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Title: Auger Spectroscopy Analysis of Spalled LEU-10Mo Foils

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Auger Spectroscopy Analysis of Spalled LEU-10Mo Foils

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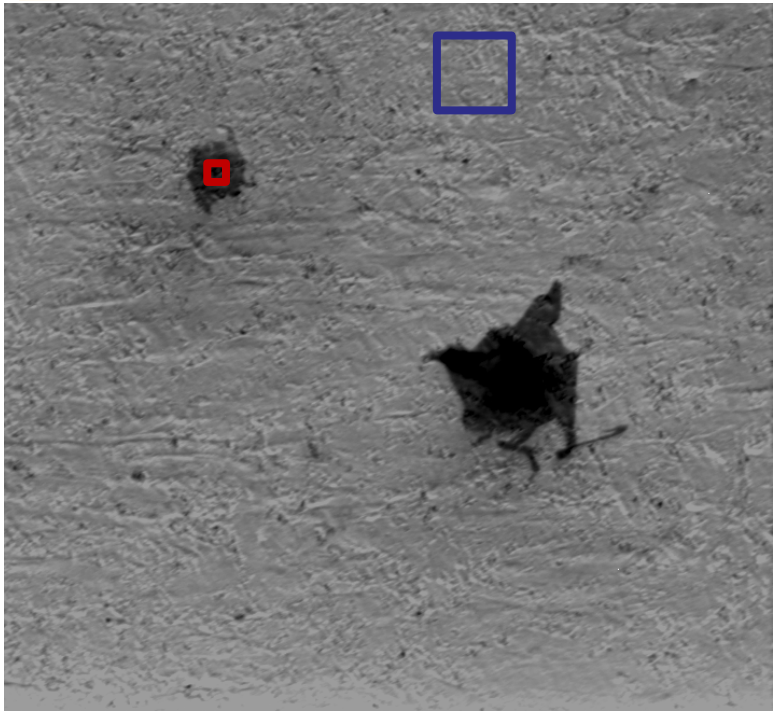
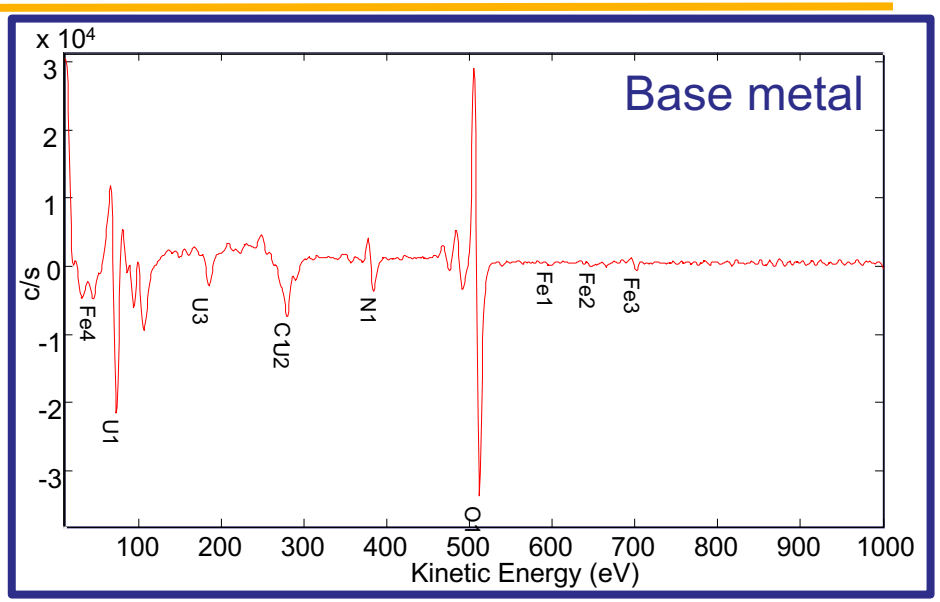
Surface Science used to probe LEU-10Mo Spall

