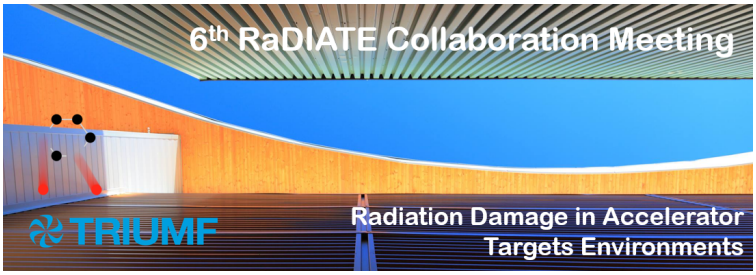

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Development of ultrasonic meso-scale fatigue testing of irradiated titanium alloys for proton beam window applications

Monday, 9 December 2019 14:25 (25 minutes)

Titanium alloys such as commercially available Ti-6Al-4V are currently used as the beam window material in the T2K (Japan) proton beam target for neutrino production due to their high specific strength and low thermal expansion coefficient. Thermal spikes from the pulsed beam cause high frequency stress waves with magnitudes well below the yield stress, which subject the component to high-cycle-fatigue (HCF) loading. The effect of proton irradiation on the fatigue life in the HCF regime is largely unknown, especially at the high radiation damage doses seen in operation. With the desire to increase the incident beam power to in excess of 1 MW in future experiments, causing damage doses well in excess of 1 dpa per annum, there is a growing need for the beam window manufacturer (STFC, UK), to fully understand the material performance limits under these extreme conditions.

In this collaborative research project, thin foils of titanium alloys have been irradiated to 0.25 and 1 dpa at the Brookhaven Linac Isotope Producer (BLIP) at the Brookhaven National Laboratory (BNL), USA. The alloys included the current Ti-6Al-4V beam window material in addition to several potentially radiation-resistant grades.

Using an evolution of the ultrasonic meso-scale fatigue test developed at the University of Oxford, we will perform high-cycle fatigue testing on these irradiated specimens at the Materials Research Facility (MRF) at the Culham Science Centre, UK. Microstructural investigation yielding crystallographic (EBSD) and chemical (EDX) information will be performed. The effect of irradiation damage on each alloy will be assessed and related to the microstructure. This will allow suitable materials to be specified for future beam window designs.

This presentation will cover the developments in the design and commissioning of an ultrasonic fatigue rig (UFR) at the MRF, UK. The capabilities of the UFR and associated real-time diagnostics will be outlined, along with the proposed ultrasonic test procedures and data analysis routines. An update on the materials research will be given, including microstructural and chemical analysis on the unirradiated specimens.

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