doi:10.1017/S1431927622004317
Microsc. Microanal. 28 (Suppl 1), 2022

Multimodal Imaging of the Evolving Interface of Irradiated Aluminide-coated Stainless-steel Cladding

Xiao-Ying Yu[1], Bethany Matthews[1], Shawn Riechers[2], Steven R. Spurgeon[1], Zihua Zhu[3], Gary Sevigny[1], and Walter Luscher[1]

[1.] Energy and Environment Directorate, Pacific Northwest National Laboratory, WA, USA.
[2.] Physical and Computational Directorate, Pacific Northwest National Laboratory, WA, USA.
[3.] Environmental and Molecular Science Laboratory, Pacific Northwest National Laboratory, WA, USA.
* Corresponding author: xiaoying.yu@pnnl.gov; yuxiaoyingbei@gmail.com

Multimodal imaging has seen an increasing interest in microanalysis and microscopy. Light microscopy and electron microscopy are the two main pillars in correlative imaging in microanalysis. More advanced chemical imaging tools, especially time-of-flight secondary ion mass spectrometry (ToF-SIMS) as a powerful imaging mass spectrometry technique, has been introduced into the repertoire of imaging and spectroscopy modalities in addition to electron microscopy tools such as scanning electron microscopy (SEM) and transmission electron microscopy (TEM) [1].

Sample preparation is a critical step to enable multimodal imaging of the same specimen. The sequence of sample analysis is another crucial factor to consider in achieving successful results [2]. In this talk, we will show recent multimodal imaging results of irradiated aluminide-coated stainless steel cladding samples from a tritium-producing burnable absorber rod (TPBAR) in a light water reactor to probe the evolving material interfaces and light element distributions on and near the surface of the irradiated material.

Because the cladding materials of interest have been exposed to neutron irradiation, sample handling is challenging. Proper experimental procedures were established to reduce potential hazardous exposure to staff and the instrument. Consequently, only a small section of the irradiated samples could be safely handled and transferred among different analytical platforms. Specifically, we used scanning electron microscopy – focused ion beam (SEM-FIB) to lift out a small section of the sample from the aluminide-coated surface of the cladding material to permit multimodal analysis of irradiated cladding using atomic force microscopy (AFM), ToF-SIMS, and TEM. Figure 1 depicts the correlative SEM, AFM, and ToF-SIMS imaging of an irradiated cladding sample.

When comparing irradiated vs. un-irradiated samples, 3D distributions of isotopic hydrogen and lithium of the cladding from ToF-SIMS indicate material transport as a result of neutron irradiation, leading to new understanding of light element transfer and diffusion [3]. This novel analysis sequence of irradiated cladding material demonstrates that the advancement of correlative imaging can bring more scientific understanding of the water reactor technology and improve applications in the future [4].

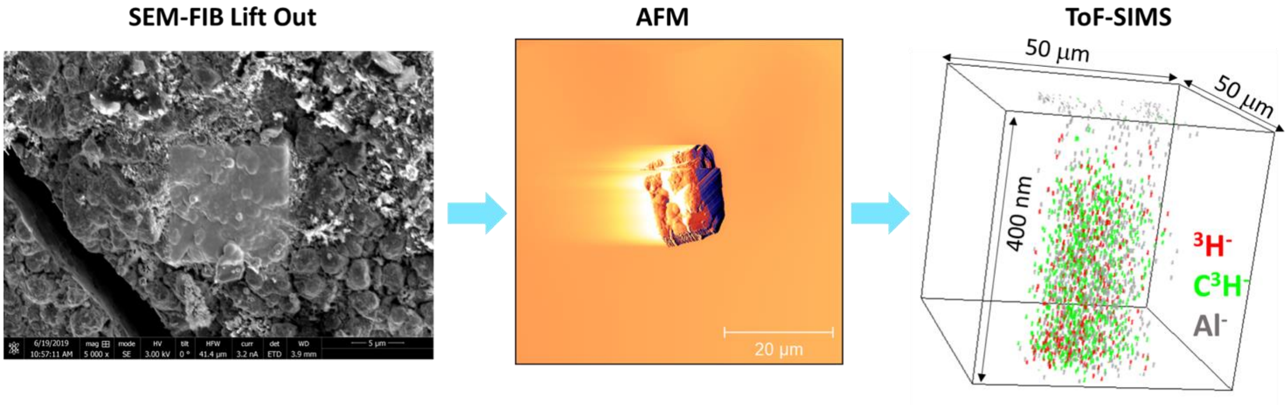

Figure 1. The correlative SEM, AFM and ToF-SIMS imaging of an irradiated cladding sample.

References:

[1] X-Y Yu, J. Vac. Sci. Tech. A, (2020) **38**(4), art. 040804, DOI: 10.1116/1.5144499.
[2] X-Y Yu et al., Microfluid. Nanofluid., (2013) **15**(6), 725-744. DOI: 10.1007/s10404-013-1199-4.
[3] X-Y Yu et al., J. Mat. Res. Tech., (2021) **14**, 475-483, DOI: 10.1016/j.jmrt.2021.06.066.
[4] We acknowledge support from the Pacific Northwest National Laboratory (PNNL) Nuclear Science Processing Initiative (NPSI) Laboratory Directed Research and Development (LDRD) fund and Tritium Modernization Program of the Department of Energy's National Nuclear Security Administration (DOE/NNSA). The authors are indebted to Dr. David Senor and Dr. Weilin Jiang for insightful discussions. PNNL is operated by Battelle under the contract DE-AC05-76RL01830.