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## **Materials Science Research – An Overview**

Presentation to China Academy of Engineering Physics – June 2012

By





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# Introduction

- AWE has developed dedicated capabilities in
  - New/replacement materials development and qualification
  - Materials ageing and lifetime prediction and compatibility
  - Materials characterisation
- AWE provides chemistry and materials science expertise in the following areas:
  - High explosives research and analysis
  - Plutonium and uranium chemistry & metallurgy research
  - Non-metallic materials (organic and inorganic) research
  - Tritium science and technology
  - Radiochemistry, mass spectrometry and spectroscopy capability



# Materials Science Research Division



**Characterisation, Materials Life Assessment,  
New Materials Synthesis/Development**

Actinide Chemistry and Metallurgy

Tritium Science, Handling and Storage

High Explosives Synthesis and Characterisation

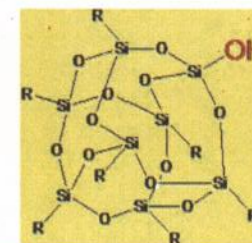
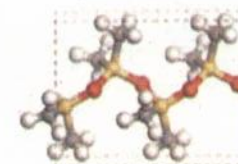
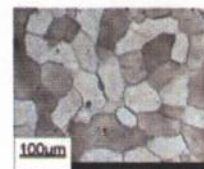
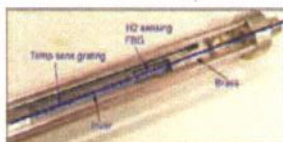
Organic and Inorganic Materials R&D

