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Accomplishments at PNNL as a NSUF Partner Facility

ANDREW CASELLA & DAVID SENOR

Pacific Northwest National Laboratory

FY 2015 NSUF Annual Program Review Germantown, MD

PNNL Goal – Provide Operational Flexibility

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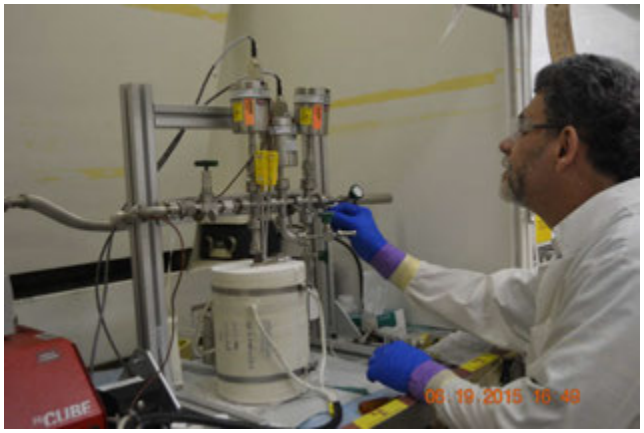

"Hydride LWR Fuel Rod Irradiation (HYFI)"
ATR NSUF Proposal Number 10-224 (10/15/2009)
UC-Berkeley Don Olander, Mehdi Balooch, Kurt Terrani

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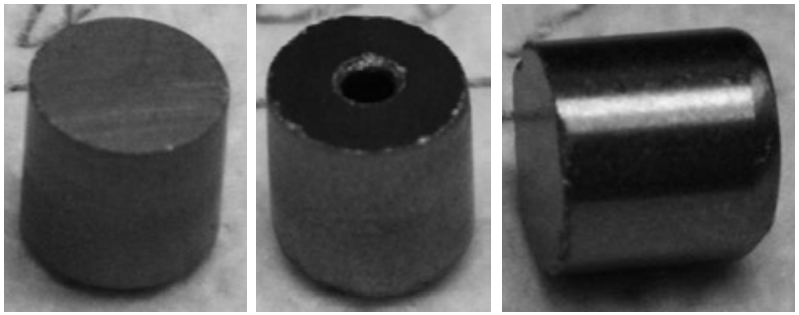
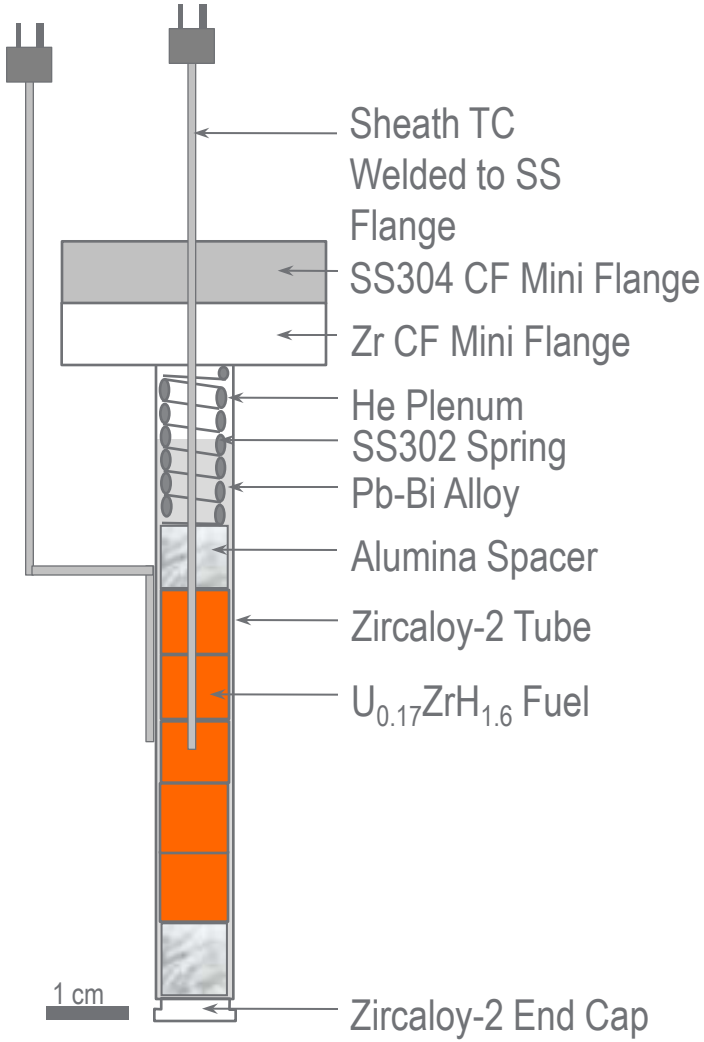
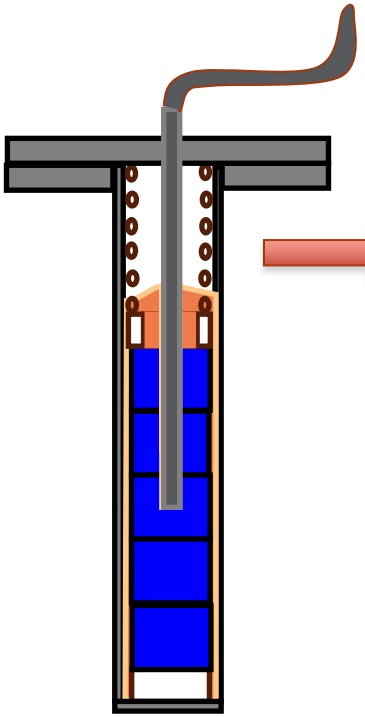
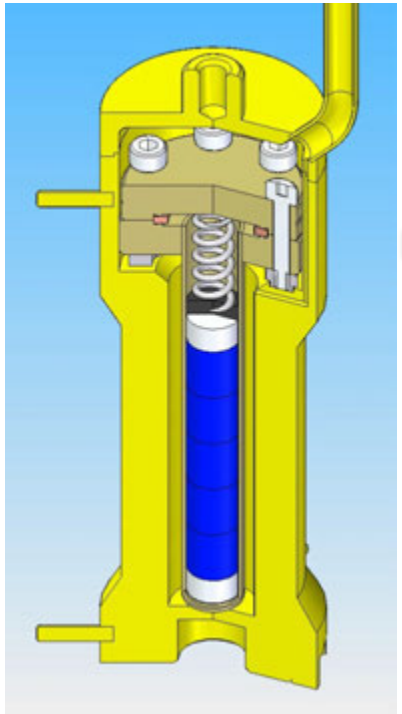
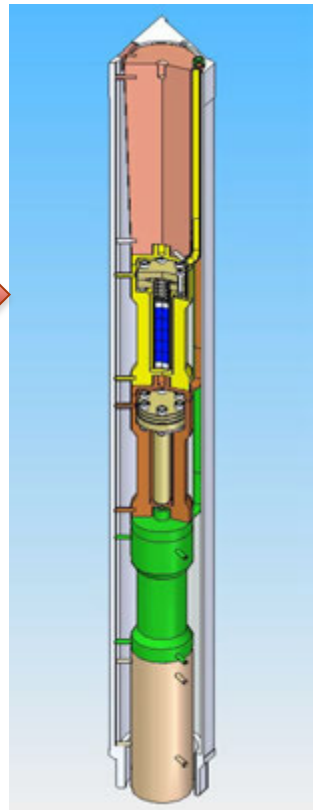