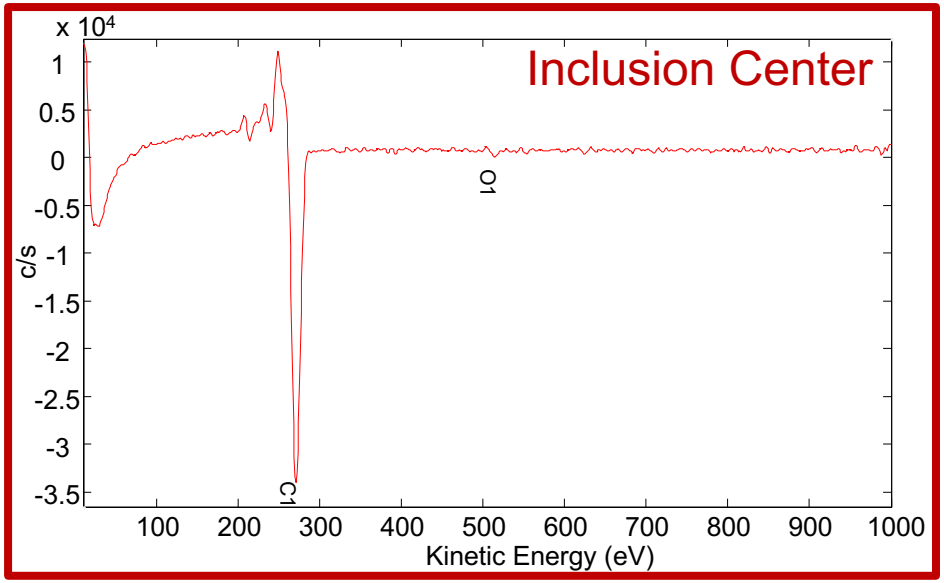
- LANL received uncoated LEU-10Mo foil after rolling at BWXT
- Isolated, but sizable spall defects were observed on the foil
- Preliminary SEM/EDS analysis detected elevated carbon content and some iron inclusions
- Subsequently, Auger spectroscopy employed to attain a higher resolution analysis of chemical composition in an effort to determine origin of spalling

