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High-Entropy Alloy R&D for Accelerator Beam Window Applications

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High-Entropy Alloys are a class of novel material that can offer improved resistance to beam-induced radiation damage and thermal shock. Development of these new alloys to serve as beam windows in multi-megawatt accelerator target applications is ongoing at Fermilab. Currently we are investigating AlCoCrMnTiV alloy systems of 4-6 components for service as beam windows; these compositions are predicted by CALPHAD simulation to have a low density and single-phase BCC crystal structure. The microstructures of these systems are being studied by electron microscopy techniques such as energy dispersive X-ray spectroscopy (EDS) to determine elemental homogeneity and composition, electron backscatter diffraction (EBSD) to quantify grain structure and orientation, and transmission electron microscopy (TEM) to observe defect structures and precipitate formation; nanoindentation is used to probe microstructural mechanical properties. Initial bulk property characterization utilizes differential scanning calorimetry to quantify specific heat capacity (c_p), dilatometry to determine the coefficient of thermal expansion (CTE), and time-domain thermoreflectance (TDTR) to measure thermal conductivity (K). A miniature tensile testing apparatus is also being developed to test tensile properties. Post-irradiation examination is currently ongoing for several of these compositions that have been irradiated by low-energy ions to damage levels and at a temperature relevant to beam window applications at future next-generation accelerator facilities. This talk will briefly describe the alloy design and synthesis before going into more depth covering microstructural pre-characterization, and post-irradiation examination results from low-energy ion irradiated specimens. This will be followed by the plans for alloy down selection and future prototypic proton irradiations.

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