Materials Modelling, Ageing and Compatibility

Spectroscopy and Sensors Development

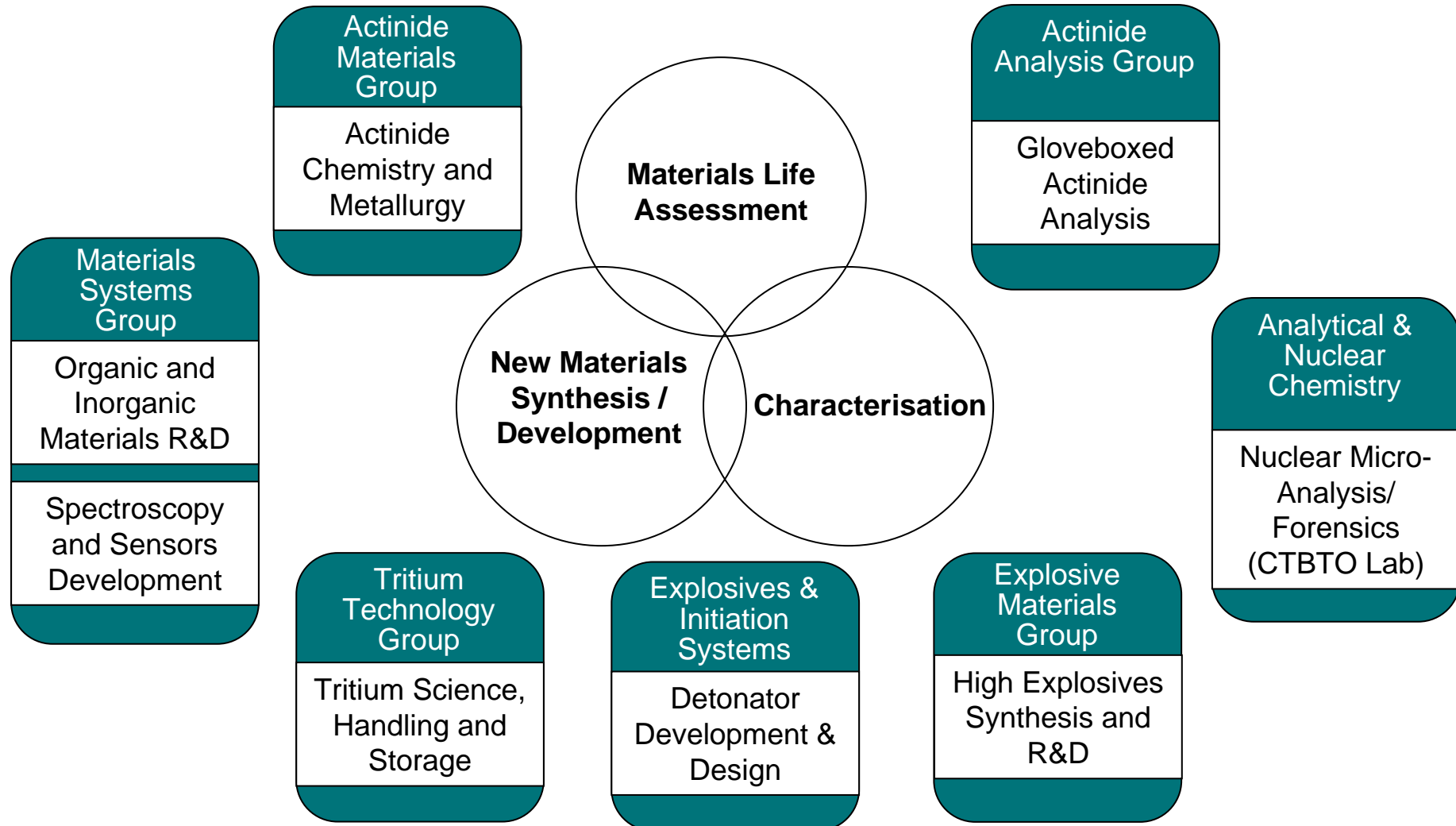
Analytical Chemistry, Radiochemistry

Nuclear Forensic Science/Micro-Analysis



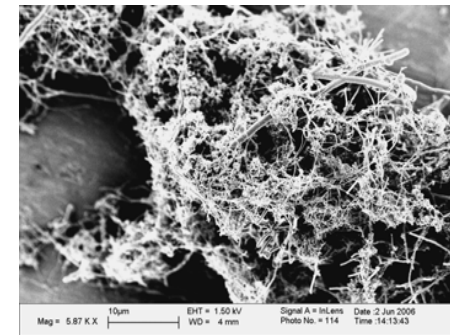
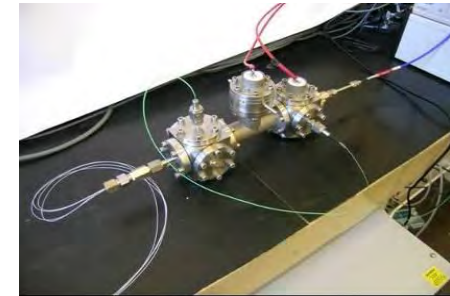


# Materials Science Research Division

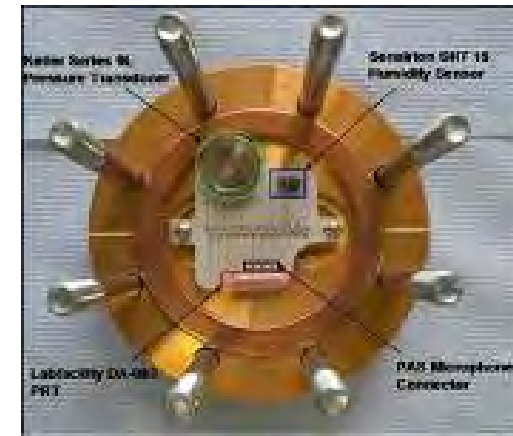


# Materials Systems

- Organic Materials
  - Ageing & Lifetime Assessment – **Multi-Material trials**
  - New Materials Synthesis and Development
  - **New Characterisation and Analysis Methods**
- Metallic Materials
  - Accelerated Ageing
  - **Mechanical and Fracture Testing**
  - Continuum Modelling of Manufacturing and Corrosion Processes
- System Monitoring
  - Sensor development
  - Materials Compatibility & Ageing