Auger highlights graphitic-like inclusions and Mo-deficient oxide on base metal

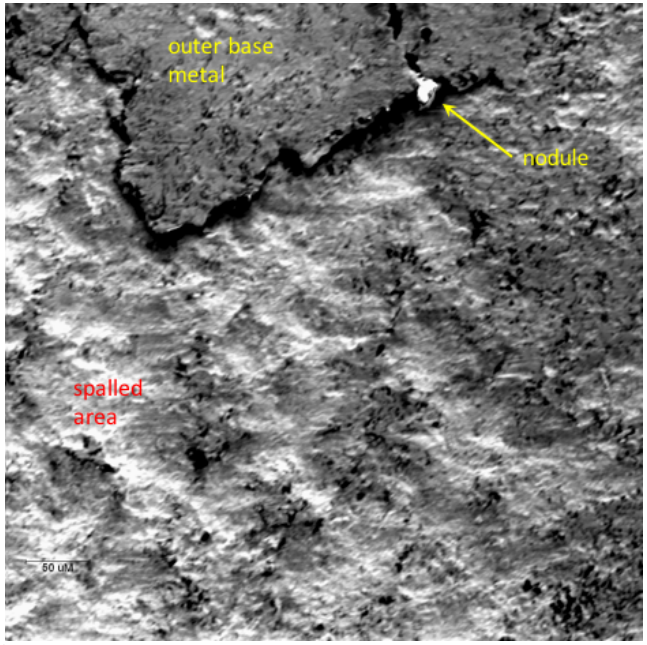


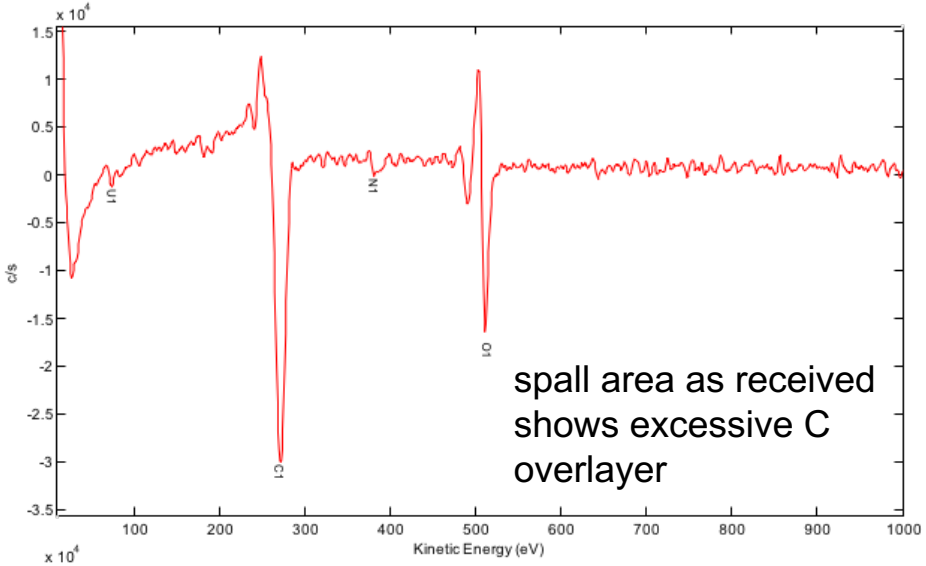
- Oxide film depleted of Mo
- Ion sputtering through oxide film reveals Mo in appropriate concentrations only when clean base metal is reached



