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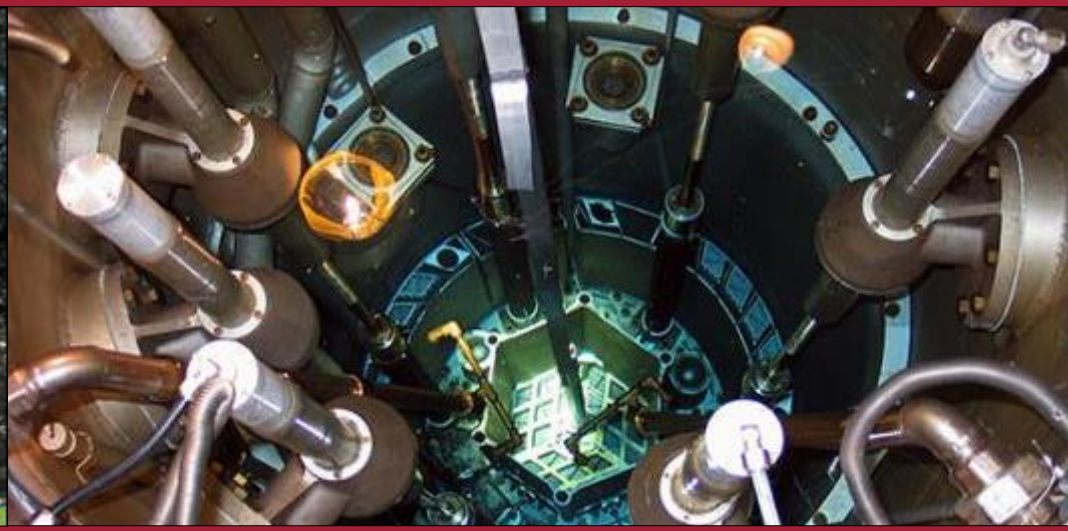

Planned FHR IRP-2 Tritium Experiments at the MIT NRL

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Outline

- Post-Irradiation Examination for FS-1/2
  - Thermal tritium release
  - Imaging
  - Other methods
- IRP-2 Experiments
  - Tritium uptake in graphite
  - Tritium and activation product release
  - Tritium diffusion from salt through metals
  - Ongoing PIE
- Suggestions, Lessons Learned?

Planned Post-Irradiation Tritium Tests

- Thermal release measurement of tritium uptake
  - Components of FS-1 and FS-2 will be progressively heated to above their irradiation temperatures to examine the tritium release
  - Important to have real-time and LSC measurement

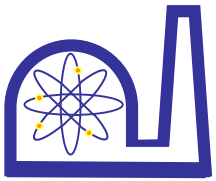
- New methods for tritium measurement are being examined:
  - Graphite powdering and/or digestion followed by LSC
  - Pyrolysis followed by LSC
  - Proton or deuterium ion beam irradiation and gamma or fast neutron detection
  - Beta-plate imaging (concentration and gradients)

Upcoming MITR FHR Irradiations




- Designing new experimental facilities based on lessons learned from the first two flibe irradiations
  - Control of salt condensates to prevent accumulation in gas lines
  - Off-gas holdup for short half-life decay (N^{16} and O^{19})
  - Avoiding <200°C radiolysis (fluorinated compound production)
- Collaboration with Chinese Academy of Sciences on irradiation of new graphite and SiC materials in flibe
- Three types of experiments planned for IRP-2
  - Release of tritium and activation product gasses from flibe
  - Tritium uptake on graphite
  - Tritium diffusion through metals

(1) Tritium and Activation Product Release



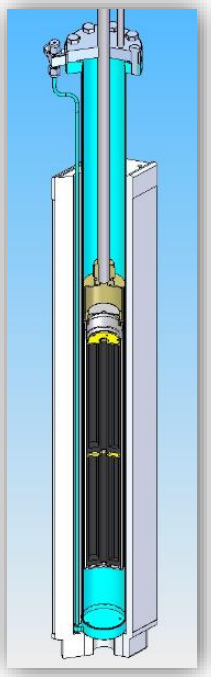
- Initial MITR irradiations highlighted (1) the effects of unmitigated activation and radiolysis product release, and (2) variability of that release with the salt temperature

- This test is dependent on simulating the FHR core environment because the proper neutron spectrum, neutron and gamma flux, and temperature is needed

- Planning new dedicated salt irradiation facility
  - Minimize tritium sinks
  - Maximize possible flibe volume
  - Variable cover gas (sparging?) with optional H injection up- and downstream
  - Improved “fast sampling”
  - Freedom to vary reactor power / temperature (electrical secondary heating)

(2) Tritium Uptake in Graphite

- The capture of tritium via adsorption onto or diffusion into graphite has the potential to be the primary method of tritium inventory management during FHR operation.
  - Tritium uptake into graphite observed during initial irradiations, but was not primary focus



- Options for uptake facility
  - In-core, most representative environment but most limiting for size, controls, sampling
  - Independent facility using tritiated flibe generated in the MITR, gives flexibility

