ADVANCED MATERIALS RESEARCH & INNOVATION

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HENRY ROYCE INSTITUTE

# NUCLEAR MATERIALS

Research Area Leads:

Dr James Wade-Zhu, Prof. Abbie Jones and Dr. Anna Widdowson (thank you!)

Research and Business Engagement Manager:

Cathy Bell

NADM2024

NUCLEAR MATERIALS

# Nuclear Materials Partners & Technology Platforms

| The University Of Sheffield. | The University of Manchester | UK Atomic Energy Authority | National Nuclear Laboratory |
|---|---|---|---|
| Materials and Thermal Treatment for Radioactive Waste Management | Irradiation Environments (DCF)<br><br>Fuels and Irradiated Materials Analysis (Hub) | Non-Actinide Irradiated Materials Handling, Characterisation, $^{3}H$ and Testing (MRF) | Irradiated Materials, Fuels and Actinides Handling and Characterisation |
| 100 MBq ($\alpha/\beta/\gamma$) | | <4 TBq ($\beta/\gamma$) | High Activity ($\alpha/\beta/\gamma$) |

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# Vision

**Enabling innovation in radioactive materials research** to facilitate the development of advanced reactor concepts in addition to providing insight into legacy material solutions.

**Deliver strategic UK research programmes in materials for nuclear energy** building skills and capability, and addressing national priorities as identified in white papers and strategies devised by His Majesty's Government, Department for Energy Security and Net Zero (DESNZ).

