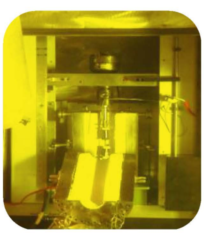
RADIOMETALLURGY LABORATORY

Radiometallurgy Laboratory (RML) was established in IGCAR in 1985 with a hot cell facility adjoining the FBTR to cater to the PIE requirements of FBR programme. The laboratory has seven interconnected concrete shielded hot cells capable of handling irradiated subassemblies with activity upto 5.5×10^{6} GBq with gamma energy of 1 MeV and a lead shielded cell which can handle activity upto 3.7×10^{4} GBq. The hot cells are of α, β, γ type with inert atmosphere ventilation to handle plutonium rich, reactive fuels. Hot cells have infrastructure such as alpha tight transfer systems, remote handling and viewing etc. and have equipments for comprehensive non-destructive and destructive examinations of fuel and structural materials.



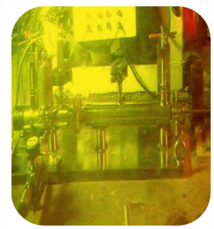


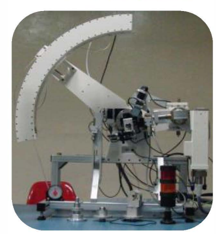
FACILITIES

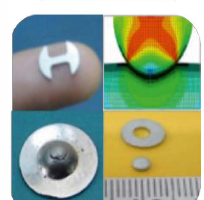
- Remote handling & viewing equipment
- In-cell equipment for metrology & NDT
- Laser based dismantling machine
- Fission gas analysis – GC and MS
- Remote specimen preparation systems
- SEM, TEM and XRD for irradiated materials
- Remote Tensile & Impact test machines
- Small specimen testing equipment
- Axial and radial gamma scanning systems
- Neutron source facility - “KAMINI” reactor
- BF_3 based waste drum monitor
- Digital Image Correlation (DIC) system

EXPERTISE

- Design, construction & operation of hot cells
- Characterisation of irradiated materials
- Design and development of hot cell equipment
- Remote & contact maintenance of in-cell equipment
- Development of miniature specimen testing
- Failure analysis of nuclear components
- Neutron radiography of nuclear & space components



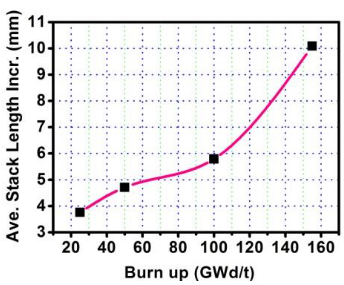


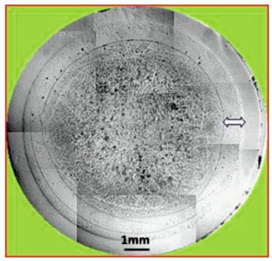


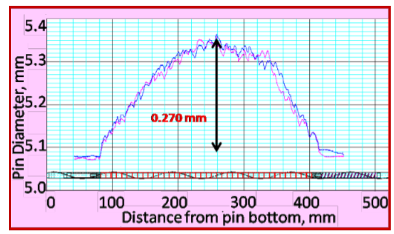
SIGNIFICANT ACHIEVEMENTS

Burnup extension of FBTR fuel

- Hyperstoichiometric ($U_{0.3}$ $Pu_{0.7}$)C, He bonded, 83 % smear density
- 20 % CW SS 316 Clad and Wrapper material
- Peak Burnup & LHR - 155 GWd//t, 400 W/cm
- Peak displacement damage – 83 dpa







- Fuel swelling rate of ~1.2% per at.% BU, lower than anticipated

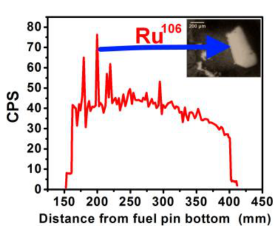
- Porosity exhaustion after 155 GWd/t due to FCMI
- Absence of clad carburisation