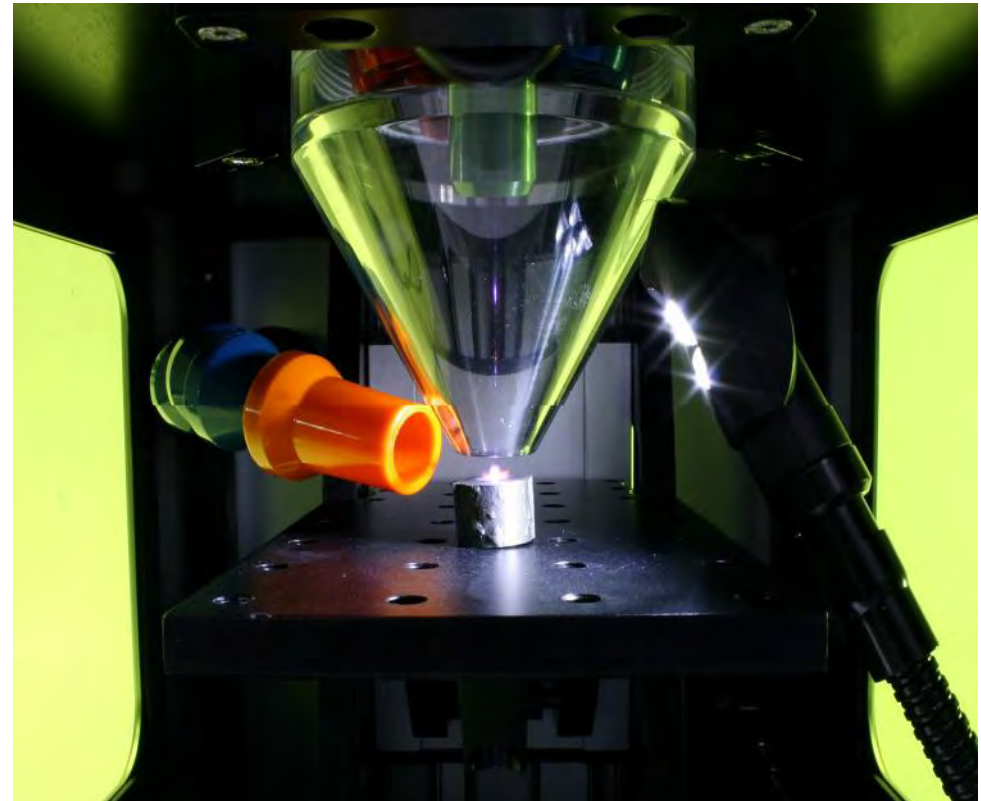
## Multi-Material Trials



- Accelerated ageing experiments for multiple material combinations
- The atmosphere provides information regarding the degradation and interactions of materials within the vessel
- Designed to study the interactions between materials
- Provides data for system/sub-system life prediction models

## New Characterisation and Analysis Methods

- Laser absorption spectroscopy
- Laser-induced breakdown spectroscopy
- Fibre optic sensors
- Micro-structured gas cells
- Logistics condition monitoring devices
- Embedded sensing