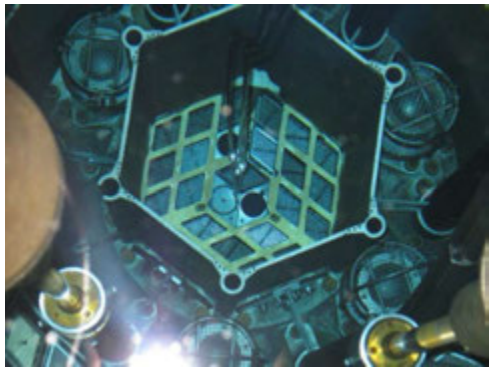


Irradiation at MIT reactor (March 2011 – December 2011)

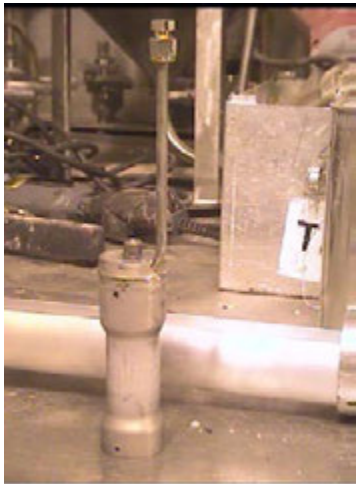


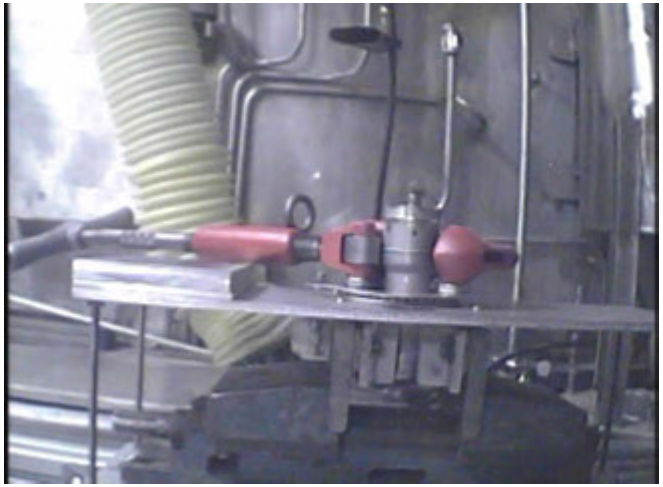


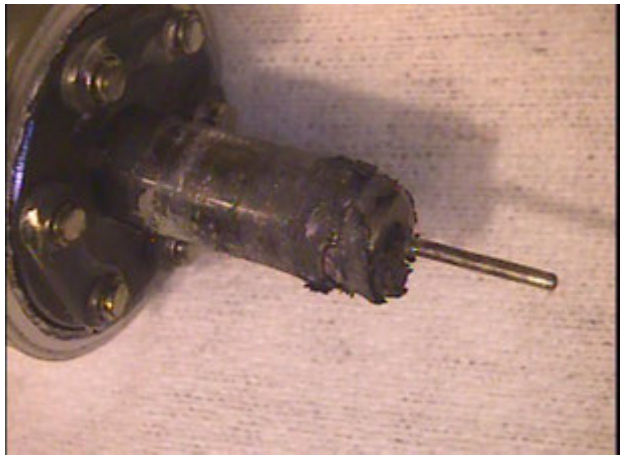




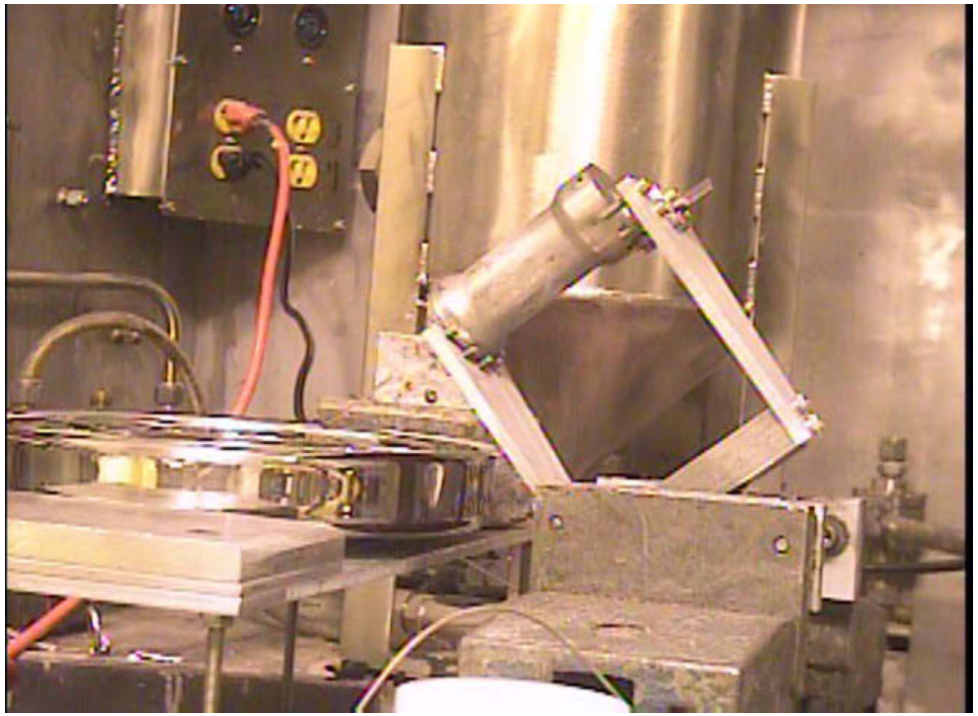
Post Irradiation Examination at PNNL – March 2014 – Present
Receipt and Disassembly