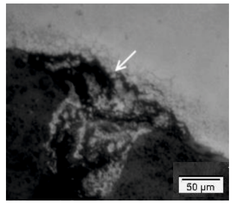
- Maximum clad strain – 5% resulting from void swelling

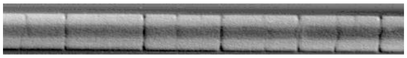
Performance assessment of MOX fuels

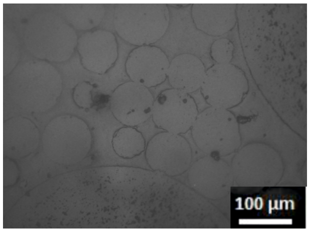
- Test irradiation of PFBR MOX fuel-($U_{0.71}Pu_{0.29}$)O_2
- Alloy D9 Clad and Wrapper material
- Peak Burnup & LHR -112 GWd//t, 450W/cm,
- Displacement damage – 60 dpa

- MOX sphere-pac fuel pins ($U_{0.56}Pu_{0.44}$)O_2
- Alloy D9 Clad
- BOL restructuring behavior evaluated
- 300 hr irradiation at peak LHR of 260 W/cm









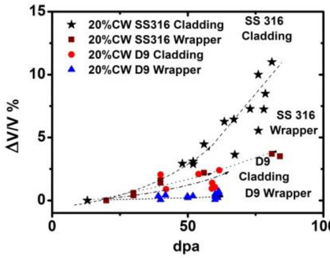
- Fission gas Release: 85%
- Central channel shrinkage at core top location

- Segregation of metallic fission products in central channel
- FCCI and clad wastage of around 100 µm

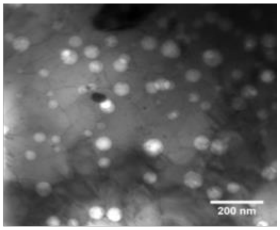
- Formation of porosities in the central region
- Initiation of necking and sintering of microspheres

Performance Assessment of Structural & Shielding Materials

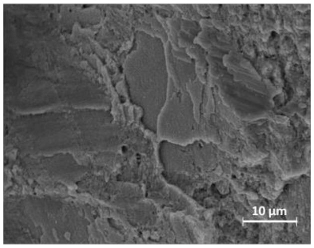
- **Replaceable Structurals: Wrapper/Cladding**
  - 20% CW 316, D9 (Ti mod 316)



- Low swelling of Alloy D9 clad

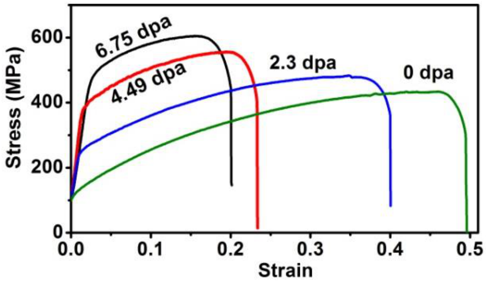


- Voids in SS316 clad

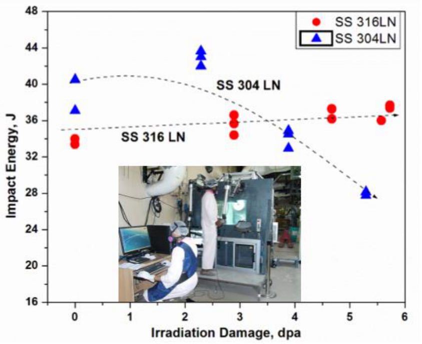


- Channel fracture of 20%CW SS 316 clad at 83 dpa

- **Permanent Structurals: Reactor Vessel, Grid plate**
  - Annealed 316, 316LN, 304LN



- Test coupons irradiated in FBTR to low dose
- Retention of adequate Tensile ductility

