DOSE RATE AND TEMPERATURE EFFECT ON IRRADIATION-ENHANCED ALPHA PRIME PRECIPITATION IN ULTRA-HIGH PURITY FeCr ALLOYS

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FeCr binary alloys suffer from irradiation-enhanced phase separation into an embrittling Cr-rich α' phase. The α' precipitation under cascade-damage conditions results from two competitive processes: radiation-enhanced diffusion and ballistic dissolution. Either process can be dominant depending upon temperature and dose rate. To understand the effect of dose rate (ballistic dissolution) and irradiation temperature (radiation-enhanced diffusion) on α' formation**,** ultra-high purity Fe18%Cr samples in solid solution state and thermally aged to form pre-existing α'precipitates were irradiated with 8 MeV Fe ions to a midrange (~1 um) dose of 0.35 displacements per atom between 300-450 °C at 10^{-3}, 10^{-4} and 10^{-5} dpa/s. We used 8 MeV Fe ions to create a relatively wide midrange region for quantitative analysis thereby minimizing potential near-surface or implanted ion artifacts. Following irradiations, the cross-section microstructure was characterized using state-of-the-art analytical scanning transmission electron microscopy (STEM) on focused ion beam lift-out foils and atom probe tomography (APT). High-throughput STEM-EDX (FEI Talos F200X) mapping revealed qualitative evidence of α' precipitation after the ion irradiations. Further, the dislocation loops appeared decorated with fringes most likely due to Cr segregation to the loop interior. APT revealed co-segregation of C, N and Cr to the dislocation loops. APT also revealed homogeneously distributed α' precipitates for irradiation temperatures as low as 350 °C and dose rate as high as 10^{-4} dpa/s, indicating that the effect of radiation enhanced diffusion still dominated over ballistic dissolution at these conditions. The density, size, volume fraction and Cr concentration of α' precipitates was also quantified from APT results. In this presentation, we will make quantitative comparisons of the α' precipitation parameters with previously published irradiation studies, and the combined results will be analyzed with precipitate stability models available in the literature.

Research sponsored by the Office of Fusion Energy Sciences, U.S. Department of Energy under contract DE-AC05-00OR22725 with UT-Battelle, LLC and grant #DE-SC0006661 with the University of Tennessee. The fabrication of the Fe-Cr binary alloys has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training program 2019–2020 under Grant Agreement No. 633053.

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