National Nuclear User Facility

NATIONAL NUCLEAR LABORATORY

CCFE
CULHAM CENTRE FOR FUSION ENERGY

MANCHESTER 1824
The University of Manchester
Dalton Nuclear Institute

HM Government

Industrial strategy: government and industry in partnership

The UK's Nuclear Future

Imperial College London

UNIVERSITY OF OXFORD

Background

- In March 2013, as part of its Nuclear Industrial Strategy, the Government announced the National Nuclear User Facility (NNUF) initiative

- The NNUF is a multi-site facility that provides academia and industry with access to internationally leading experimental equipment for nuclear research on radioactive materials at levels greater than can be handled in university laboratories

- To establish the NNUF, initial funding of £15M provided over three years from 2012/13, via the Engineering and Physical Sciences Research Council (EPSRC)

- The NNUF equipment purchased with the initial funding will be centred at the three complementary hubs of the Central Laboratory of NNL, CCFE and Dalton Cumbrian Facility (The University of Manchester)

The Concept

- The goal is to address key underlying materials problems that must be solved to facilitate the design and safe operation of future reactor fuel cycle and waste technologies (both fission and fusion) and to capture strategic intellectual property for future nuclear systems

- The NNUF initiative is expected to see expansion in future years to ensure adequate R&D equipment capability to cover all nuclear disciplines

- By upgrading our R&D facilities and strengthening the links between existing research groups, this new investment will enhance our use of, and access to, previous substantial UK and European investment

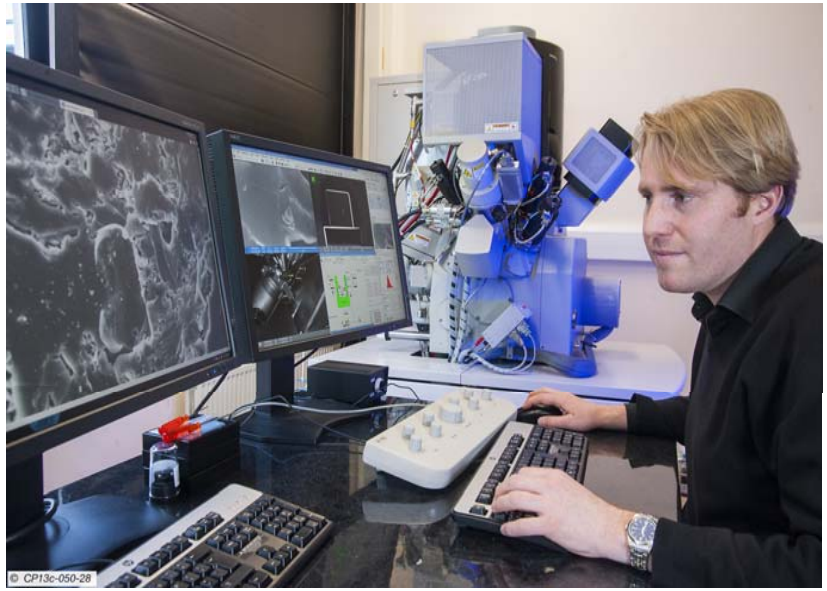
- The NNUF forms part of the overall UK R&D infrastructure to maximise exploitation of the ability to irradiate materials in the new Jules Horowitz Materials Test Reactor at Cadarache

The Facilities – NNL Central Laboratory

- Material processing;
  - Low throughput of higher active materials
- Sample Preparation;
  - FIB & sample preparation suite
- Material characterisation;
  - Comprehensive on-site PIE of active materials (prototypic materials and radiation levels), inc FEG-TEM with high sensitivity X-ray analysis capabilities for atomic-scale compositional mapping (NNUF 13/14)
  - Material transfer + transfer of lower active materials for off-site PIE

The Facilities – Culham

- **Material processing;**
  - Higher throughput of lower active materials
- **Sample Preparation;**
  - Sample Cutting, mounting and polishing
  - Sample FIBing
- **Material characterization;**
  - On-site PIE of active materials – nanoindenter, SEM, outgassing (TDS)
  - Handling & inspection of beryllium & tritiated material
- **Material transfer:**
  - Transfer of lower active materials for off-site PIE



The Facilities – DCF

- Material processing;
  - Induced higher active materials, dual beam accelerator system to support Gen IV technologies
- Sample Preparation;
  - Sample preparation suite
- Material characterisation;
  - On-site PIE of non-active materials
- Material transfer;
  - Transfer of activated materials for off-site PIE