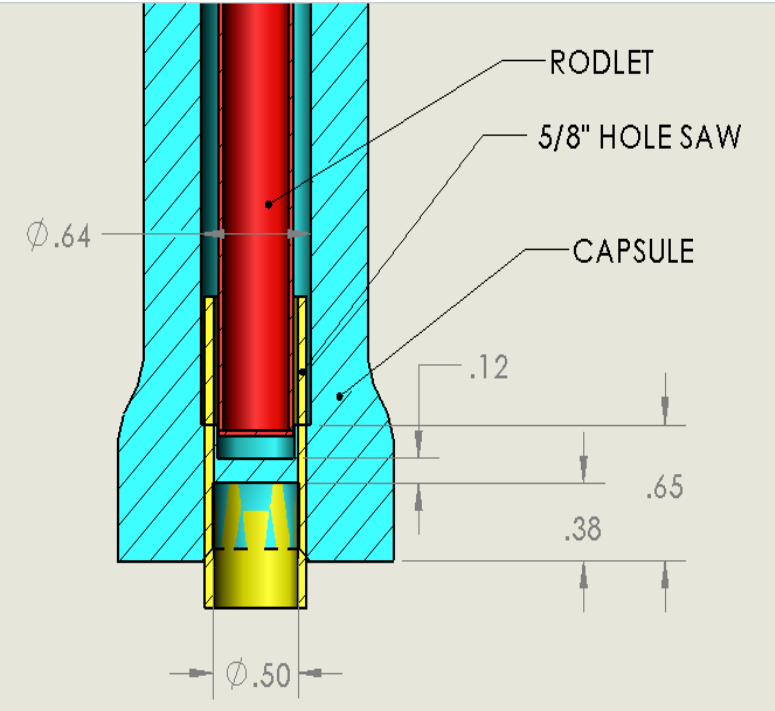




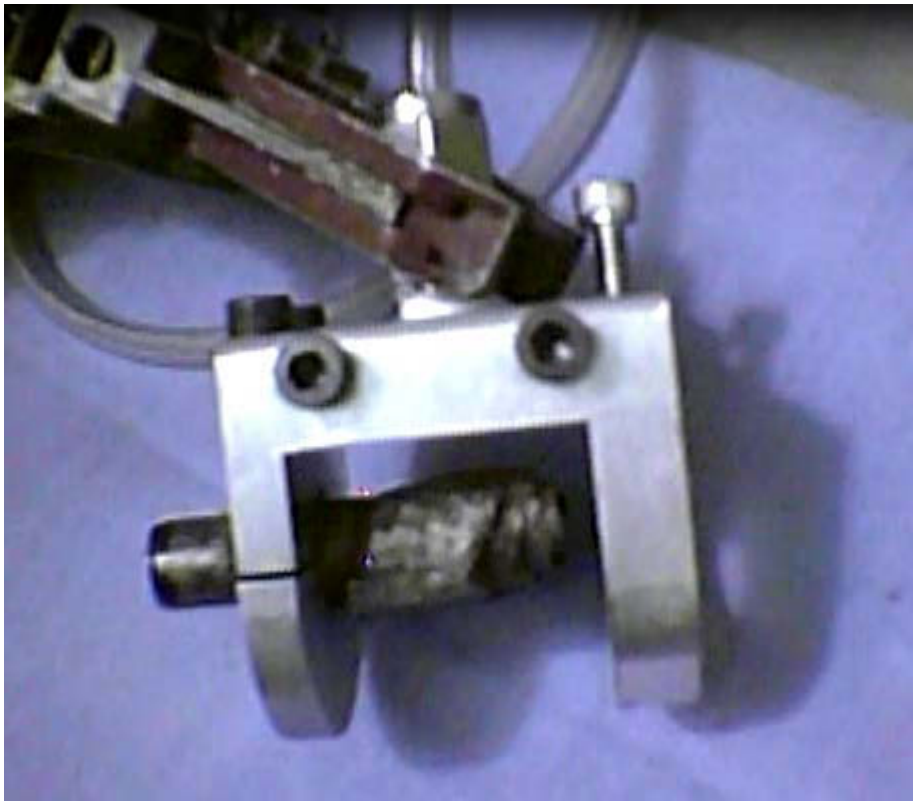


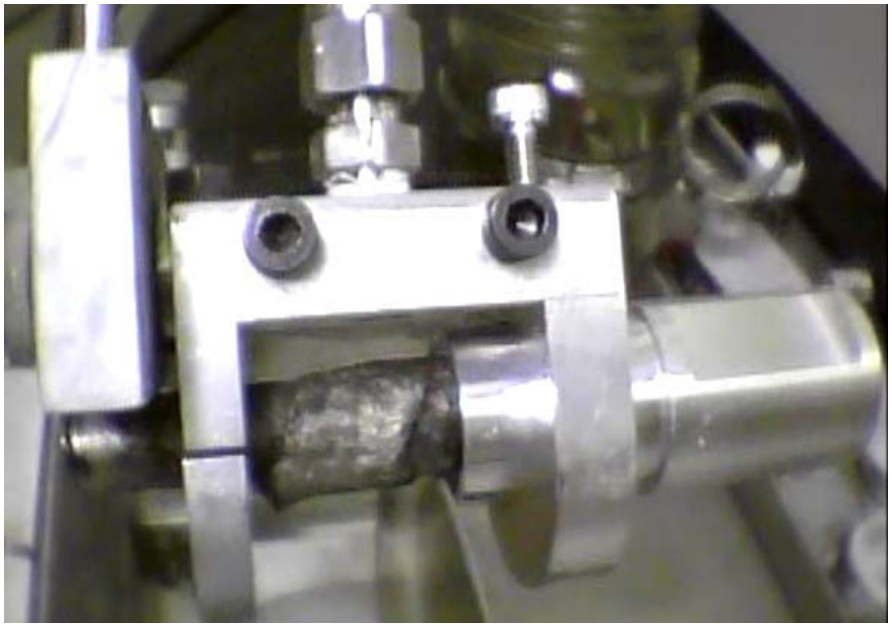
Post Irradiation Examination - Extraction



