Microstructural Characterization of Proton-Irradiated Ti-15V-3Cr-3Sn-3Al and SiC-Coated Graphite

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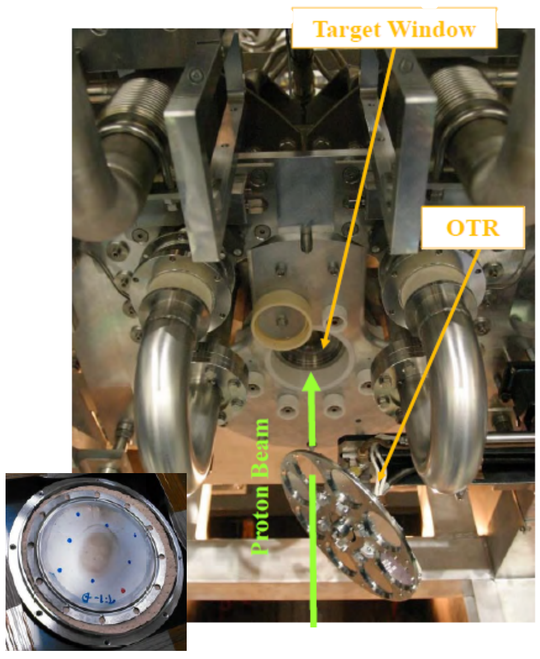
Optical Transition Radiation (OTR) Monitors

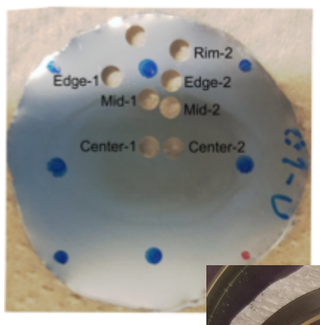
Backgroud: The OTR foil, made of metastable β-Ti alloy about 50 μm thick, indicates proton beam shape and alignment

Motivation: After exposure to the 30 GeV proton beam at 100-130°C, the area of the foil illuminated by the beam became discolored, with reduced sensitivity

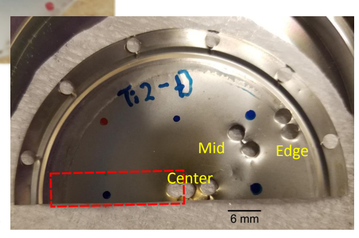
Objective: To understand if radiation damage or other effects caused the foil degradation



Transmission Electron Microscopy



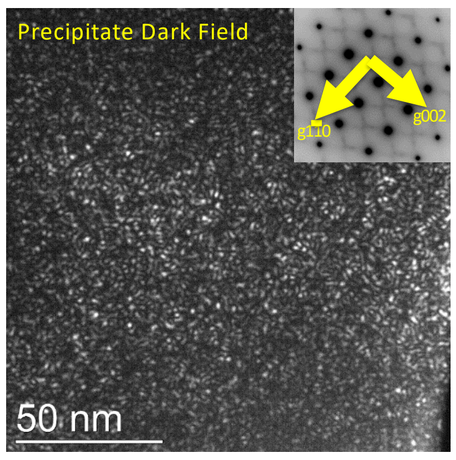
Ti-1



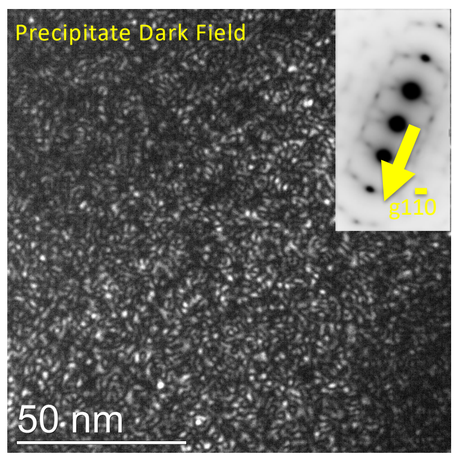
Ti-2

- Three OTR foils studied
  - Unirradiated archive
  - Ti-1 (1.4 x 10^{20} pot, ~0.1 dpa)
  - Ti-2 (5.2 x 10^{20} pot, ~0.3 dpa)
- TEM samples prepared from 3 mm disks punched from OTR foils
- Disks electrochemically etched in a Tenupol jet polisher

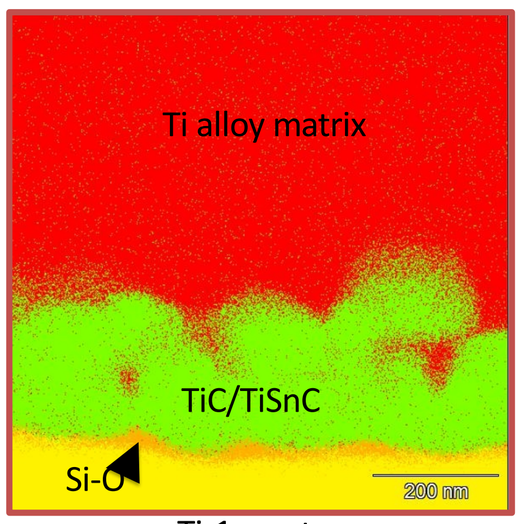
- Dark field images centered on one of the diffuse streaks in the diffraction pattern shows typical precipitates in Ti-1 and Ti-2
- Believed to be fine w-phase precipitates of 1-2 nm in size
- Comparable to precipitates observed in unirradiated archive foil and TEM samples taken near the edge of Ti-1 and Ti-2, thus not the result of irradiation damage
- Any incipient radiation damage must be at or below resolution limit