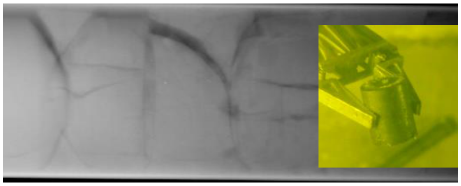


- Retention of Tensile & Impact properties of 316 LN better compared to 304LN

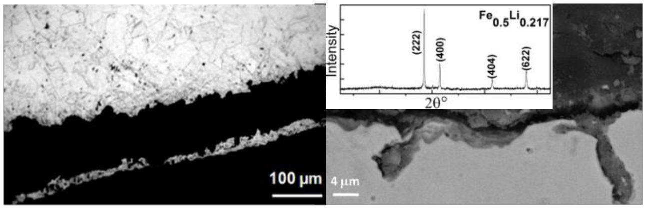
Shielding Materials

- **Boron Carbide B_4C**
  - PIE of B_4C control rod exposed to 7.0 x 10^{22} nvt fluence to assess ^{10}B depletion, pellet swelling and Pellet - Clad interaction

- **Ferroboron (FeB)**
  - Advanced shielding material for future FBRs
  - Significant cost savings due to core volume reduction



- Cracking of pellets & "Na" ingress
- Marginal swelling in highly exposed pellets



- Reduction in clad wall thickness ~200 µm
- Formation of Fe-Li phase at FeB- clad interface

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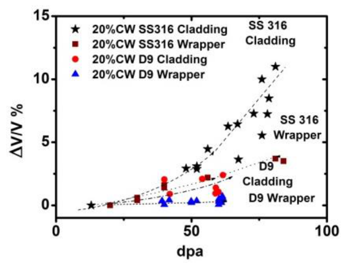

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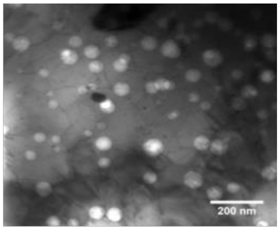
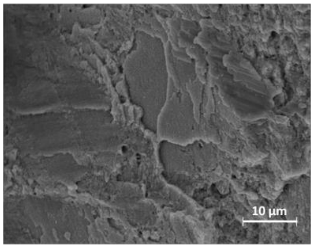


• Voids in SS316 clad



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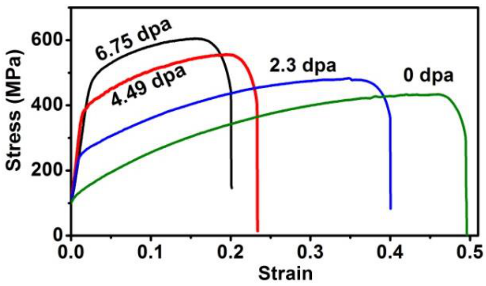

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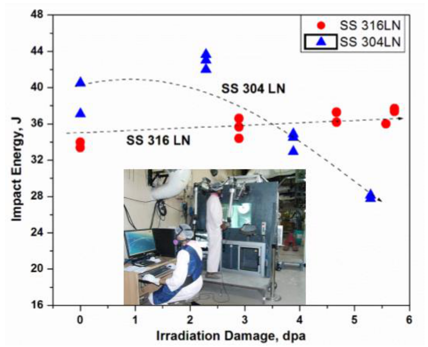

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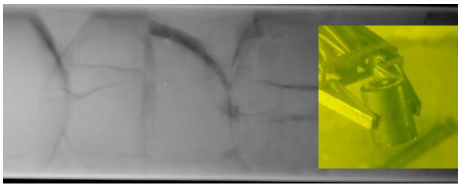

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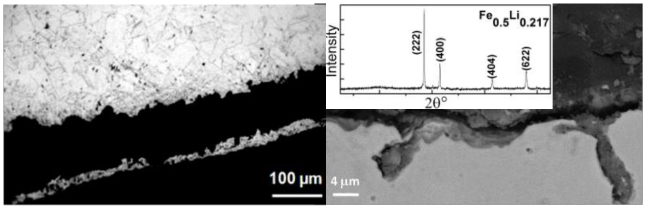

• Reduction in clad wall thickness ~200 µm
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RADIOCHEMISTRY LABORATORY