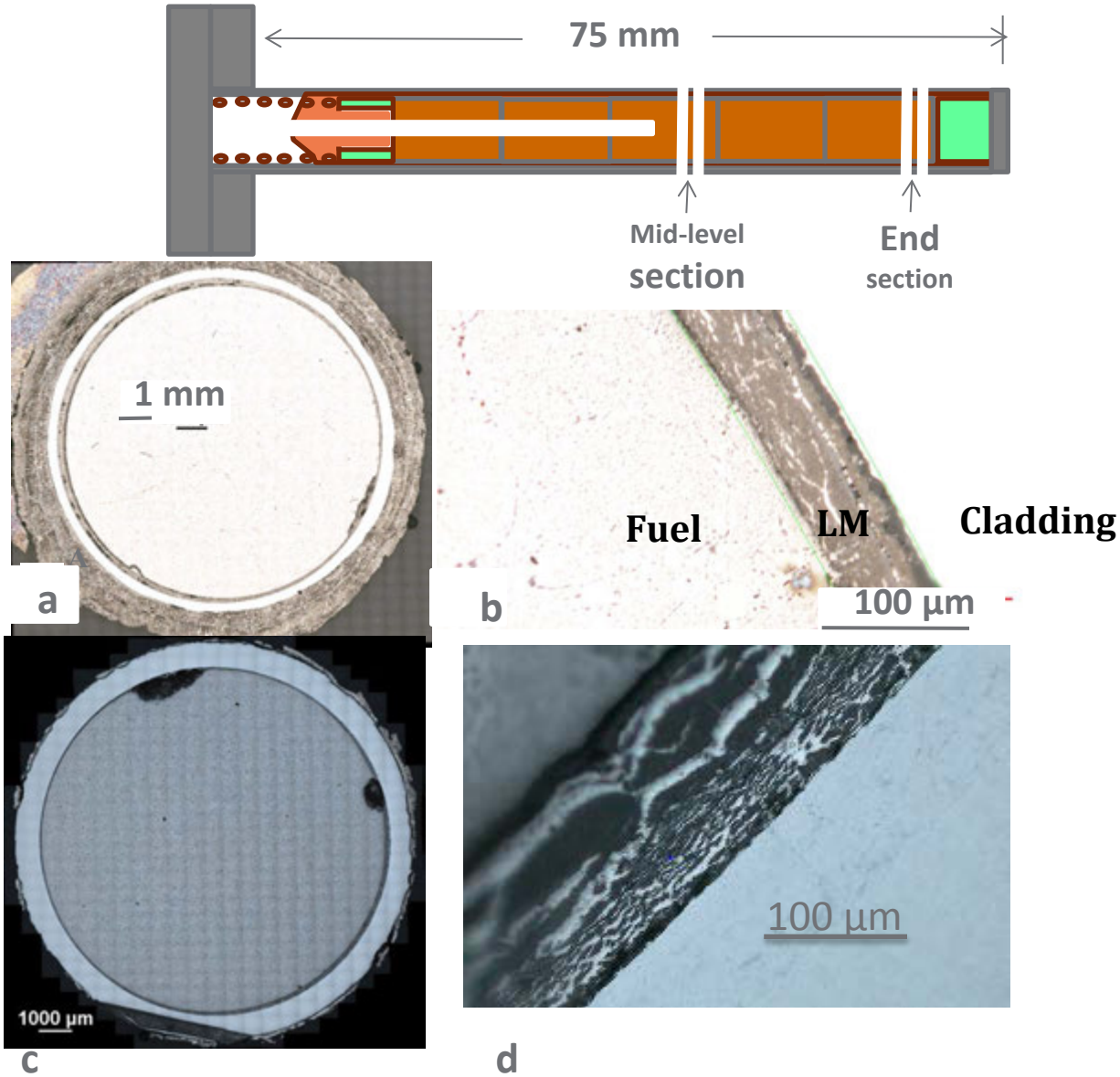


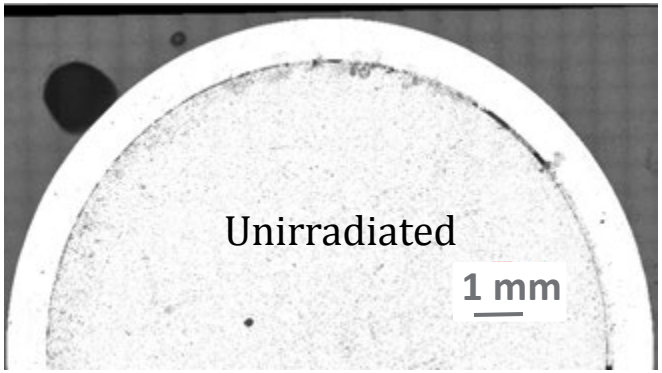
Post Irradiation Examination - Sectioning

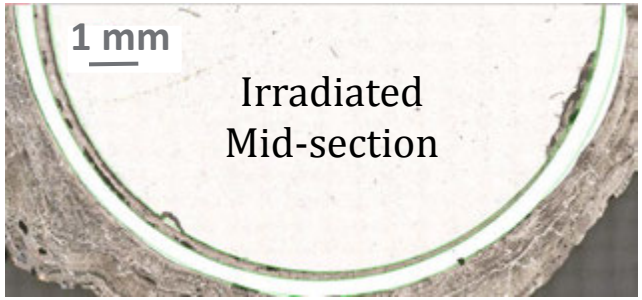


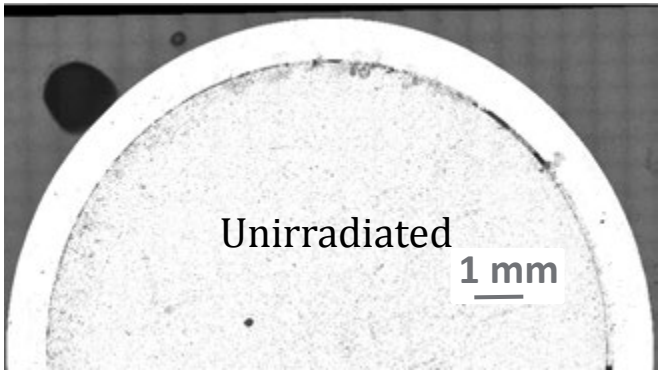


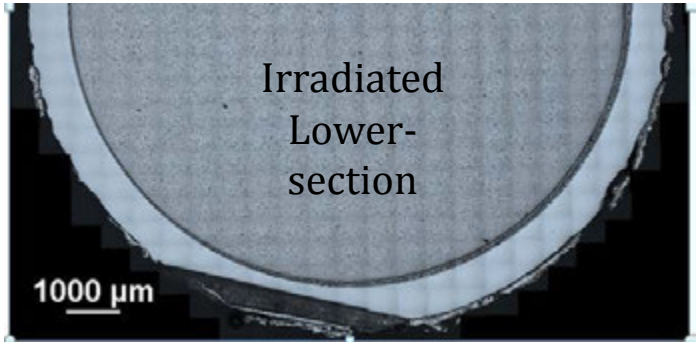
Optical Microscopy of Irradiated Rodlet Sections



