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A Snapshot of the Microstructural Evolution of Alloy 800H Under Heavy Ion Irradiation

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Alloy 800H is widely used in chemical processing facilities, industrial heating, and power generation units because of their high temperature strength and resistance to swelling, corrosion, and creep rupture [1]. The commercial alloy is code certified for nuclear systems with operating temperatures up to 760 ºC and a candidate material for Generation IV nuclear reactors [2,3]. However, uncertainty remains regarding the microstructural stability of alloy 800H under irradiation.

Recent work on radiation damage in various alloys has utilized heavy ions in order to simulate the damage cascade produced by neutron irradiation. Indeed, ion irradiation is comparatively faster, i.e. performed at much increase damage rates, less expensive, and produces samples that are safer and more convenient to study than in neutron irradiation [4]. In this context, Alloy 800H was subjected to ion irradiation at 440°C using 5 MeV Fe^{2+} ions to a nominal dose of 20 dpa (at 600 nm) at a dose rate of ~10^{-4} dpa/s. However, unlike neutrons, heavy ion irradiation creates a shallow damage layer with gradients of dose and fluence. The shallowness of the damaged region represents a challenge for the interpretation of the microstructures that can be affected by the proximity of the surface and the implanted interstitial region.

In an effort to understand the microstructural evolution under heavy ion irradiation, he microstructure of Alloy 800H sample was analyzed as a function of depth to expose a correlation with the damage profile. Figure 1 shows APT maps from the irradiated surface to a depth of about 2 µm. The figure includes the damage peak of the implanted Fe^{2+} ions for comparison with the APT maps. The observed microstructural features include spherical Al, Ti, and Ni rich solute clusters consistent with the irradiation-assisted formation of the γ' phase, Ni and Si segregation to dislocation loops, and abundant growth of Cr-Ti-rich carbides. This work exposes the microstructural evolution of Alloy 800H along the entire damage profile using atom probe tomography (APT) and identifies relationships between the damage peak and the observed features [5].

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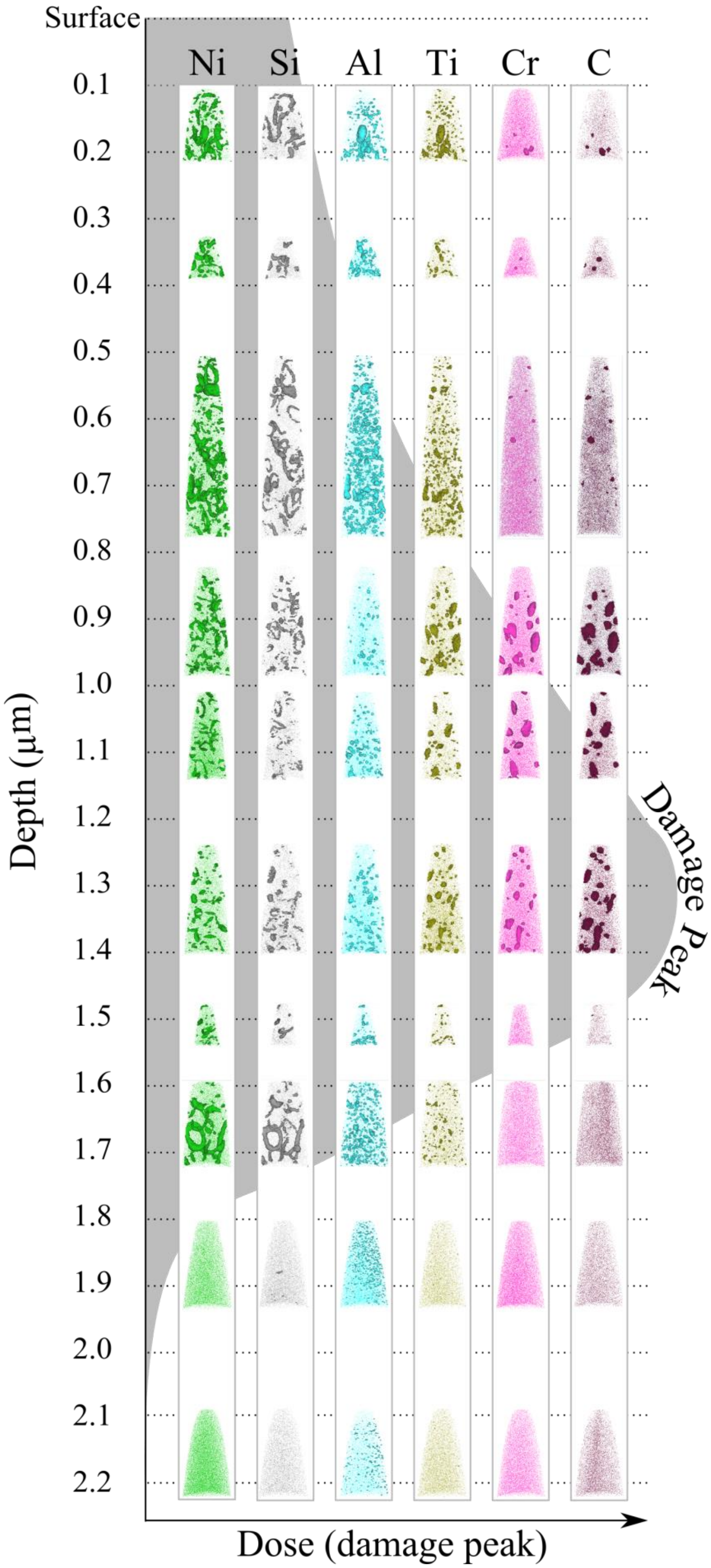

Figure 1. The microstructural profile of heavy ion-irradiated Alloy 800H as a function of depth. At 600 nm, the dose is 20 dpa with a dose rate of 10^{-4} dpa/s and 440°C. The microstructure is represented with APT maps for Ni, Si, Al, Ti, Cr, and C. The damage profile of implanted Fe^{++} ions was calculated with SRIM using the Kinchin-Pease model with displacement energy of 40 eV and is represented by the shaded area below the maps.

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