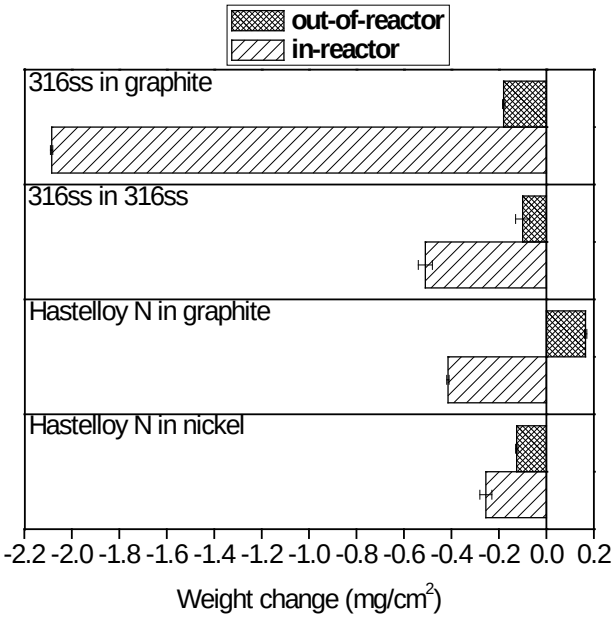
- Variables to investigate
  - Saturation
  - Temperature and thermal gradients
  - Radiation damage to materials, radiolysis, *in situ* generation
  - Salt chemistry, cover gas mixture
  - Material preparation (graphite types, surface preparation, etc.)

(3) Tritium Diffusion Through Metals

- Tritium transport out of the primary system is a critical phenomenon to understand and reliably control
  - Important to enable coupling to once-through gas turbine (i.e. salt-air heat exchangers)
- Work is underway (UNM) investigating double-walled heat exchangers
- Out-of-reactor facility with tritiated flibe to measure tritium transport from salt through metal surfaces
  - Primary piping
  - Heat exchangers
  - DRACS components
- Need to consider test matrix
  - Flow or static
  - Salt chemistry and temperature
  - Thermal gradients
  - Barrier coatings
  - Sweep gasses and secondary side media (air, helium, water, salt)

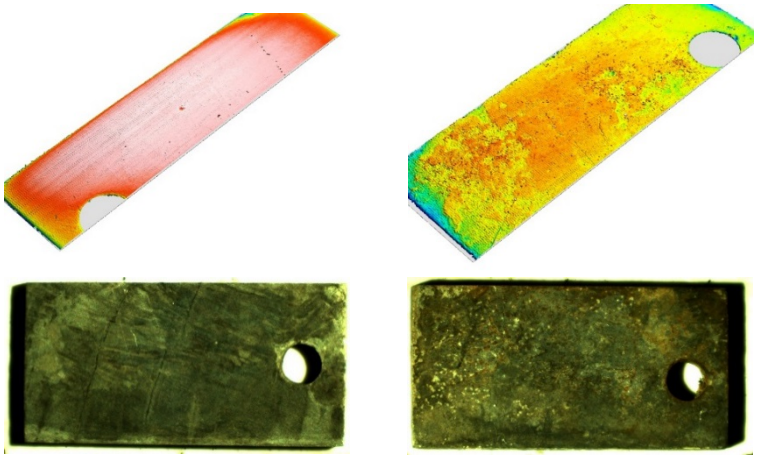
Post-Irradiation Examination

- Additional analysis on IRP-1 specimens continues – wealth of data is available
  - Weight, dimensions, spectroscopy, optical microscopy, and profilometry completed
  - Analysis of cracking in TRISO particles linked to combination of irradiation and salt freeze-thaw cycles



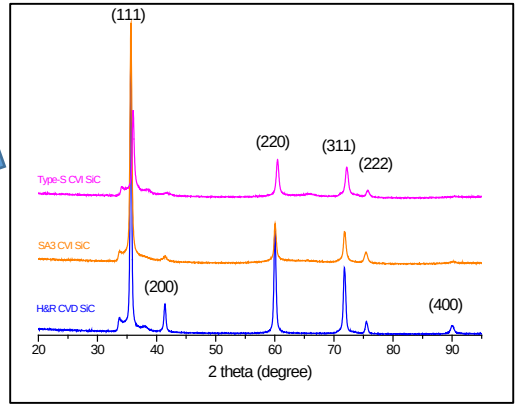
Accelerated corrosion of metals in-reactor compared to UW autoclave tests.

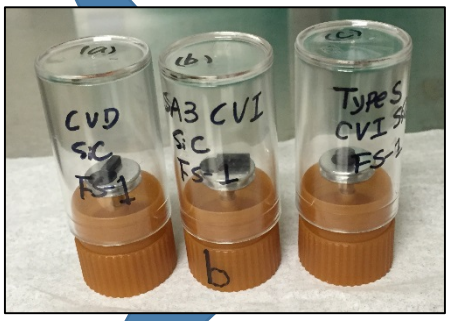
Observing effects of a flibe-only and a ternary environment.

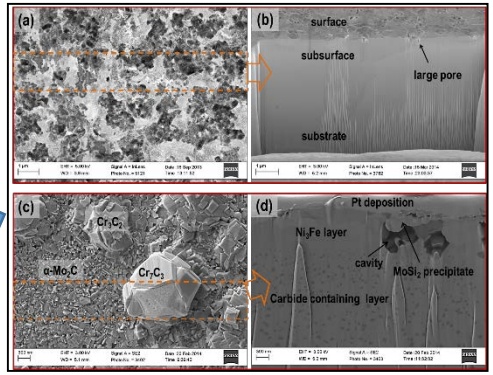


SS316 + flibe **SS316 + graphite + flibe**

Irradiated Microstructure Analysis







- Have begun x-ray diffraction analysis of irradiated specimens
  - SiC has lower activity, good for initial measurements
  - Hastelloy N and stainless steel specimens planned
  - Probing changes in phases, swelling
- SEM/EDS starting soon
  - Identify microstructural features such as grain size, layer formation
  - Map depletion/infiltration of elements
  - Important for SiC/SiC and C/C fiber composites with matrix porosity, fiber-matrix interfaces
- Tritium thermal extraction
  - Have custom-designed furnace for tritium desorption from solids with re-capture for counting
  - Also capable of running out-of-pile tritium exposures at high temperature.