**Underpinning advancements for all nuclear sectors** including civil, space, defence, and medical isotopes.

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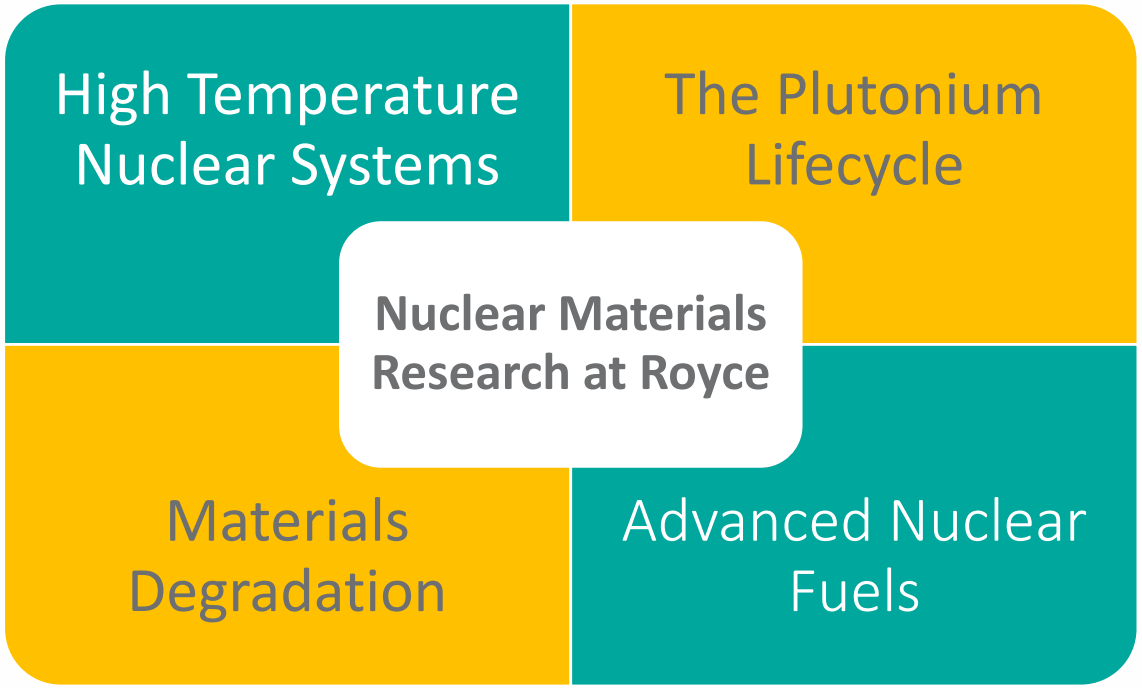
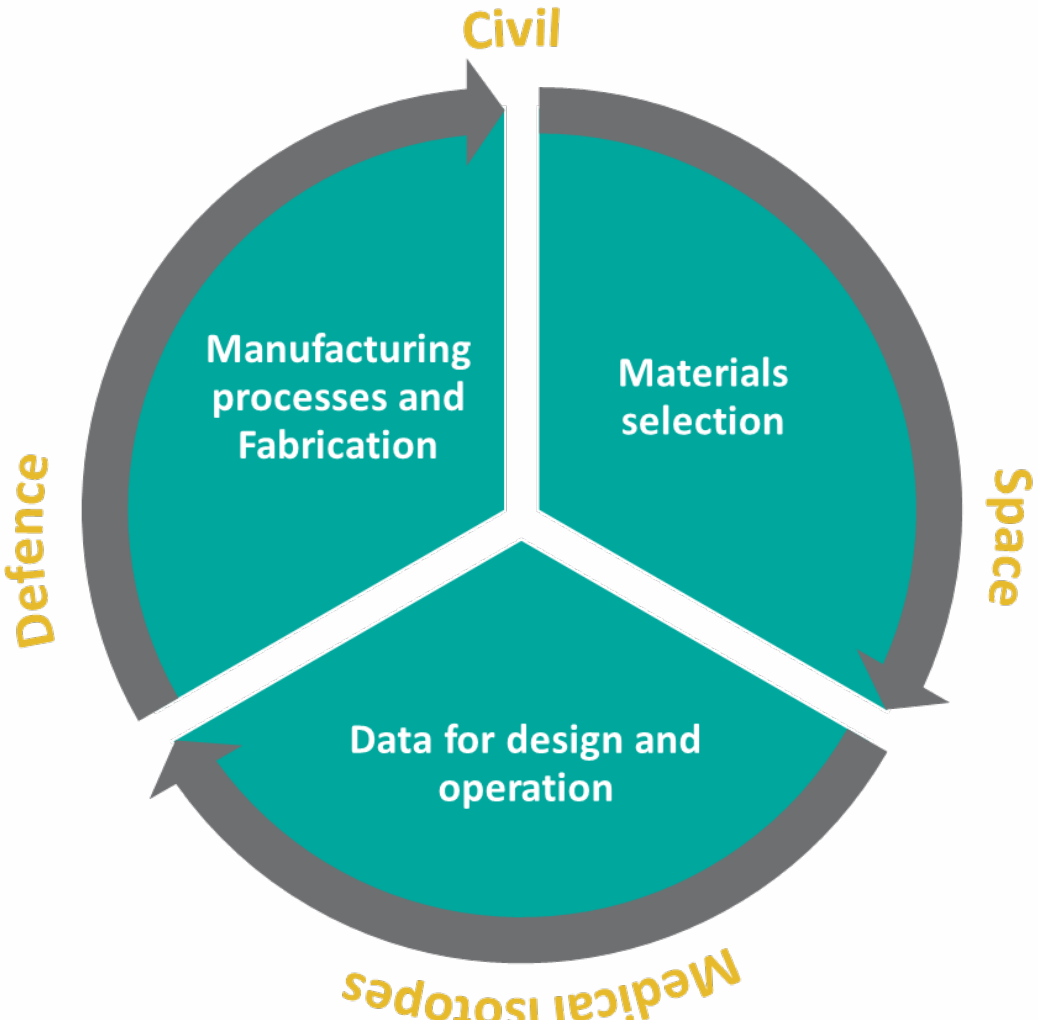
# Nuclear Materials Research

Nuclear Materials Platforms




Nuclear Materials Challenge Areas

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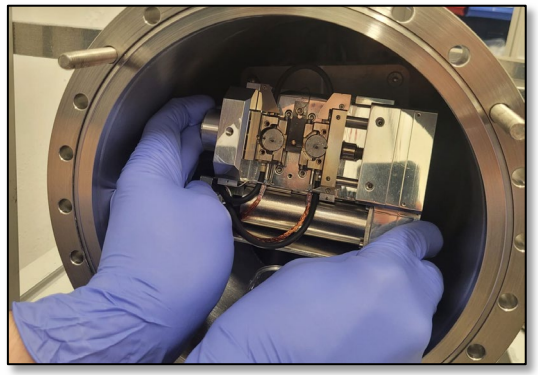
# Technology Platform updates - Irradiation Environments (DCF)

- **New Henry Royce equipment:**
  - Scanning Electron Microscope:
    - Compatibility with existing in-situ tensile test stage
    - Allows analysis of active samples
    - Commissioning planned for early 2025
  - Two new Agilent Cary UV-Vis Spectrometer
  - Two new ARCoptix OEM011 FT-IR modules
  - Lead safes for storage of active material
- **New beamline capabilities:**
  - First dual-beam irradiation experiments completed in early 2024
  - First irradiations with in-situ tensile loading on the NewTec MT1000 adapted loading rig completed