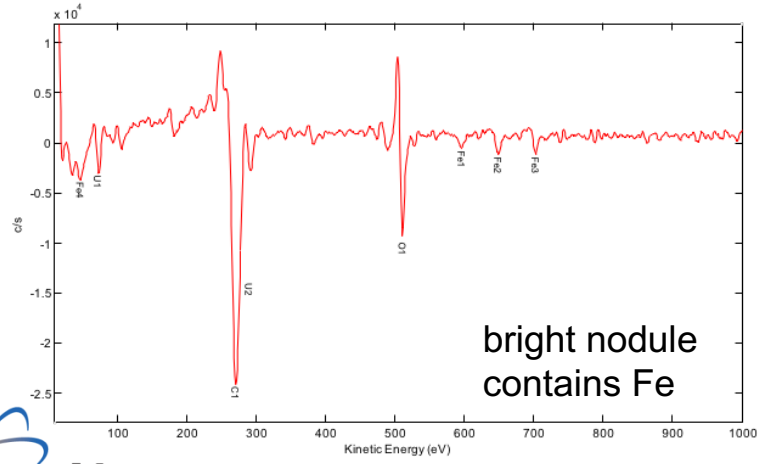


Higher C concentration detected within spall area

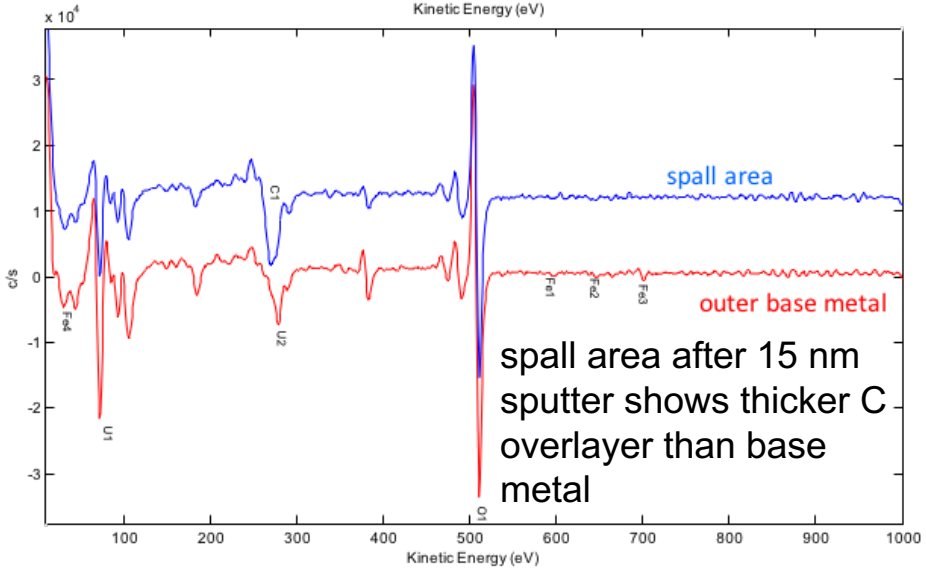




spall area as received shows excessive C overlayer



bright nodule contains Fe



spall area after 15 nm sputter shows thicker C overlayer than base metal

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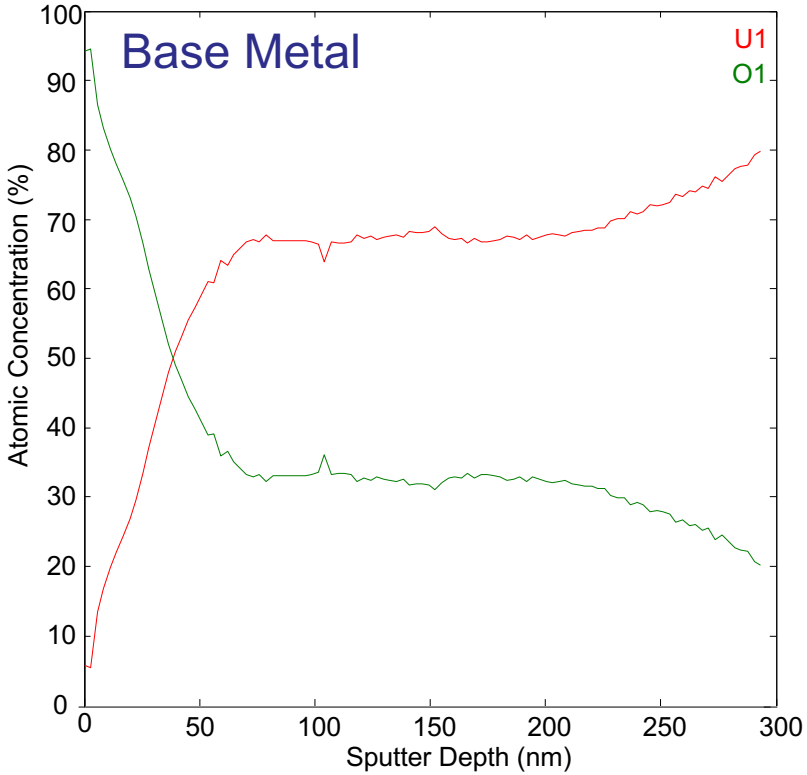
Images Courtesy of Roland K. Schulze

NNSA

Depth profiling reveals thick oxide; Mo concentration nears nominal only at depths ~400 nm



- UO_2 layer estimated to be ~37 nm thick by sputter ion etching
- Lower oxygen level (~30% in metal) extends ~460 nm in depth
- Mo only evident after sputtering through the full oxide/ oxygen-enriched metal thickness

Key Findings

- The surface of the base metal shows graphitic-like inclusions (carbon only, not metal carbide), d= 50-100 μm.
- The UO_2 oxide layer thickness at the base metal surface is ~37 nm, determined by sputter ion depth profiling; a lower level of oxygen at about 30% atomic (probably dissolved oxygen in metal at a high level) extends into the surface to ~460 nm.
- The surface oxide layer is deficient in Mo; the ratio of Mo:U is much less than 10%, and in fact the Mo may have been fully excluded.
- The higher level of hydrocarbon within the spalled area leads us to believe that, at some point in the processing, there was trapped hydrocarbon at this subsurface location that prevented bonding of adjacent metal leading to delamination (spalling) at this site.