Ti-1, center



Ti-2, center

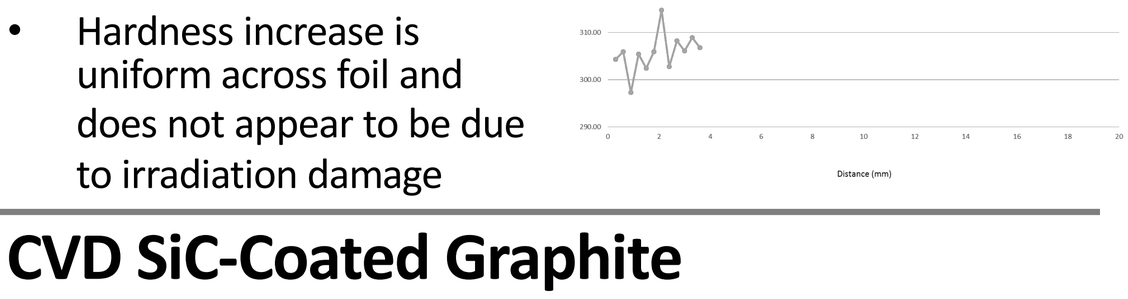


Ti-1, center

- A combination of elemental mapping via energy dispersive x-ray spectroscopy (EDS), principal component analysis (PCA) and precession electron diffraction (PED) identified the composition of the surface discoloration
- The Si and C impurities on the surface were attributed to backstreaming diffusion pump oil, not radiation damage

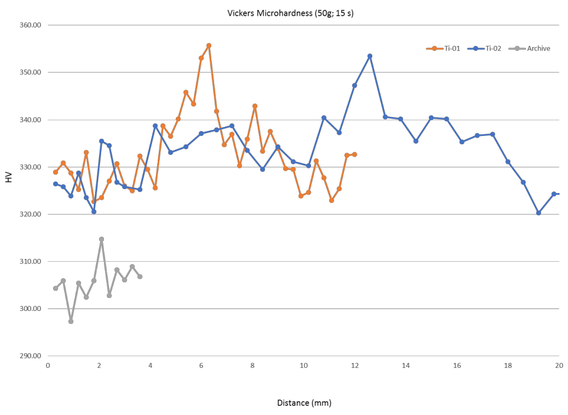
Atom Probe Tomography

- No obvious difference between APT results for unirradiated and irradiated OTR foils
- No statistically significant elemental segregation or precipitates observed



Microhardness

- Results suggest a ~10% increase in hardness for the irradiated foils compared to the unirradiated archive
- Hardness increase is uniform across foil and does not appear to be due to irradiation damage

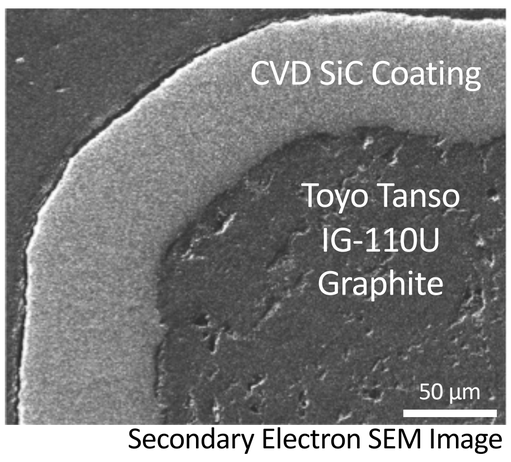


CVD SiC-Coated Graphite

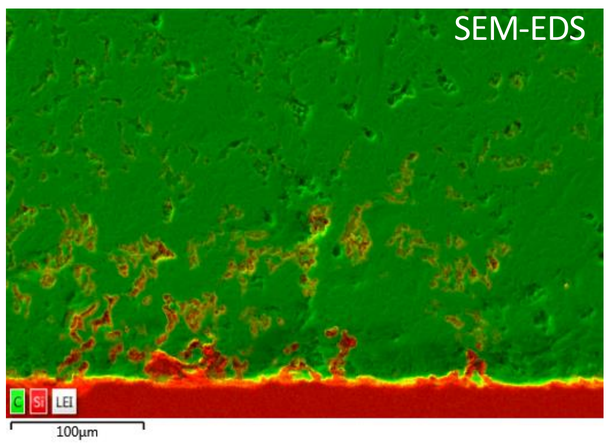
Background: Graphite is an excellent pion/muon target but is susceptible to oxidation under operating conditions

Motivation: The chemical vapor deposited (CVD) SiC coating has the potential to improve oxidation resistance without significantly degrading physics performance

Objective: Determine if SiC coating retains integrity after irradiation



Secondary Electron SEM Image of as-fabricated SiC-coated graphite



- As-fabricated SiC coating is dense and has good adhesion
- Some ingress of SiC into porous graphite during CVD
- Samples irradiated by 160 MeV protons at 240°C and 0.05 dpa
- Irradiated samples successfully extracted from capsule

- SEM microscopy on irradiated samples to evaluate condition of SiC coating is pending

ABOUT

Pacific Northwest National Laboratory

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