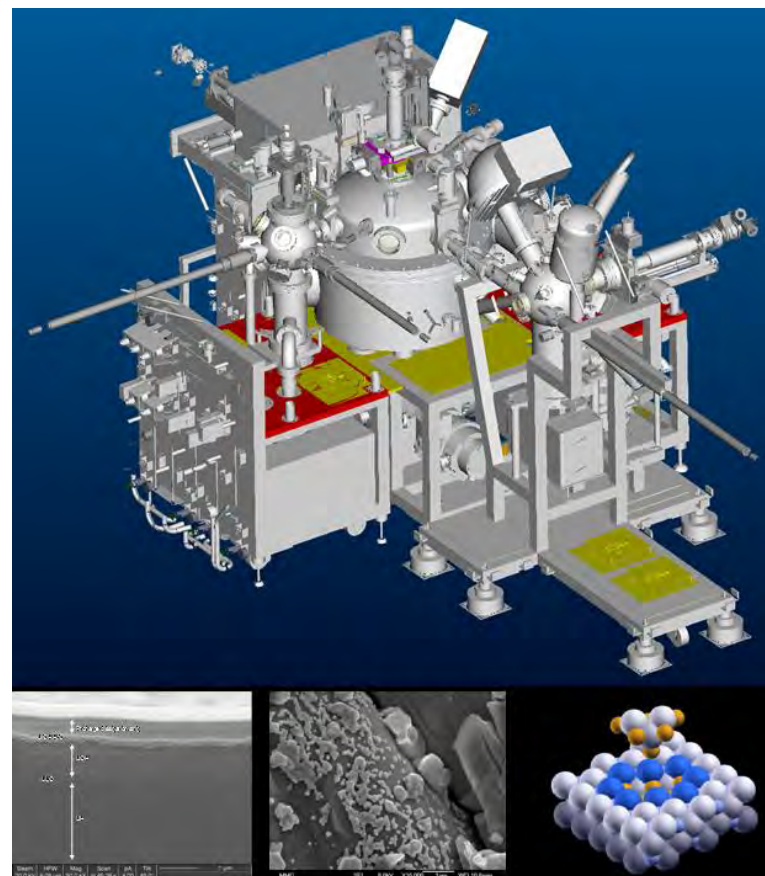
LIBS analysis of material samples

# New Characterisation and Analysis Methods

## Inorganic Surface Science

### Capability

- X-ray & UV photoelectron spectroscopy
- Auger electron spectroscopy
- Low energy electron diffraction
- Secondary ion mass spectrometry
- Molecular beam ( $O_2$ ,  $H_2$ ,  $H_2O$ ,  $CO_2$  and  $H_3CCOOH$ )
- Sputter source and gas-atomiser
- Metal vapour deposition
- Secondary Electron Multiplier
- Dedicated glovebox for sample handling
- Thermal desorption studies
- Mass spectrometer
- Vacuum transfer vessel