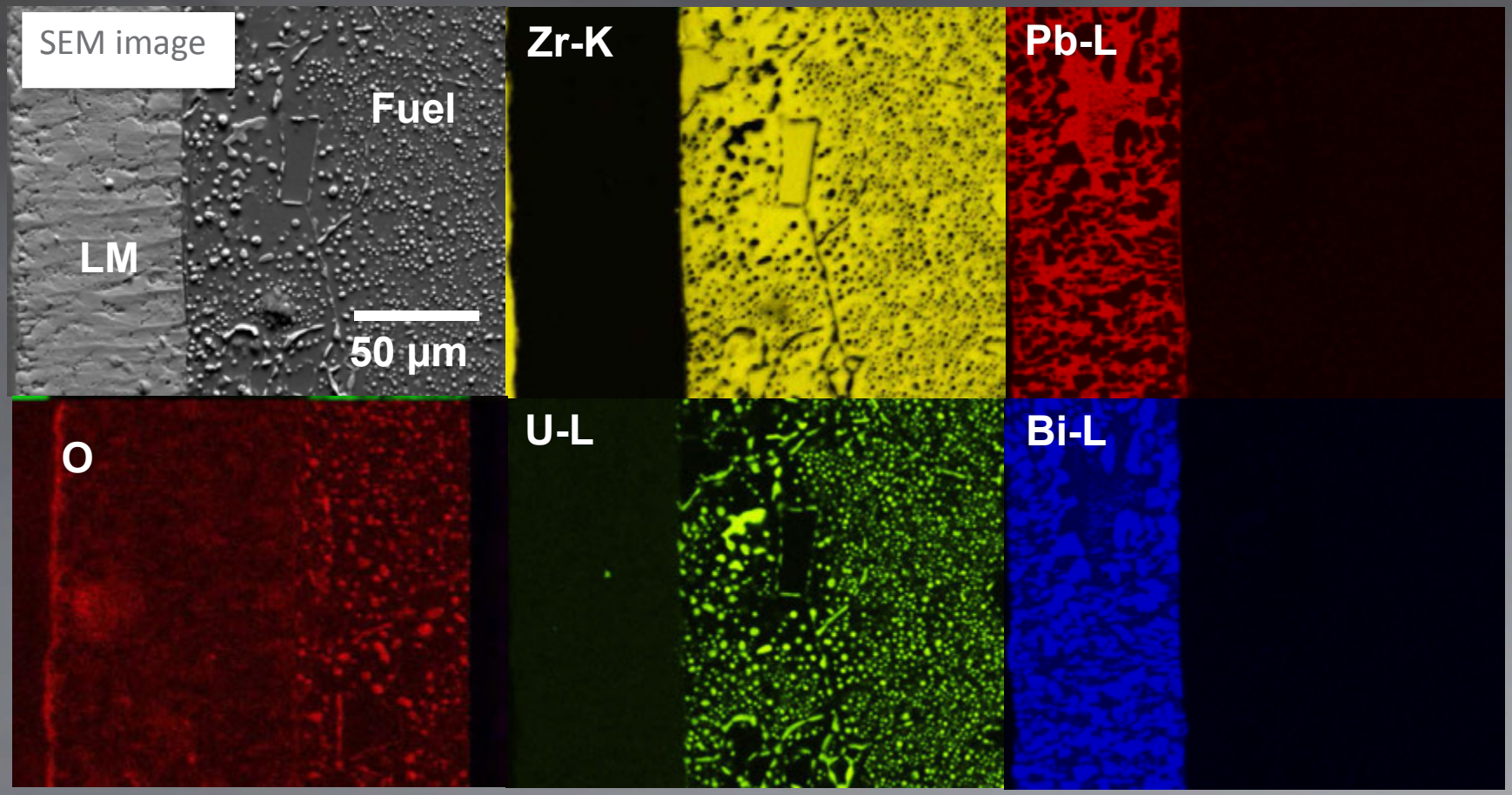

Unirradiated
1 mm


1 mm
Irradiated
Mid-section

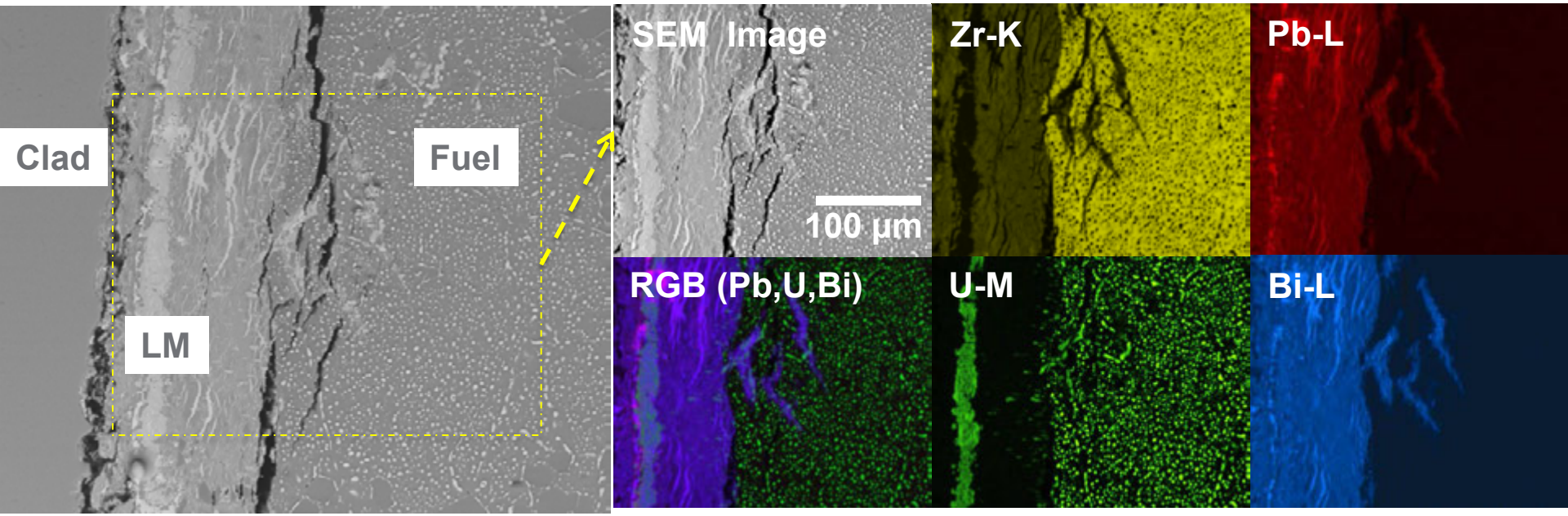

Unirradiated
1 mm


Irradiated
Lower-
section
1000 µm

Unirradiated Sample – SEM/Elemental Mapping



Irradiated Upper Sample SEM/Elemental Mapping



Irradiated Lower Sample SEM/Elemental Mapping

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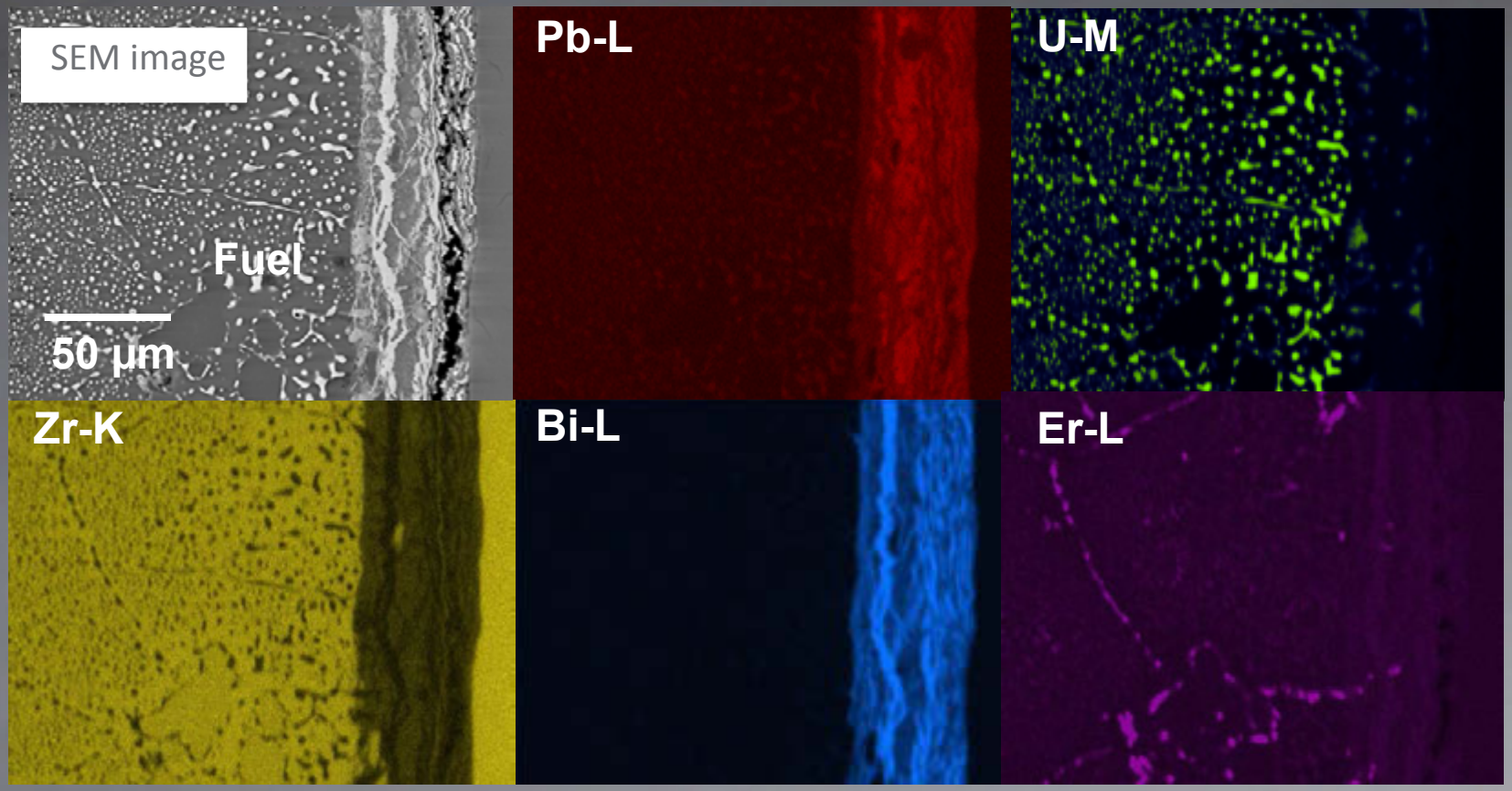

