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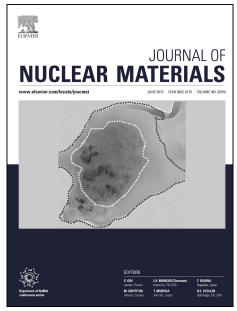

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Microstructural evolution of the 21Cr32Ni model alloy under irradiation

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The microstructural evolution of the 21Cr32Ni model alloy under ion irradiation is investigated. A set of bulk materials were irradiated at the Michigan Ion Beam Laboratory using single beam (5 MeV Fe^{++}) to 1, 10 and 20 dpa at 440°C and dual beam (5 MeV Fe^{++} plus energy degraded 1.95 MeV He^{++} ions) to 16.6 dpa at 446°C. The average diameter and number density of the faulted loops and cavities formed under irradiation were characterized using Transmission Electron Microscopy (TEM). The behavior of faulted loop in the model alloy was also investigated in-situ using the Intermediate Voltage Electron Microscope (IVEM) at Argonne National Laboratory (ANL). Results show that the average faulted loop diameter decreases, but the faulted loop number density increases with increasing dose. In-situ experiments showed that the faulted loops become unfaulted during ion irradiation by interacting with network dislocations. Although the average faulted loop diameter after 16.6 dpa dual beam irradiation at 446°C was found to be similar to those seen in samples irradiated with single beams to 10 and 20 dpa, the faulted loop number density was significantly higher in the dual beam irradiated sample. Moreover, the dual beam irradiated model alloy exhibits a significantly higher density of smaller cavities. It is also found that the size and density of the faulted loops and voids calculated for the dual beam irradiation of 21Cr32Ni model alloy at 446°C are in good agreement with those measured in a neutron irradiated sample at 375°C compared to the single beam irradiation. Further discussion is presented in this study.

Keywords: Austenitic stainless steels, helium, irradiation, faulted loop, cavity, segregation, dual beam irradiation, 21Cr32Ni model alloy, 800H.

1. Introduction

Fast neutron irradiation of materials in nuclear reactors causes radiation damage in the form of displacement cascades through which a large number of defects and defect clusters, both interstitial and vacancy in nature, are created. At high irradiation temperatures some of these clusters are mobile; they can diffuse and form even larger clusters in the form of dislocation loops or cavities. All these defect-defect and defect-sink interactions are at the root of 'microstructural evolution' which can alter the properties of the materials used in the reactor core. This issue is particularly important for the advanced reactor systems since in those systems, radiation damage levels can reach up to 200 dpa (displacement per atom) at operating temperatures of 400°C or above **[1]**. Stainless steel alloys have been developed and improved to withstand in high temperature corrosion environments **[2]**. Because high dose neutron irradiation experiments require impractically long exposure times and can activate the irradiated samples, heavy-ion irradiation has been widely used to understand the effect of radiation on the materials behavior **[3-9]**.

Alloy 800H (Fe-21Cr-32Ni) has been proposed as a candidate material for advanced reactor systems due to its high corrosion resistance **[10]**. Because of this, its microstructural changes under irradiation have been subjected to studies using both ions and neutrons. Gan et al. irradiated alloy 800H to 50 dpa using a single 5 MeV Ni ion beam at 500°C. They observed faulted loops (average size of ~8.4 nm) and fine precipitates with an average size of ~6 nm and no void swelling **[10]**. The type of the precipitates are not reported, however the authors reported that the average faulted loop number density increases with