ISSC apparatus



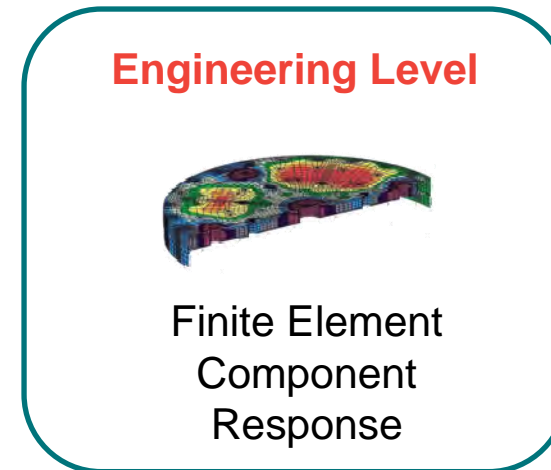
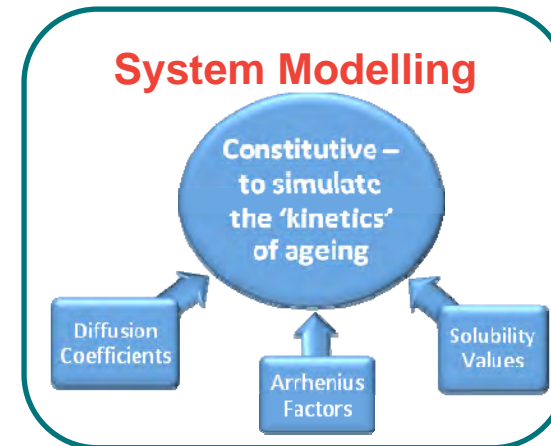
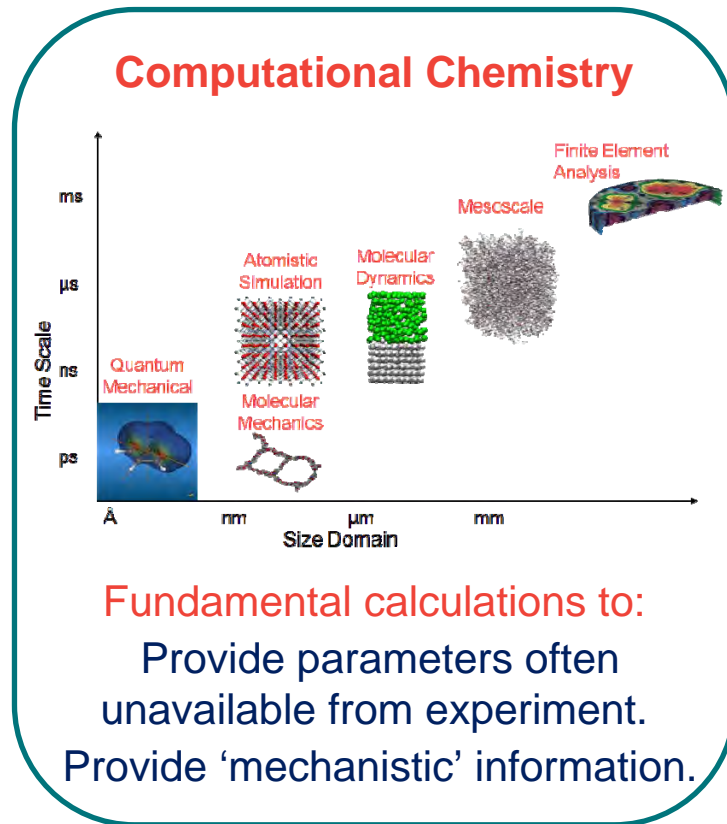
# Metallic Materials-Mechanical and Fracture Testing

- Mechanical Testing
  - Compression and tension, quasi static to  $10^3 \text{ s}^{-1}$
  - Fatigue and fracture mechanics testing
  - Environmentally assisted cracking testing
  - Indentation and impact excitation testing
- Electron Microscopy
  - FEG-SEM with EDS, EBSD, STEM
  - TEM with EDS
- Raman Spectroscopy
  - Raman for analysis of corrosion products
- Electrochemistry
  - Standard electrochemical polarisation equipment
- NDE
  - Robot mounted eddy current and conductivity systems for automated scanning of components

