UK Atomic Energy Authority

Materials Research Facility

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Content

• Introduction
• MRF current facility and capabilities
• Plan for facility extension
• Examples of materials research at MRF
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UKAEA MRF hot-cell line

- Control room
- Fusion line
- Non-active sample preparation lab
- Research Room lines
- Hot-Cell line
UKAEA MRF hot-cell line

Samples up to 3.75 TBq Co$^{60}$
UKAEA MRF Research Rooms

Samples up to 3.75 GBq Co$^{60}$
UKAEA MRF glovebox line

Samples up to 10 µSv/hr
UKAEA MRF Control room
Instrument integration in active area
UKAEA-MRF: Sample Preparation

Non active Sample prep lab
  Cutting, grinding, polishing
  Electro polishing
  Optical microscopy
  Non active sputter coater

PIPS-II ion polisher
Lab scale EDM
3mm disc punch
3 zone tube furnace 1200°C
Dimple grinder
Active sputter coater
Hot-cell lab-scale EDM
Glovebox cutting, grinding, polishing

Note:
Currently available
To be commissioned 2019/20
UKAEA-MRF: Microstructural Characterisation

FEGSEM
  Tescan Mira XH
  EDX, EBSD, TKD, WDS

Dual beam FIB
  FEI Helios
  GIS: Pt, W, C
  Nano-manipulator for sample lift-out

AFM
  Veeco D3100

PMI XRF
  Olympus delta premium
  PMI XRF

Scanning Confocal Raman Microscope
  AFM
  In-situ (e.g. Heating, liquid, & gas)

XRD goniometer
  High brilliance X-ray source

Note:
Currently available
To be commissioned 2019/20
UKAEA-MRF: Thermo-physical Analysis

Thermal Desorption Spectroscopy
  Hiden TPD workstation
  Up to 1000°C

Gas Impregnation Technique
  Ar, N₂, Air, He, D₂, Tritium
  Ion energy < 500 eV, RT – 500°C

Dilatometer
  Linseis L75V, dual pushrod
  -150°C – 600°C and RT – 2000°C

Laser Flash Analyser
  Linseis LFA 1000
  -100°C – 500°C and RT – 2000°C

TGA/DSC
  Linseis STA PT1600
  -150°C – 500°C and RT – 1600°C

Gas pycnometry

Note:
Currentely available
To be commisioned 2019/20
UKAEA-MRF: Mechanical Testing

Nanoindenter
Agilent G200

Static load frame 10 kN
Shimadzu AGS-x
Environmental chamber for up to 800°C

Dynamic load frame 15 kN
TA Electroforce 3500
Environmental chamber for up to 800°C
Small-punch testing
Vacuum chamber with induction heating

In-situ SEM load frame 5 kN
DEBEN MTEST
Clamp heating up to 600°C

Instrumented indenter

UltraSonic Fatigue Setup

DIC strain measuring system
Impulse excitation testing

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MRF Summary – Non-Active (operations)

- **Plant Room**
  - Upgraded plant

- **Active Store Room**
  - Goods receipt

- **Mtg Room**
  - Extended Control Room (24 + 1 total)

- **Office**

- **Lobby**

- **Lobby**

- **Toilets**

- **Active change area**

- **Non-Active Sample Prep Lab**

- **Extended NASP**

- **NEW Chemical Lab**

- **NEW Storage + Archive**

- **NEW Kitchen**

- **Mtg Room**

- **Office**

- **Building Management System**

- **NEW Mtg Room**

- **NEW Larger Room**

- **NEW Cleaners Cupboard**

- **NEW Lockers / Coats**

- **NEW Showers**

- **NEW Toilets**

- **New Truck air lock and store**
  - (13.5m x 12.5m = 168.75m²)

- **Extend Building – Non-Active**
  - (13 m x 30m = 390m²)

- **NEW Storage + Archive**

- **NEW Office**

- **NEW Mtg Room**

- **NEW Building Management System**
MRF Summary – Active

- 2x hot cells
- 12x Research Rooms
- NEW Truck Access
- Clean store
- Additional Ventilation
- NEW Truck Access
- 12x Research Rooms
- 2x hot cells
- Sample Storage
- Inert Sample Storage
- New Active Workshop
- RR Line 4
- RR Line 5
- RR Line 6
- NEW Chemical Lab
- NEW Storage + Archive
- Extend Building – Active
  (27 m x 30m = 810m²)
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Relevant Expertise at the UKAEA-MRF

Sample preparation
FIB machining on all fusion relevant metals, expertise with low activity samples
TEM sample prep with FIB and PIPS on low activity materials, currently working towards electropolishing on active materials

Micromechanical testing
Nano-indentation, size effects
- Different indenter geometries (Berkovich, Cube, Spherical, …)
- Post indentation AFM analysis of pile up and indenter contact area
- Post indentation cross sectional analysis with SEM-TKD and TEM for plastic zone size determination

Micro-cantilever bending tests
Nano indentation at RT, high T is top priority for future investment programs (18/19 onwards)

Microstructural Analysis
TEM, SEM, Raman imaging, XRD, etc..

Through collaborations
- APT (Oxford)
- Chemi-STEM (Manchester)
- Materials modelling at various length scales (CCFE, Imperial, Oxford)
Advanced Laser Scanning Confocal Raman Microscope (LSCRM)

- High resolution 3D Raman imaging capability
- In-situ Raman imaging capability (at temperature, liquid and gas)

Liquid & gas heating stage (up to 1300°C)

Optical Micrograph of Alloy 625

3D depth Raman signal profile of the oxides

High Res. surface topography of a nano-indent on a Cu-alloy
TEM Specimen preparation using ion beams (FIB & PIPS-II)

- Ga\(^+\) beam induced damaged
- PIPS-II 100 eV “cleaning”
- 5MeV Fe\(^{2+}\) induced damage (Bragg Peak)

Ions Implantation direction
Large area EBSD mapping using SEM

EBSD grains orientation maps showing (a) grain orientation at direction of IPF-Z, (b) grain orientation along the deposition/melting direction, i.e. IPF-X or RD of a 3D printed stainless steel
Technique comparison to qualify the lab-scale EDM (Electric Discharge Machining) samples (0.3 mm thick SS 316L) against Wire EDM cutting / Photo chemical etching / Laser cutting using tensile samples.

Tensile test & fracture surface evaluation:
GL = 5x1x0.3 mm

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