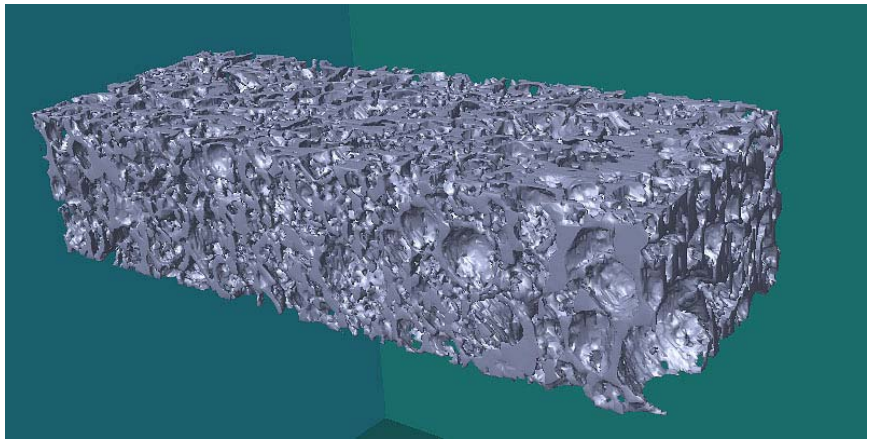
Progress Statement

- All three laboratories (NNL, CCFE, DCF), in collaboration with Imperial College and Oxford University, have commenced purchasing and installing equipment aimed at creating leading edge facilities for the production, handling, and detailed examination of irradiated materials, thus facilitating new insights into material properties and structures to support the development of advanced fission (and fusion) technologies.

- Further, the NNUF investment at DCF is creating the world's highest energy dual beam accelerator system, capable of replicating the material damage associated with Generation IV reactor systems.

- Some major equipment items have already been installed and are operational, either in a non-active or in some cases active mode, and are starting to attract requests for access from universities (eg Manchester/Bristol), and there are plans to deploy the new capabilities to support industry needs.

NNL early NNUF based studies



- 11 Megapixel micro-Computed Tomography.
- Up to 8000X8000 pixel images for each slice.
- Resolution limit of ~0.8µm
- Object sizes up to 27mm (or 50mm using multiple scans).
- Provides detail of internal structure non-destructively including quantitative measurements of porosity
- Provides measurement of relative density

NNL early NNUF based studies

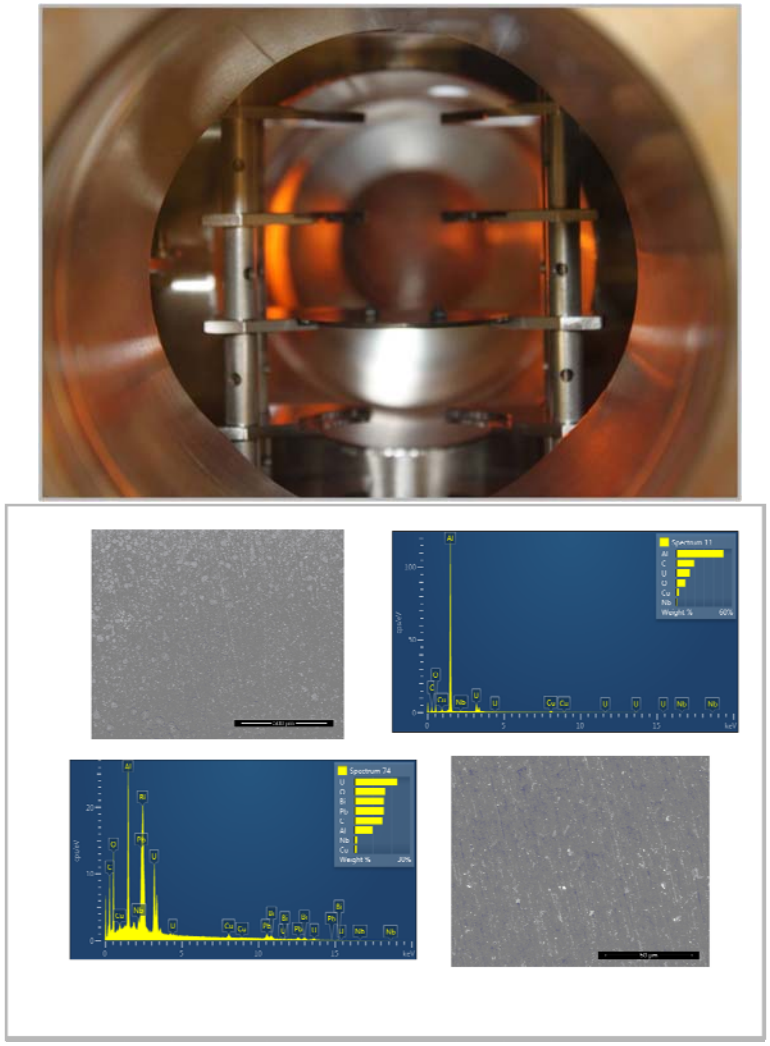
NNL IR&D Carbonaceous deposit on AGR Fuel Pins

- Measure thickness, porosity and density
- Characterise structure
- Use above results to assist the evaluation of impairment of heat transfer from fuel pin to coolant caused by deposit

Manchester University Characterisation of AGR Core Moderator Graphite

- Characterise porosity, including open/closed porosity
- Evaluate density profiles through samples