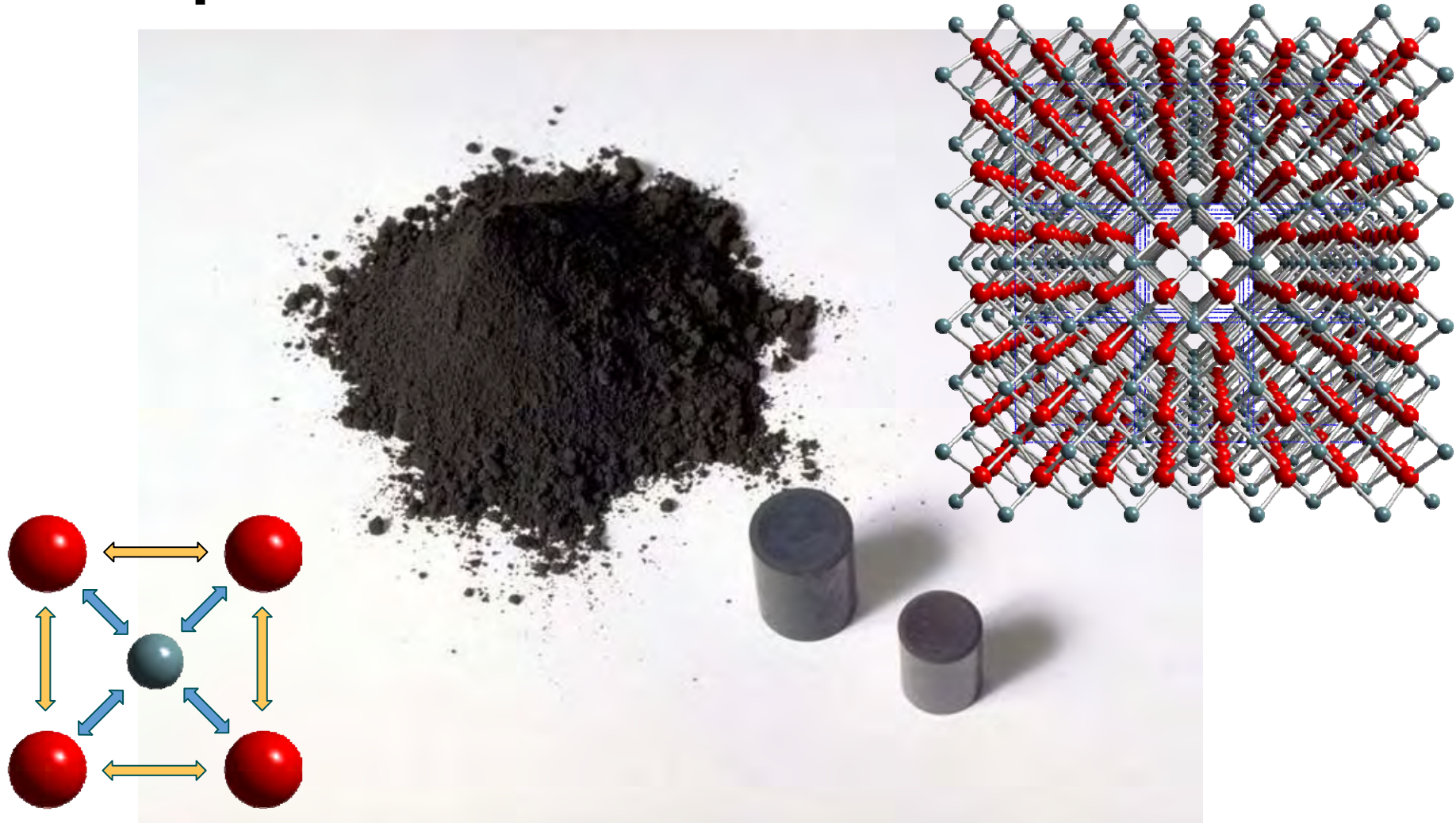


FEG-SEM

# Ageing Models and Life Prediction



# Example : Simulation of Uranium Dioxide

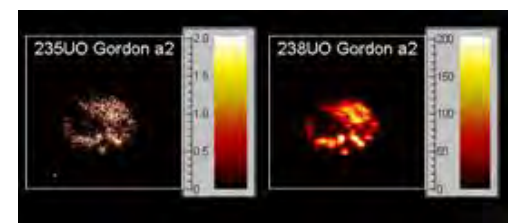




# Analytical And Nuclear Chemistry

## Radiochemical Sciences

- Radiochemistry & Radiometry
- UGT Rad-chem Data
- Fissile Particle Detection/Analysis



## CTBTO GB15 Laboratory

## Mass Spectrometry

- Gas & Organics
- Warhead Isotopics
- Trace Actinide Isotopes
- SIMS & Organics

## Nuclear Forensic Capability

- Conventional Samples Laboratory



# Explosive Materials

- Ageing and Life Prediction
- New Materials
  - Synthesis of Novel Energetic Ingredients
- Chemical Characterisation
  - Explosive Chemical Analysis
  - Trace Explosives Analysis
  - Compatibility
- *Physical Characterisation*
  - *Explosive Hazard Testing*
  - *Mechanical Properties*
  - *Particle Characterisation*
- *Formulations*
  - *Future Plastic Bonded Formulations*





