Accelerated Irradiation and Evaluation of Ultrastrong and Elastic Glassy Carbon

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ABSTRACT:

Advanced glassy carbon with unique attributes beyond those of nuclear graphite have the potential to boost the innovation and development of nuclear materials for wide applications in the existing nuclear fleet and advanced reactors. The proposed project will conduct accelerated irradiation and post-irradiation evaluation of ultra-strong and elastic glassy carbon fabricated through our established advanced manufacturing processes. High-fluency irradiation will be mimicked using ion beams at temperatures correlating to operation and accident conditions of advanced reactors. Characterization of control samples and irradiated samples by a range of advanced techniques will enable the identification of irradiation-induced microstructural changes at different length scales, as well as property changes of the samples. This will make it possible to elucidate the mechanism of the observed changes. Moreover, the correlation among the changes, irradiation, and fabrication parameters will provide useful feedback for product improvement and process development. Preliminary irradiation studies of fabricated glassy carbon will be leveraged to jump-start the project. The overall project objective is to evaluate the irradiation tolerance of advanced glassy carbon materials through accelerated irradiation with high-energy proton, carbon-ion, and copper-ion beams and to investigate irradiation-induced microstructural and property changes. The testing matrix considers the need to understand damage morphology effect and implantation-induced catalyst effects for studying stability limitations against possible bond reconfiguration and phase changes under extreme conditions.

The project offers an excellent opportunity to examine how fabrication parameters affect material responses to irradiation through the analysis of carbon-carbon bonding, and to explore the relation among irradiation, properties, and atomic structures. If successful, the proposed project will benefit the development of high-performance nuclear components such as lightweight structural materials, accident-tolerant fuels and materials for encapsulation of high-level nuclear waste, the advancement of next-generation nuclear reactor technologies, as well as test reactors. Therefore, the proposed project closely aligns with DOE-NE's mission for enhancing long-term ability and competitiveness of the existing fleet, developing the advanced reactor pipeline, and implementing the national strategic fuel cycle.