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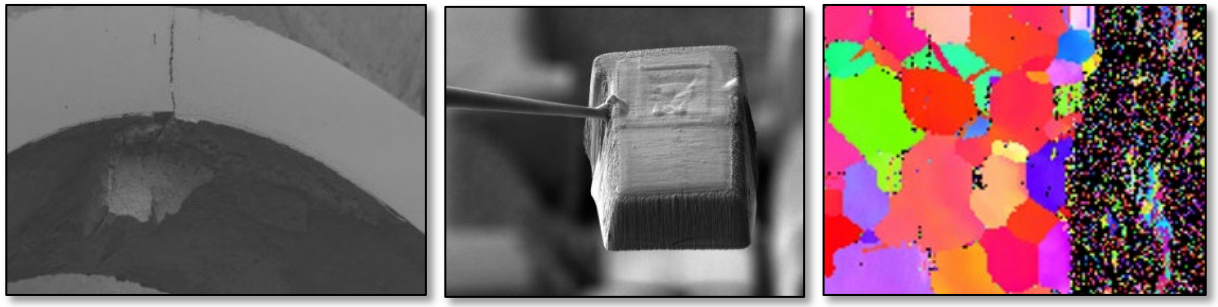
Key contact: samir.demoraesshubeita@manchester.ac.uk

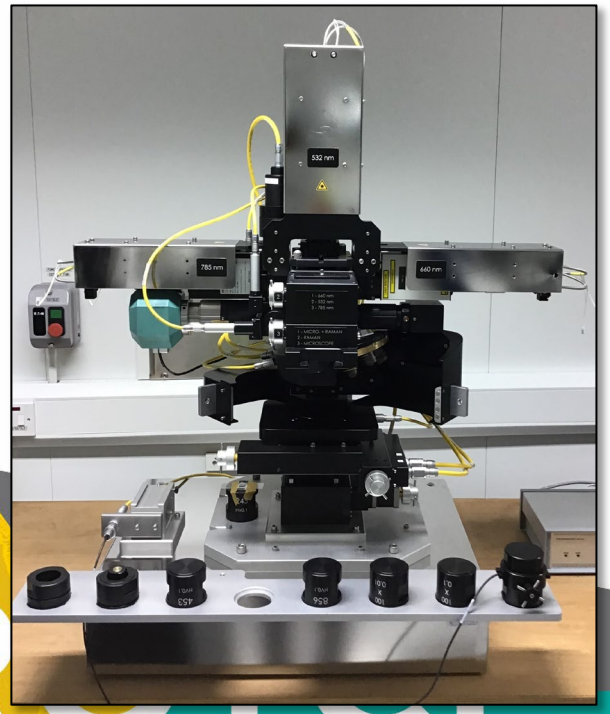
# Technology Platform updates – Active testing (NNL)

**Henry Royce available active equipment:**

- Tescan XEIA Plasma FIB with SIMS, EDS and EBSD
- Helios 600i Nanolab FIB with Cryo Stage
- JEOL 2100 (S)TEM
- JEOL ARM-200F FEG (S)TEM (awaiting final sign off)



*Cube extraction and EBSD analysis of irradiated BWR cladding*



**New Henry Royce equipment:**

- Hot Cell remotely operated optical and Raman microscope:
  - Characterisation of ex-service nuclear material, both fissile and activated using optical, Raman and microhardness capabilities
  - Due for installation in NNL's Active Handling Facility in September 2024
- LAVision DIC: A new 50kN universal test machine from Tineus Olsen:
  - Contains a Linear Variable Differential Transformer (LVDT) for measuring linear displacement which will allow verification of the strain data output.
  - In the early stages of non-active commissioning.

Key contact: Suzy.Morgan@uknnl.com

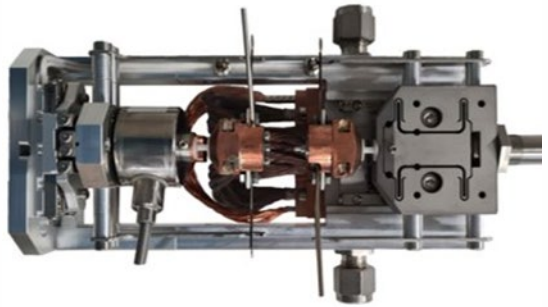
# Technology Platform updates – Active testing (MRF)

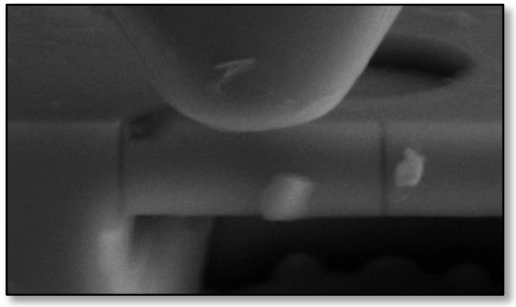
**Henry Royce available active equipment:**

