opens:
Plus workshop and experimental areas for JET tiles and other work - limited to start with.
Mini-tritium handling facility coming from RAL
Analysis available: SEM

High resolution electron imaging

Energy Dispersive X-ray (EDX) analysis
Electron Backscattered Diffraction (EBSD)
Transmission Kikuchi Diffraction (TKD)
Analysis available: FIB

Lift-out Technique
- Atom Probe Samples
- TEM samples

Micro-mechanical test specimens

3D tomography
Residual Stress Analysis

Fe lamella during thinning of four ‘windows’ (ion beam image)

Array of micro-cantilever specimens in irradiated/un-irradiated grain of Fe12%Cr
Analysis available: Nanoindenter

Indentation up to 10N:
- Spherical: R=0.3 to 120µm
- Berkovich
- Cube Corner
- Knoop

Micro-cantilever and micro-pillar testing
Contact AFM

Several stress-strain curves produced from micro-cantilever tests on Fe12%Cr un-irradiated (green) and irradiated (red).
Case Study: Small Scale Testing (Jim Hickey, CCFE)

Spherical nanoindentation to measure true stress-true strain properties in small volumes.

The use of differing radii provides a measure of the effect of probed volume on the measurement.
Case Study: Small Scale Testing (Alex Cackett, CCFE)

FIB production of lamella

• Focused ion beam used to mill cross-section through indents
• Lamella mounted on TEM grid and thinned to ~200nm

Transmission Kikuchi Diffraction

• Like EBSD but in transmission mode, resolution 10 nm
• Strain calculation from cross correlation of Kikuchi patterns using CrossCourt 3

\[ \varepsilon_{33} \]

\[ \varepsilon_{12} \]
Case Study: Fracture Properties of Irradiated Tungsten: (Moritz Lessmann, Manchester PhD)

Scatter plot showing increase in elastic modulus with implantation damage.
Case Study: PIE activated beryllium (Slava Kuksenko)

0.1 MBq/sample (0.75 ± 0.09 MBq/g)

20 µSv/h in contact
Case Study: PIE activated beryllium

FIB lift-out

superpose the microstructural data with the dpa, appm and hardness data

- minimize the activity of samples
- minimize the toxicity of samples
And many more…

MRL Jobs and Users: Universities

• **Bristol:** Nanoindentation (of Bivalves etc. to investigate the effects of ocean acidification).

• **Sheffield:** Various projects including novel alloy development and additive manufacturing

• **Strathclyde:** SEM analysis and micro-mechanical testing of W-Cu braze interlayers

• **Oxford:** Micro-mechanical testing, indentation, TEM and APT specimen preparation, EBSD and active tungsten, steel and beryllium.

• **Manchester:** Micro-mechanical testing (fracture), residual stress measurement, SEM imaging, EBSD, 3D tomography, nanoindentation.

• **Queen Mary University, London:** FIB specimen preparation, TKD of indents within Ni single crystal.
And many more...

MRL Jobs and Users: Industry

• **UKAEA (MASTU):** Braze composition analysis, 316SS phase analysis EBSD.
• **UKAEA (JET):** SEM/EDX/EBSD tie rod failure analysis, SEM/EDX JET Dust analysis, bolt testing fractography, EBSD of additive manufactured Inconel 718, SEM-EDX investigation of anomalous flywheel wearing
• **UKAEA (Special Techniques Group):** EDX braze filler identification, furnace contamination analysis
• **ISIS Innovation:** SEM imaging and EDX chemical analysis of electrode erosion
• **Reaction Engines:** Sample preparation for cross-sectioning miniature thin walled tubes, FIB surface preparation, SEM/EDX of nickel super alloy tubes, SEM analysis of HIP titanium components
• **CEA, France:** Micro-mechanical testing of Eurofer and ODS Eurofer, FIB specimen prep and nanoindentation
• **AMECFW:** Nanoindentation of Be-CuCrZr braze interlayer and parent materials.
Future capabilities in the MRF:

- The MRF is a user facility
  - This means that the MRF must cater for the needs of academia and industry
  - Sustainability of the MRF relies on its users

- Investment in the future instrumentation and capability of the MRF must represent the greatest demand from users.

- The MRF requires your input into making the best use of future investment into extending capability… after lunch…!
Thank you