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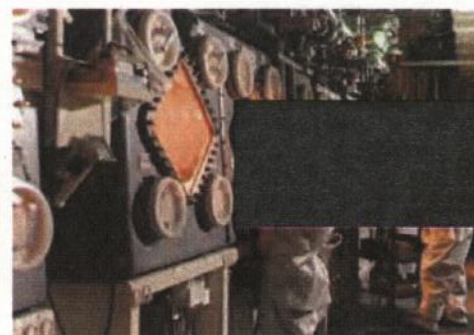
# Actinides Analysis

## Operations

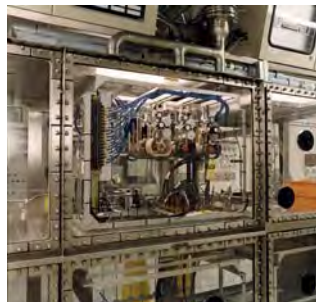
- Glovebox Facility
- Component Certification
- Process Control
- Ageing
- Actinide Material Recycle [INRM]
- Inter-lab Comparison Exercises

## Development

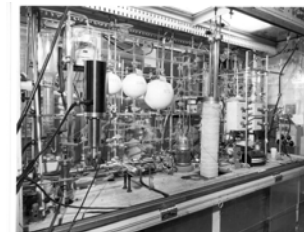
- Decrease Risks
- Reduce Wastes
- Reduce Wet Chemistry



# Tritium Technology



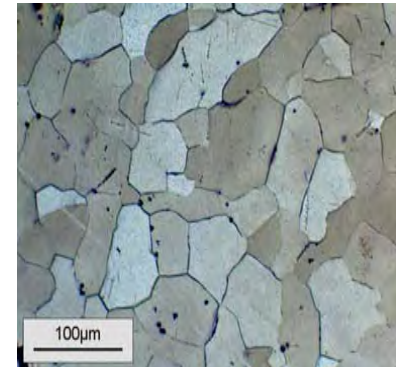
- Purpose built tritium laboratory with Modern Standards Safety Case
- Tritium 'Loading'
  - Hydrogen storage beds
  - Accelerator Targets
- Hydrogen Adsorption Studies
  - Thermodynamics and Exchange Kinetics
  - Ageing – tritium and helium release studies
- Tritium Analysis
  - Gas assay – High resolution tritium and Helium



# Actinide Materials

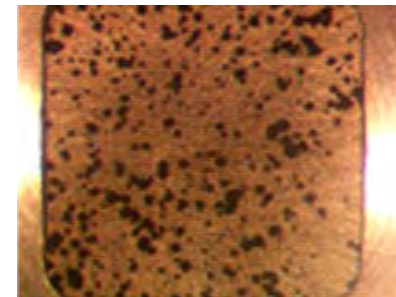
## Metallurgy and Materials Microstructure

- Modern set of in-box equipments
  - DSC, FEG-SEM, EPMA etc
- Materials characterisation and stability studies
- Casting Development – inc modelling