- Tescan Mira3 XMH SEM
- FEI Helios NanoLab 600i FIB/SEM
- Tescan AMBER X P-FIB
- In-SEM Alemnis ASA indenter with a heating-stage (up to 1000°C)
- Rigaku Smartlab X-ray diffractometer (up to 1000°C)
- WITec Alpha 300 ARS Confocal Raman Spectroscopy (up to 1500°C)

**New Henry Royce equipment:**

- Hot Cell extension well underway:
  - Incorporating in cell machining and testing capability
  - 20kN hydraulic load frame with high T capability to 900°C with DIC and 1100°C without
  - Due to complete in March 2025





*In-situ observations of damage mechanisms in active materials*

*Two new cells to be installed with machining and thermomechanical testing facilities*

*Hot-cell decontamination ahead of extension install*

Key contact: ed.eardley@ukaea.uk

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# Irradiated materials archive at UKAEA

- Neutron irradiated samples from the MARIA reactor – most are discs of Ø10 or Ø3 x 0.5 mm and/or 3 x 3 x 3 mm blocks

| Sample | Dose (dpa) | Temps. (°C) | Sample | Dose (dpa) | Temps. (°C) |
|---|---|---|---|---|---|
| W | 0.09-0.62 | 100, 200, 300, 400 | ODS steel | 0.6-1.21 | 100, 200, 300, 400 |
| Ta | 0.6-1.21 | 100, 200, 300, 400 | T91 steel | 0.41-0.83 | 100, 200, 300, 400 |
| Ti | 0.14-0.94 | 100, 200, 300, 400 | 316L SS | 0.13-0.86 | 100, 200, 300, 400 |
| Zr | 0.41-1.35 | 100, 200, 300, 400 | AM 316 SS | 0.18-1.2 | 100, 200, 300, 400 |
| V | 0.19-1.23 | 100, 200, 300, 400 | FeCr (3-14%Cr) | 0.4-0.84 | 100, 200, 300, 400 |
| V-4Cr-4Ti | 0.19-1.21 | 100, 200, 300, 400 | Inconel | 0.22-1.46 | 100, 200, 300, 400 |
| Cu | 0.25-0.82 | 100, 200, 300, 400 | Ni | 0.32-1.06 | 100, 200, 300, 400 |
| Cu 15/25/60Al | 0.12-0.82 | 100, 200, 300, 400 | REBCO | 0.44-0.89 | 100, 200 |
| CuCrZr | 0.12-0.81 | 100, 200, 300, 400 | SNG | 0.33-1.04 | 200, 300, 400 |
| EUROFER97 | 0.4-0.83 | 100, 200, 300, 400 | Gilsocarbon | 0.16 | 100, 200 |

- If interested in access, a workshop is being organised by UKAEA later this year. https://doodle.com/meeting/participate/id/bqD7Wxra or contact: heidi.edwards@ukaea.uk

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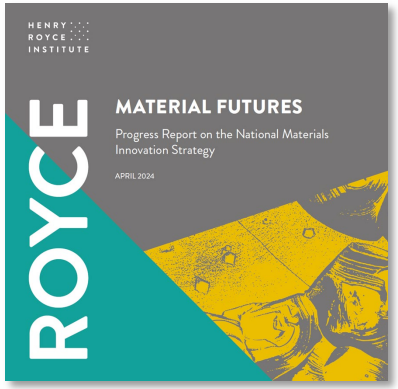
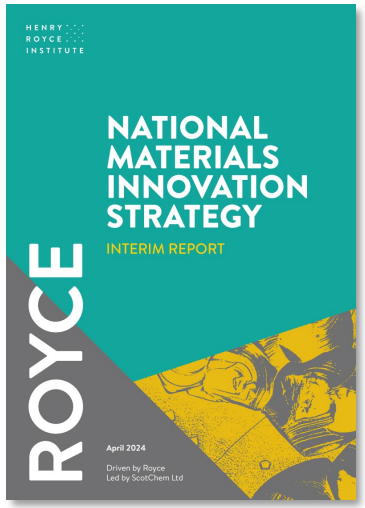
# National nuclear materials strategy

- **Henry Royce released two new reports on the UK's Materials Strategy:**
  - Core theme 1: Energy – Advanced nuclear fuels
  - Core theme 4: Structural Materials – Specialist structural materials for demanding environments such as in nuclear fission and fusion reactors

https://www.royce.ac.uk/content/uploads/2024/04/Royce-National-Materials-Innovation-Strategy-April-2024.pdf