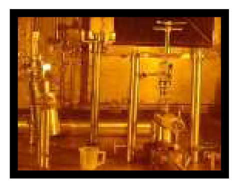
Hot cell facility of the radiochemistry laboratory (RCL) was commissioned in 1992 to carry out the post irradiation examination of the FBTR and MAPS fuel. The facility consists of five hot cells in a row and all are under one roof of 12.45 m high bay, equipped with Master slave manipulators and in-cell cranes. Each of these cells is designed to handle 370 TBq of Co-60. Radiation shielding is provided by 1500 mm thick ordinary concrete (2.4 g/cc) in the front and the rear side and by 900 mm thick high density concrete (3.5 g/cc) in between the cells. Mini Hot Cell of RCL is a shielded facility with 300 mm thick Lead brick walls around. These mini cells contain Glove boxes and sample transfer ports compatible with Hot Cell ports.

HOT CELL OF RCL

MINI CELL OF RCL

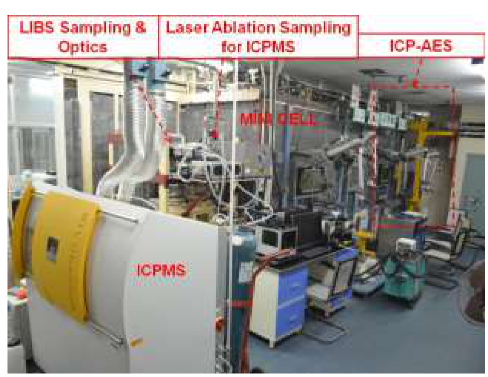
FACILITIES

- Fuel pin puncturing device
- Dissolution of irradiated fuels from MAPS and FBTR
- Transportation and remote handling of solid / liquid radioactive materials
- Laboratory scale pyro-processing facility for irradiated fuels
- Facility for dissolution and Solvent Extraction of Strontium-89 from irradiated yttria pellets
- Mixer-settler facility for minor-actinide partitioning from HLLW



ANALYTICAL FACILITIES

- Thermal conductivity measurement apparatus,
- ICP-AES for elemental characterization of active samples, ICP-MS and LIBS.
- ICP-MS augmented with Laser ablation sampling facility for solid sample analysis
- LIBS to characterize both solid and liquid samples.

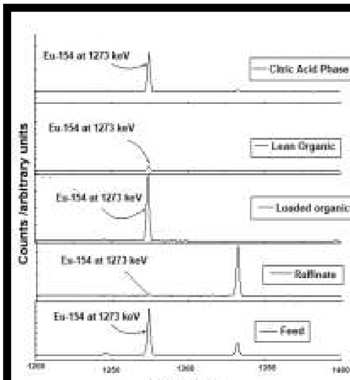


EXPERTISE

- Design and development of in-cell equipments adaptive to hot cells.
- Remote repair and maintenance of in-cell facilities
- Characterization of irradiated fuels
- Regeneration of window oil
- Retrieval, Servicing and Re-fixing of Radiation Shielding Window
- Maintenance of argon atmosphere containment box with less than 50 ppm of moisture and oxygen

SIGNIFICANT ACHIEVEMENTS

- Design and fabrication of a special alpha tight vessel for transportation of 2.5L HLLW from RDL to RCL
- Demonstration of Minor actinide partitioning from HLLW [155GWD/T] using the 16 stage ejector mixer settler.
- Design, Fabrication and commissioning of a Pick & Place radial hoist crane with precision movement control from operating area for the pyro-process facility in hot cells.
- Electro-refining of U-Zr fuel and demonstration of Uranium deposit on the cathode by remote operations inside hot cell
- Complete dissolution of irradiated yttira pellets in high acidic condition without any residue or vapour loss.
- Design, fabrication and commissioning of a remote quartz tube cutting device for retrieval of the irradiated yttria pellets.
- Separation of Strontium-89: a pain palliative medicine for bone cancer metastases from irradiated yttria dissolver solution by solvent extraction process



Gamma Spectrum of samples obtained from minor actinide partitioning