Elemental Line Scans Across the Liquid Metal Region of the Unirradiated (Left) and Irradiated (Right) Samples

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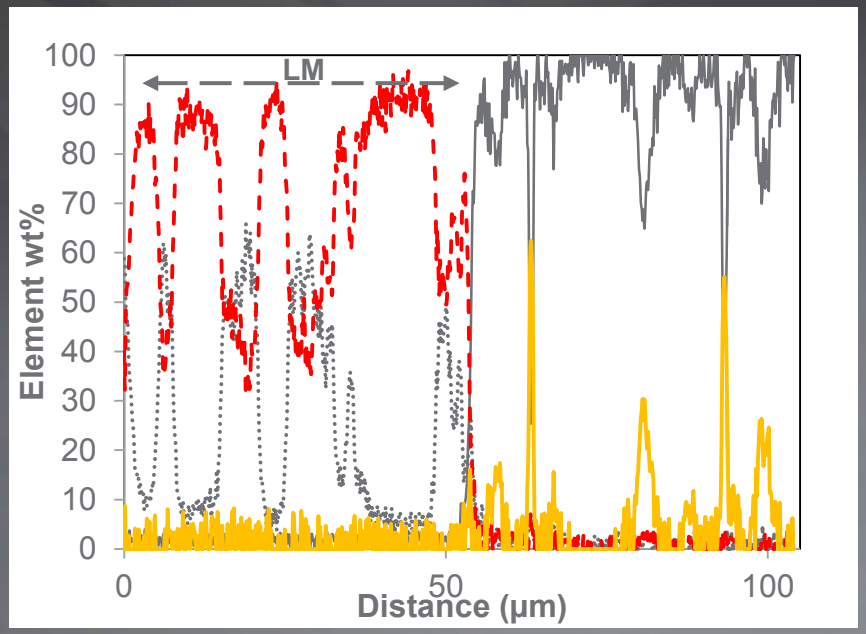

