The Effect of Helium Co-Injection on the Cavity Evolution in Ion Irradiated 21Cr32Ni Model Alloy

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Candidate materials for future advanced fission and fusion reactor systems must keep their dimensional stability against changes driven or enhanced by the high dose neutron irradiation. In particular, material swelling is considered as one of the major degradation modes especially for austenitic type stainless steels where cavities are generally in the form of bubbles stabilized with insoluble helium gas atoms that are generated as a result of transmutation reactions.

Austenitic alloy 800H has been proposed as a candidate material for high temperature applications because of its high corrosion and creep resistance. The alloy is also expected to show low swelling due to its high nickel content relative to other austenitic alloys. However, its behavior at high irradiation doses is still unknown due to the lack of experimental neutron irradiation data. High dose neutron irradiation experiments require long exposure times, and produce highly radioactive materials requiring dedicated instruments for their characterization. Ion irradiation can be used as an alternative approach for the assessment of irradiated microstructures since the damage rates by ions are ~100-1000 times higher than those by neutrons with no or very low activity.

In this study, the influence of helium on cavity evolution in alloy 800H has been investigated using a chemically similar but compositionally simpler model alloy of Fe21Cr32Ni (2132). The model alloy was dual ion irradiated with 5 MeV Fe^{2+} in the defocused mode and co-injected He^{2+} ions to ~17 dpa at two different He levels (of 1 appm/dpa and 17 appm/dpa) at 460°C at the Michigan Ion Beam Laboratory. Results showed that even low-He injection can influence the cavity evolution in the austenitic alloy microstructure. The microstructure included a high density of small cavities, -likely gas bubbles-m compared to the no-helium case at a similar temperature suggesting that helium promotes cavity nucleation in the alloy. As amount of helium injection increased, the average cavity diameter increased by a factor of ~3 and the cavity density by a factor of ~8, suggesting that helium can also cause cavities to grow in this material.

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