DCF early NNUF based studies



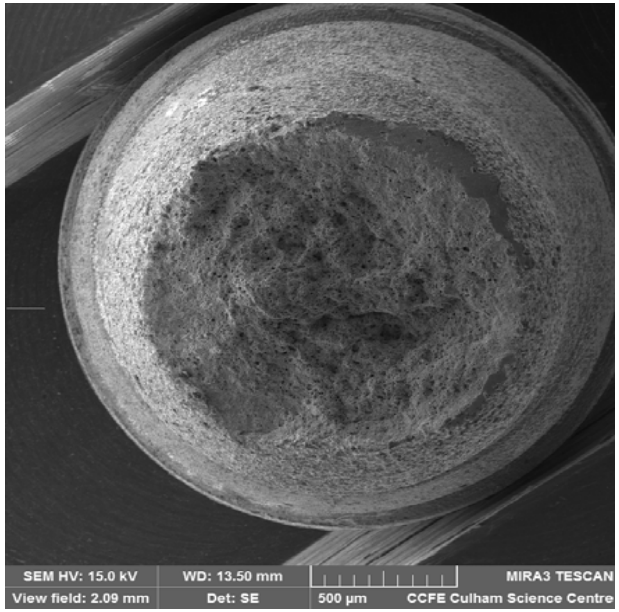
- Area of research; improving models for energy loss of ions in materials - uranium dioxide & silicon carbide
- University of Bristol; Magnetron sputtering loading chamber to form uranium oxide thin films on glass and aluminium
- DCF – Irradiation of uranium dioxide target with 7 - 10MeV He2+ ions at 50 - 150nAmps
- DCF – FEGESEM with EBSD analysis to compare pre and post irradiation elemental spectra

CCFE early NNUF based studies

- Dual beam FIB, Nanoindenter, SEM
- Available now for non-active specimens, new building with hot cells operational in 2015
- Bristol and Oxford using it already, discussions with Imperial starting
- See CCFE staff at this meeting – Damian Brennan, Chris Hardie and Martin O'Brien

SEM Fracture image of novel Hf-containing ODS steel, from mechanical alloying followed by hot isostatic pressing and hot forging, for possible Gen-IV fission and fusion applications

Courtesy M Gorlay (Oxford University)



NNUF – Benefits (academic and industrial)

- Provide the R&D infrastructure to facilitate the design and safe operation of reactor fuel cycle, decommissioning and waste management technologies
- Support and develop the environment for greater collaboration between industry, academia and the public sector
- Creation and capture of strategic intellectual property: support the more effective translation of academic ideas into industrial prosperity
- Provide the opportunity for greater engagement in international research and development programmes in partnership with industry, and
- Ensure the UK has the necessary skills for the future

NNUF – Next Steps

- The NNUF Steering Group currently comprises representatives from CCFE, Imperial University, Manchester University, Oxford University, and the NNL. It is proposed to expand this membership to include other universities and we would like two to be nominated via this workshop.

- A separate workshop will be held to discuss the direction and priorities for future NNUF related purchases (post 15/16) – probably in conjunction with another major UK based nuclear conference.

NNUF – Material Archive

Nuclear Energy Research and Development Roadmap: Future Pathways identifies the following enabling action:-

'Establish organisational infrastructure (a 'National Nuclear User Facility' (NNUF)) to ensure access to key active research facilities, equipment and materials for the wider nuclear research community'

We have opened discussions with the NDA with regard to conducting a review on the potential formation of a national nuclear and irradiated material archive.

NNUF – Material Archive

The outline proposal suggests that the Review would include:

i. a statement of perceived material ‘needs’ based on a stakeholder survey (to include the NDA, SLC's, NNL, industry and academia)

ii. an assessment of the available materials (to include identification of the current ‘stewardship’ arrangements, location and timeframe for potential disposals)

iii. an assessment of the benefits of international collaboration (ie access to other material archives)

NNUF – Material Archive

iv. an assessment and recommendations of future storage arrangements (eg a centralised or dispersed archive)

v. an assessment and recommendation of ‘stewardship’ arrangements (including addressing the processes for the assessment of changing needs and agreement to dispose of items)

vi. an initial assessment of costs associated with iv) and v) above

Material Movement

Move	Item	Activity	Container
248	Ferritic steel swarf to NNL Preston Laboratory	1.55E+06 Bq ^{60}Co	Al cans inside a Pelicase
219	39 x 3mm TEM steel discs to Oxford University	65000 Bq ^{60}Co	Zarges Box
199	12 x solid irradiated steel needles (crimp mounted in copper) to Oxford University	20000 Bq ^{60}Co	Zarges Box
157	3 x U/Nb alloy samples to NNL Preston Laboratory	96573 Bq ^{238}U	Clamped Steel Drum
156	4 x 3mm TEM discs of U/Nb alloy to JEOL UK	40 Bq ^{235}U 859 Bq ^{238}U	Al brief case