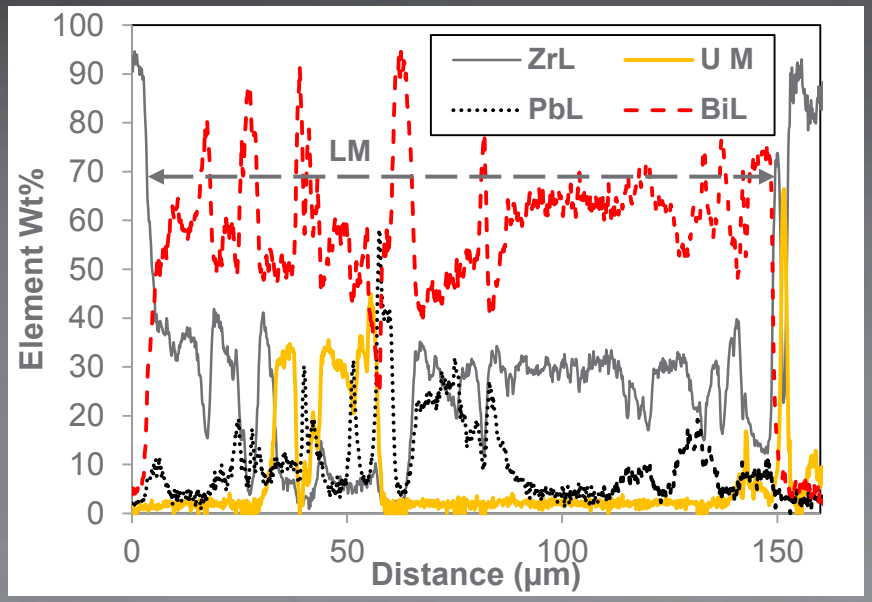

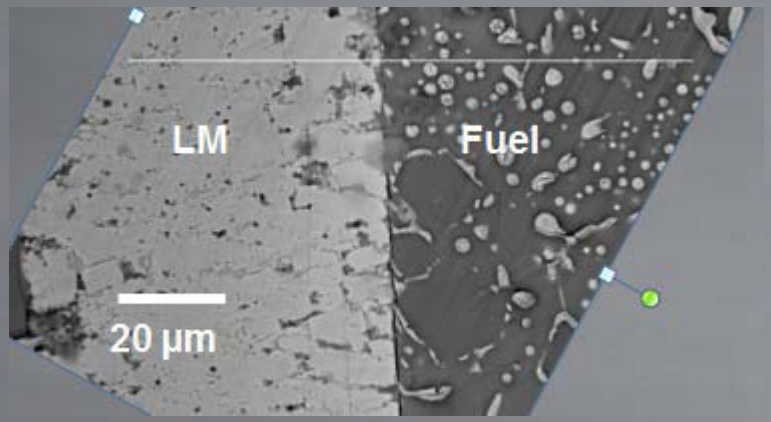

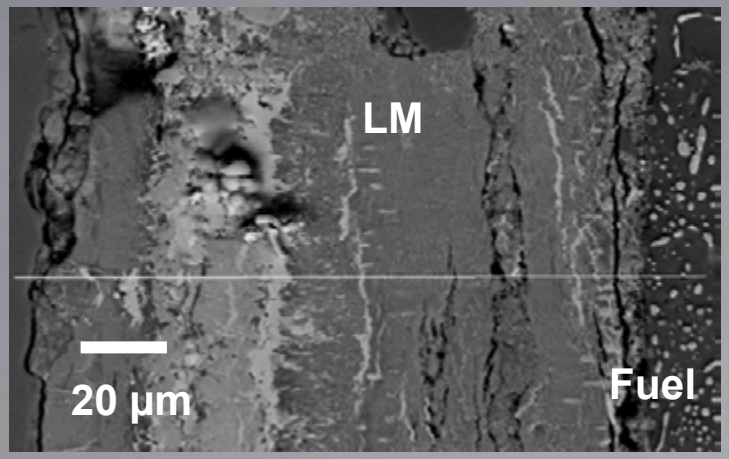

Elemental Line Scan of Outer Liquid Metal Region

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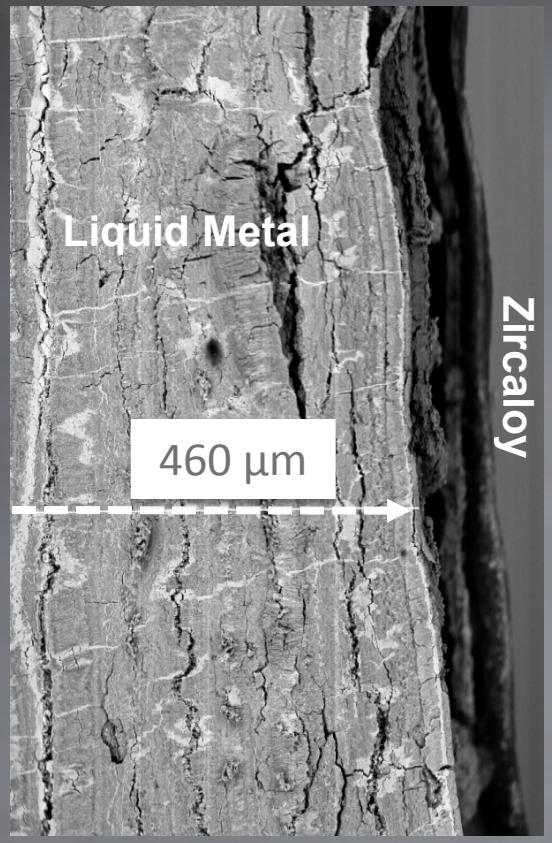
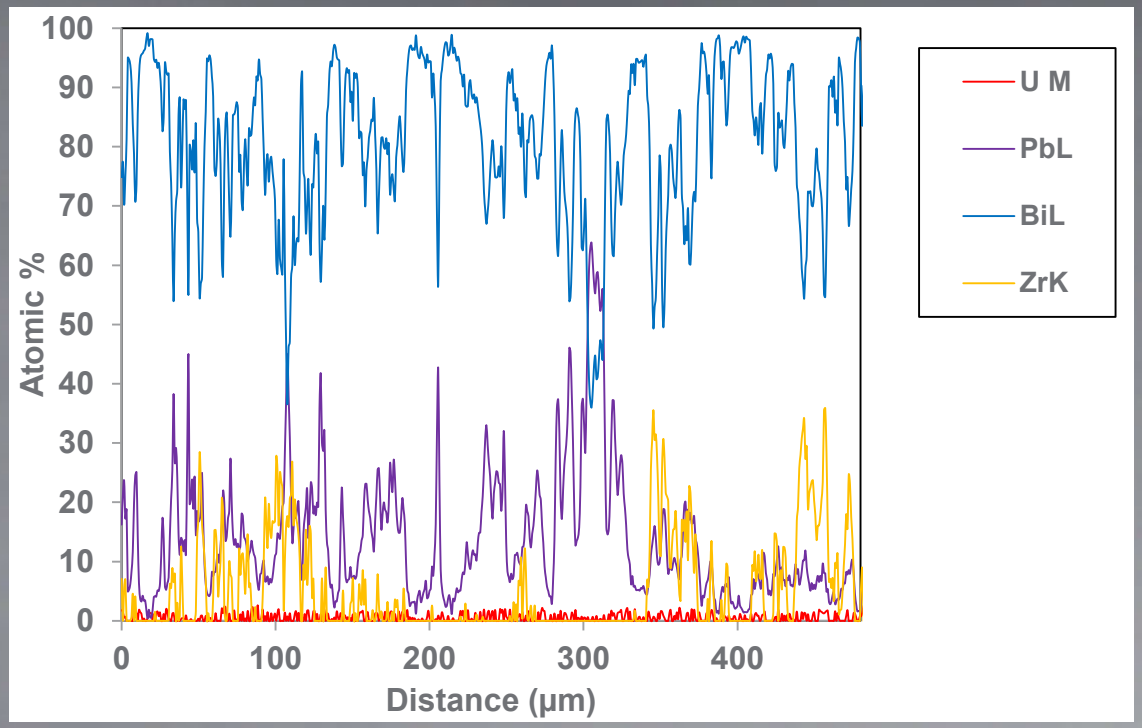
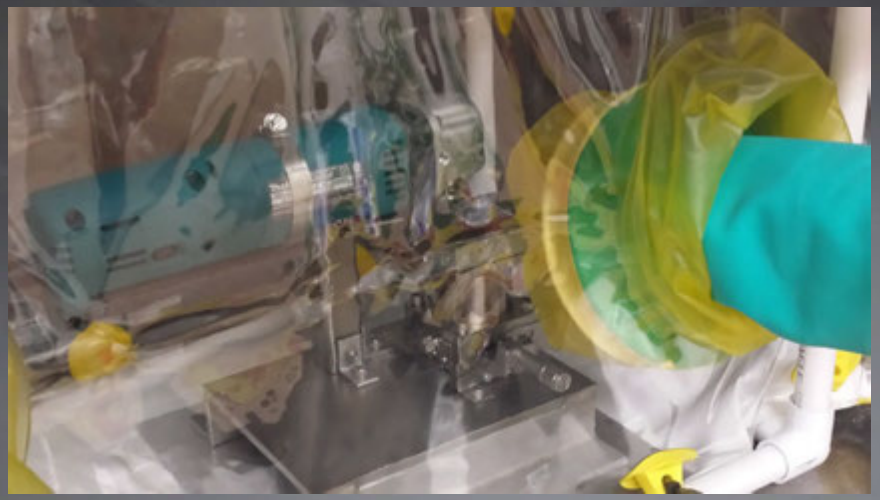
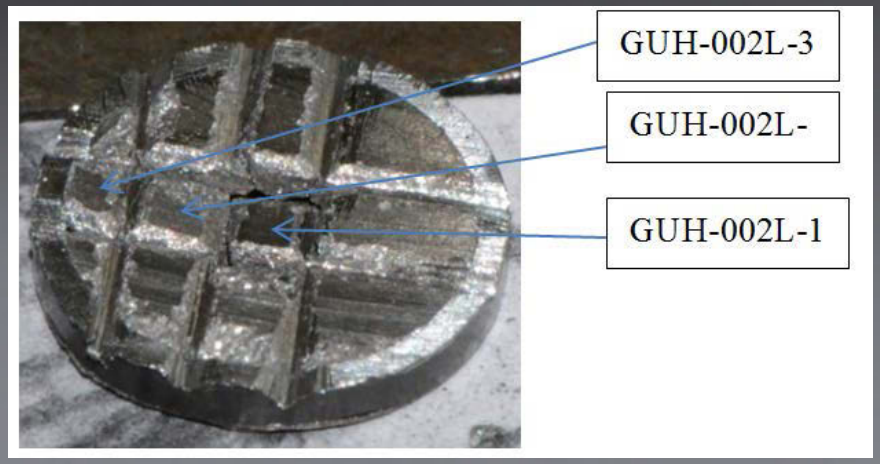