**Fusion Materials Roadmap v2: Pillar leads kick-off meeting held on the 10th of June 2024**

UK-Fusion-Materials-Roadmap-030921-Interactive.pdf (ukaea.uk)

**Version 2.0 will:**

- Update current state-of-play, based on recent advances in fusion materials development.
- Ensure the entire range of fusion materials challenges are captured.
- Focus on magnetic confinement (highlighting cross-overs with other fusion tech) and journey to UK commercial fusion: **facilities and funding required.**

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# Royce Industrial Collaboration Programme

**Good success for nuclear-focused research projects in the recent Royce ICP call:**

- Amy Gandy - UK Atomic Energy Authority

*"Demonstrating UK capability in near net shape manufacture of complex ODS steel components for fusion energy using scalable techniques"*

- David Allen – European Technology Development Ltd

*"Novel elevated-temperature "BRAFM" boronated steels – optimised tantalum alloying for fusion energy applications (INFUSION)"*

- Yiqiang Wang – UK Atomic Energy Authority

*"Prediction of RAFM steel components performance with designed microstructures"*

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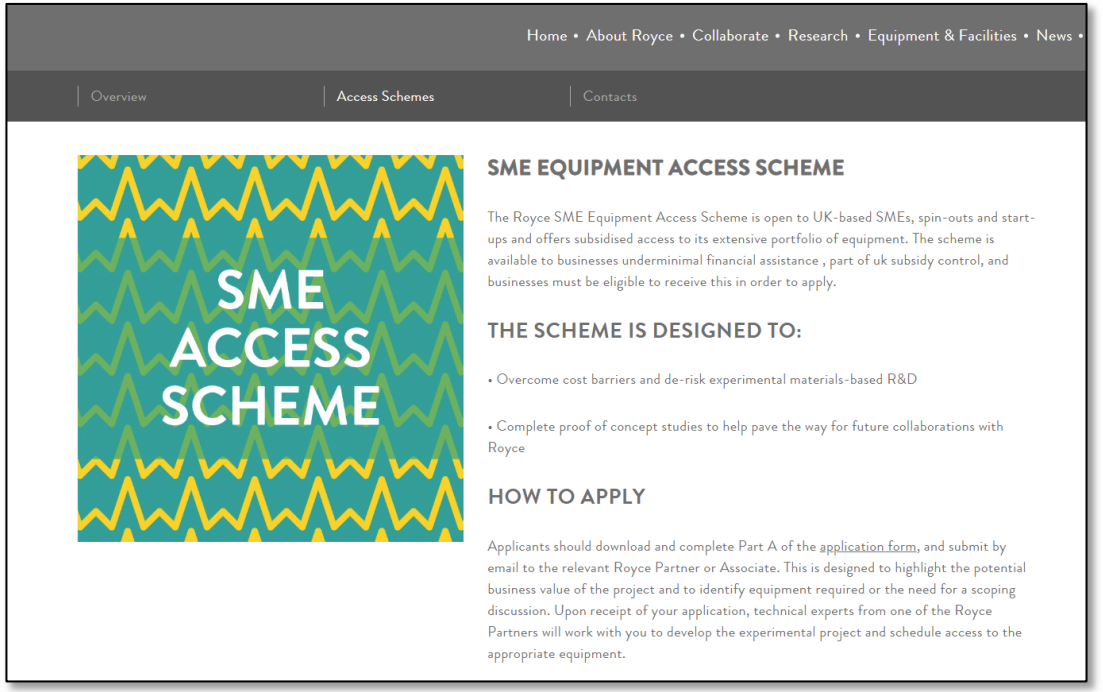
# Royce Subsidised Access Schemes and ICP

1. Researcher & Student Equipment Access Scheme
   - Open to UK based doctoral and research masters students, and researchers at all stages of their career from PDRAs through to tenured academics.
2. SME Equipment Access Scheme
   - Open to UK-based SMEs, spin-outs and start-ups to overcome cost barriers and derisk experimental materials-based R&D
   - Help pave the way for future collaborations with Royce
3. Annual Industrial Collaborative Programme (ICP).
   - Universities, Research and Technology Organisations and companies can apply for funding to explore innovative ideas with a focus on technology translation.

- Royce has an extensive catalogue of equipment including facilities to make, test and characterise materials: www.royce.ac.uk
- General enquiries: info@royce.ac.uk

**Fill in the form on the Royce access scheme website**




Royce Access Schemes - Henry Royce Institute

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