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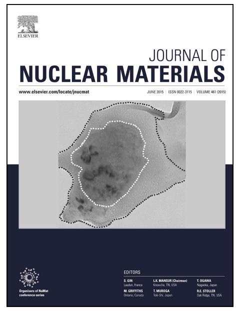

Nanoindentation and *in situ* microcompression in different dose regimes of proton beam irradiated 304 SS

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Nanoindentation and *in situ* microcompression in different dose regimes of proton beam irradiated 304 SS

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Abstract

Recent developments in micromechanical testing have allowed for the efficient evaluation of radiation effects in micron-scale volumes of ion-irradiated materials. In this study, both nanoindentation and *in situ* SEM microcompression testing are carried out on 10 dpa proton beam irradiated 304 stainless steel to assess radiation hardening and radiation-induced deformation mechanisms in the material. Using a focused ion beam (FIB), arrays of 2 μm x 2 μm cross-section microcompression pillars are fabricated in multiple dose regimes within the same grain, providing dose-dependent behavior in a single crystal orientation. Analysis of the microcompression load-displacement data and real-time SEM imaging during testing indicates significant hardening, as well as increased localization of deformation in the irradiated material. Although nanoindentation results suggest that irradiation hardening saturates at low doses, microcompression results indicate that the pillar yield stress continues to rise with dose above 10 dpa in the tested orientation.

Keywords: microcompression, nanoindentation, ion irradiation, stainless steel

1. Introduction

Irradiation assisted stress corrosion cracking (IASCC) in austenitic stainless steels has become an increasing impediment to the long term integrity of light water reactor structural components [1]. Predictions of IASCC susceptibility continue to be hindered by poor understandings of the deformation mechanisms at hand, as well as the difficulties of reproducing reactor conditions in laboratory tests. In the past several years, much research has been devoted to tackling both of these issues by performing standard mechanical testing on ion beam and neutron irradiated austenitic SS and correlating observed deformation mechanisms with crack initiation [2-4]. In 2011 Jiao & Was [2] demonstrated that a primary contributor to IASCC in SS is localized deformation via dislocation channeling, in which irradiation defects are cleared out in a narrow channel by gliding dislocations. This clearing of barriers to dislocation motion allows subsequent dislocations to easily follow the same path, causing strain to localize in these channels and reach values orders of magnitude higher than the bulk applied strain [5,6]. McMurtrey et al. [3,7,8] continued this line of investigation by characterizing the various mechanisms by which dislocation channels interact with grain boundaries. The authors found that in cases where dislocation

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