U.S. DEPARTMENT OF ENERGY | Office of Science

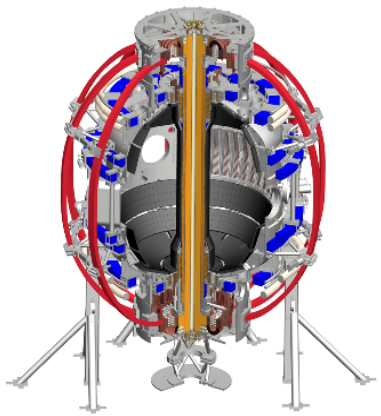
NSTX-U

High resolution imaging of W deposits on DIII-D graphite samples

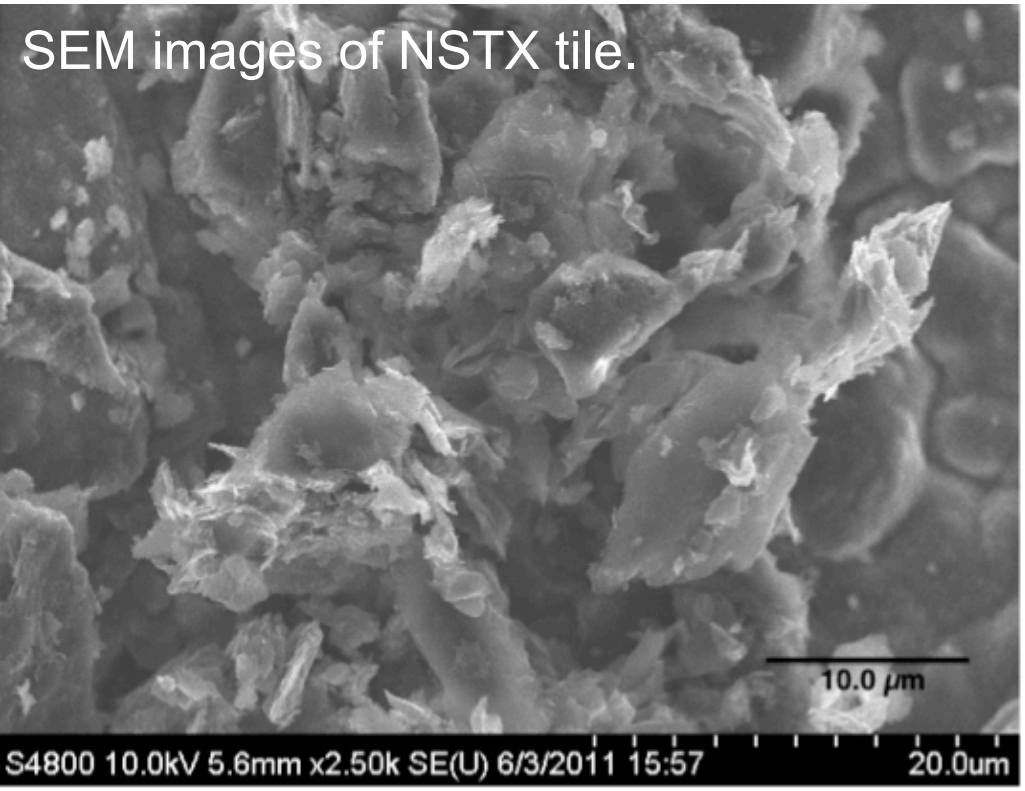
C. H. Skinner, W. R. Wampler, B. E. Koel

