Effects of high fluence helium ion irradiation on the micromechanical properties of Eurofer97 and ODS Eurofer steels

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This study aimed to address the challenge posed by elevated levels of transmutation helium in materials for advanced nuclear reactors, both fusion and fission, which leads to the formation of helium bubbles, causing embrittlement and swelling [1]. While current research primarily examines fundamental aspects such as defect evolution and void swelling at the nanoscale, our study specifically investigates the bulk properties of these materials and their practical engineering applications.

To study the effects of transmutation helium, we subjected Eurofer97 and its ODS variant, as well as five other structural steels–SIMP, PM2000, OSD Eurofer, SS 310S, and 800H–designed for use in demanding radiation environments, to high fluence helium ion irradiation. Using multiple ion energies ranging from 17 MeV to 1 MeV, we conducted the irradiation experiment with the 6 MV tandem accelerator at the ion beam laboratory at ATRI MTF STU. We systematically decreased the energy levels to create a uniform ”box-profile” with a helium concentration of 1000 appm [2]. This method resulted in a consistently irradiated layer approximately 65 μm thick, allowing us to focus on assessing changes in the micromechanical properties, particularly hardness, of the irradiated Eurofer97 and its ODS variant using the nanoindentation method.

In this contribution, we present the initial findings of our work, focusing on the nanoindentation analysis of the irradiated steel samples.

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