Sub-sectioning



Hydrogen Assay



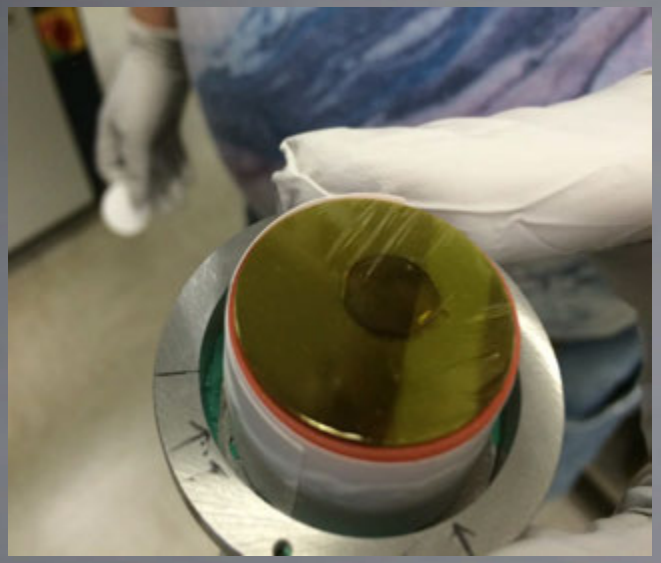
Fraction of Expected Hydrogen Inventory Recovered

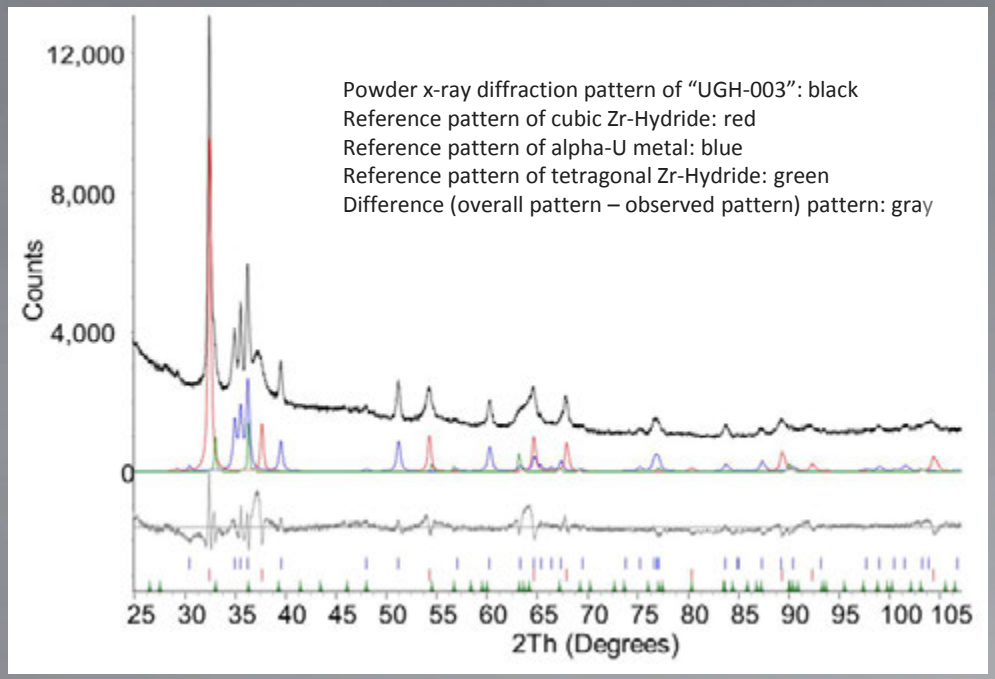
	Center	Intermediate	Outer
Unirradiated	89%	85%	95%
Irradiated	89%	86%	91%

Analytical Chemistry – TIMS/ICP-OES

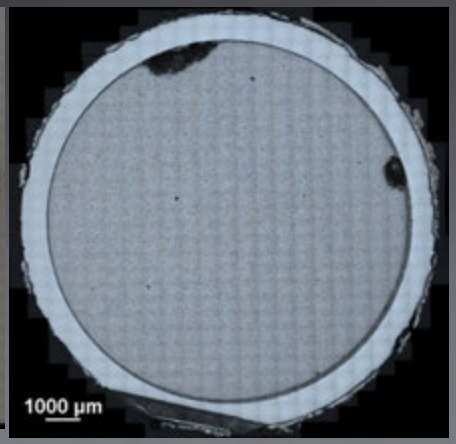
- Samples were analyzed with ICP-OES to confirm that the fuel was indeed 30 wt%.
- Samples were analyzed with TIMS to confirm that the fuel burnup was indeed 0.29 FIMA % as calculated.

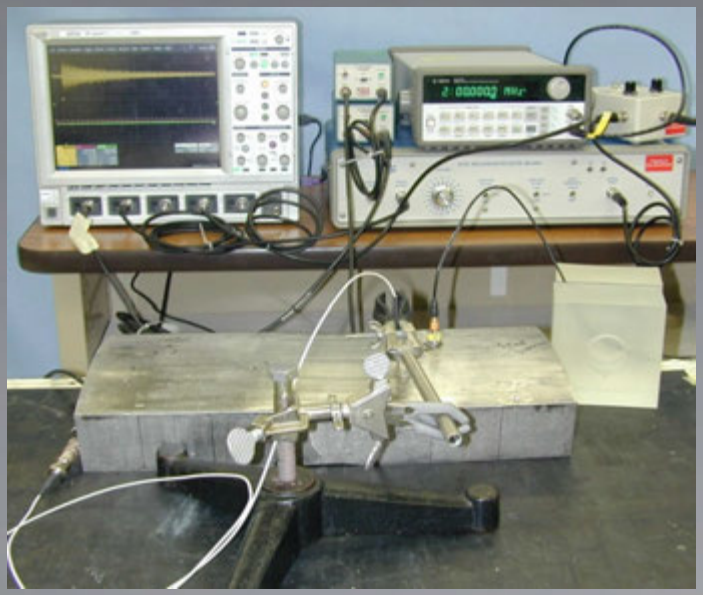
X-Ray Diffraction





Rapid Turnaround Experiments





Conclusions

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- The first NSUF project to be executed at PNNL allowed us to demonstrate and improve capabilities across the entire range of operational flexibility, while providing useful information to the project PI.
- While the current fuel design allows for greater heat transfer performance, additional design considerations involving material performance and compatibility are needed.
- Lead Bismuth Eutectic appears to have attacked both the zirc-2 cladding (outer surface as well as inner zirconium buffer layer) as well as the fuel
- The extent of the attack was not uniform along the length of the rodlet. It appears as though the attack increased in the axial direction from the bottom of the rodlet toward the top flange. This may be an effect of temperature gradients.
- Suggested design change is to focus on the liquid metal itself rather than the cladding material for this fuel design due to zirconium being the main component of the fuel matrix. Existing studies suggest that adding Sn to the liquid metal (Sn-PB-Bi) will help form a protective layer between the liquid metal and the Zr materials.
- Work presented at TMS (February 2016) and journal article is being prepared.
- Two follow-on RTEs are currently in progress

Acknowledgements

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