DIII-D National Campaign Ideas forum
PPPL B318
2:30 PM Friday Oct 7th 2016

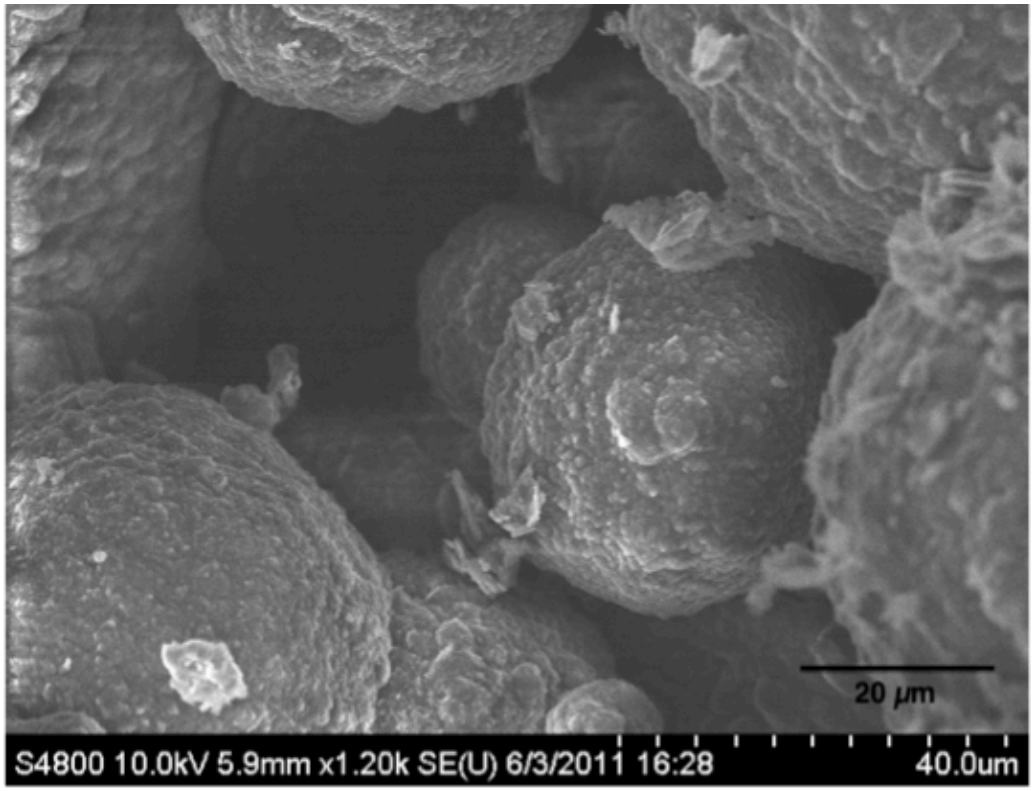
PPPL



Question: How does PFC surface topography (pits, pores, machining grooves…) affect erosion/redeposition ?



(a) SEM image of NSTX tile removed following their experimental run campaign. Wall surfaces in the reactor, such as this one, illustrate how rough the surfaces are. Lithium deposition applied to such a rough surface does not grow in flat, uniform layers, but results in shadowing, non-uniformities, and an effective thinning of the nominal lithium dose.



(b) Image taken from a different location on the same ~10 cm x 15 cm tile. The lithium spherical clusters in this region are 10s of μm in diameter and further illustrate the rough surface.

C.N. Taylor PhD Thesis Fig. 10.3

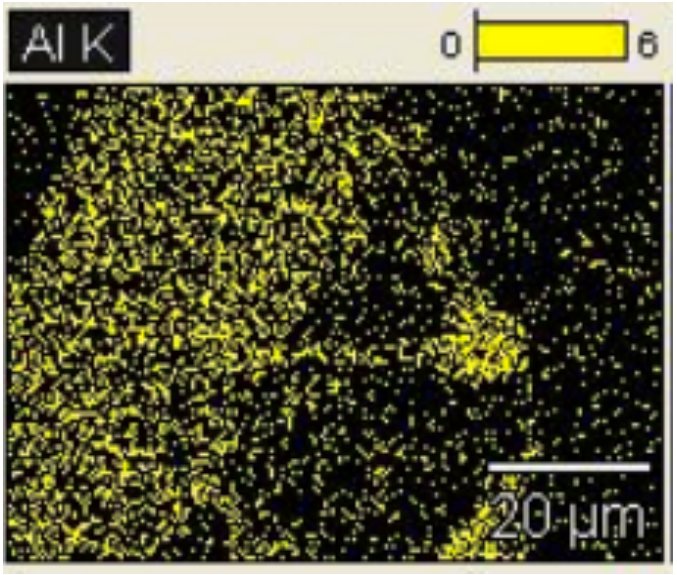
Redeposition on rough surfaces?