## Chemistry

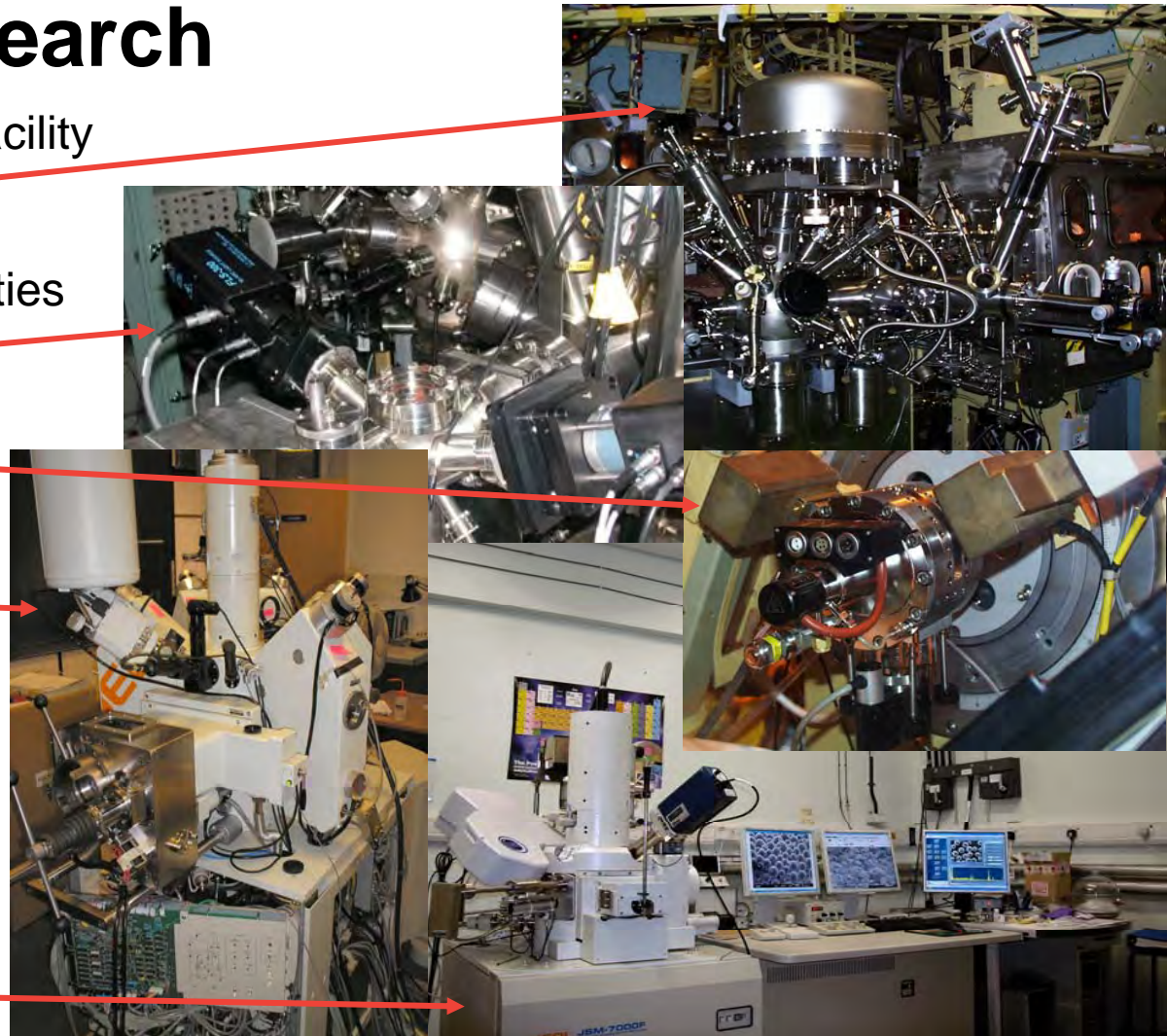
- Hydriding – testing and characterisation
- Oxidation Characterisation
  - XPS, ellipsometry, FTIR
- Computational Chemistry
  - Mathematical and Molecular modelling





# Plutonium Research

- Pu Corrosion Research Facility
- XPS/UPS
- Hardness/tensile test facilities
- Ellipsometry
- XRD
- Heat treatment furnaces
- EPMA
- SIMS
- DSC & TMA
- Density measurement
- Casting furnaces
- FEGSEM





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## Summary

- AWE supports the UK's National Nuclear Security by providing materials science expertise in the following areas:
  - High explosives research and analysis
  - Plutonium and uranium chemistry & metallurgy research
  - Non-metallic materials (organic and inorganic) research
  - Tritium science and technology
  - Radiochemistry, mass spectrometry and spectroscopy capability
- Materials that are sustainable, well-characterised, with controlled manufacturing processes and consistent properties.