- Recent experiment with Al on DiMES by Chrobak, Wampler et al., [*"Characterizing Low-Z Erosion and Deposition in the DIII-D Divertor Using Aluminum*" Chrobak et al., PSI-2016]
- Rutherford Back Scattering (RBS) found more Al redeposition on rough (graphite) substrates than on smooth (Si).
- Results attributed to redeposition in hidden areas.
- Spatial resolution available from SNL RBS (Wampler) is ~ 1 mm, to high to spatially distinguish deposition in pits and pores…
- Spatial resolution available from PU Imaging Analysis Center, Scanning Electron Microscope Energy Dispersive X-ray Spectroscopy is ~ 100 nm. sampling depth ~1 μm (to be checked).
  (FEI Verios 460 Extreme High Resolution Scanning Electron Microscope (XHR SEM))
- Spatial resolution available at PPPL microimaging lab (Scanning Auger Microprobe (SAM) is down to ~ 0.2 μm.
  Depth sampled is ~10 nm (Auger electron imfp).

Idea in progress:

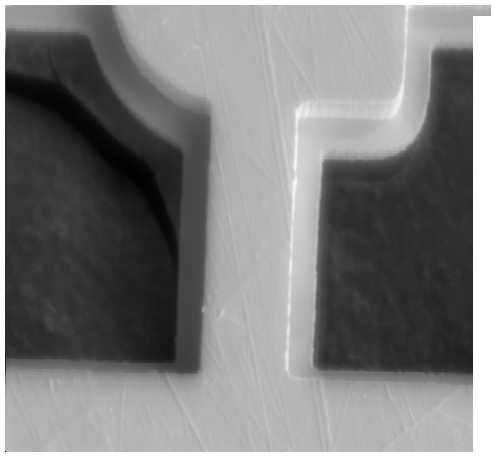
- Collaborate with W. Wampler (SNL) et al., to do elemental high resolution imaging of existing DiMES samples or new samples from DIII-D graphite tiles exposed during W ring campaign.
- Measure spatial distribution of W on graphite tiles samples using EDX, SAM et al. Directly detect any spatial non-uniformity due to pits, pores etc…
  Compare to erosion/deposition models.

SEM EDAX image of Al from Wikipedia
http://www.charfac.umn.edu/instruments/eds_on_sem_primer.pdf

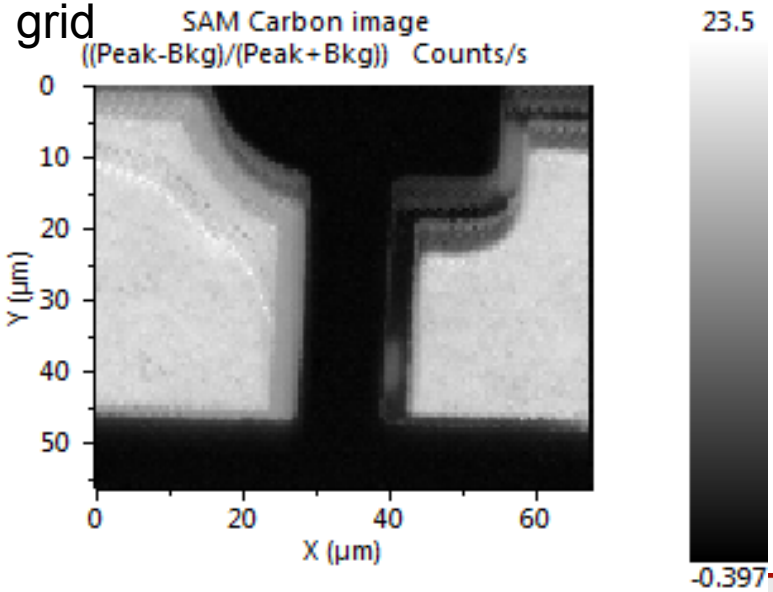


Images from SAM at PPPL

SEM image of Cu grid on C



SAM image of carbon in between grid



Summary

- Seems to be nice opportunity to match PU/PPPL Surf. Sci. capabilities with relatively unexplored aspect of erosion/redeposition.
- Does not need dedicated DIII-D run time.
- Relevant to lithium & Mo erosion / redeposition in NSTX-U

Near term tasks:

- Check capabilities of IAC FEI Verios 460 Extreme High Resolution Scanning Electron Microscope (XHR SEM) and other IAC instruments
- Coordinate with UT, SNL, UCSD… also working on DIII-D redeposition.
- Continue dialog with Wampler, Chrobak etc…
- Check if DiMES samples are available or samples need to be cut from DIII-D tiles….

Longer term:

- Validate erosion/redeposition models of surface roughness by experiments measuring to deposition on surfaces intentionally patterned using focussed ion beam (FIB).