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# Heavy Ion Irradiation-induced Microstructural Evolution in the Next Generation Nuclear Material – Alloy 800H

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Alloy 800H is considered one of the candidate alloy systems to be used in the next generation advance nuclear energy systems [1, 2]. This is because this alloy is code-certified for high temperature (up to 760 $^{o}$C) use in nuclear systems [3]. Also, the high Ni and Cr concentration in the alloy provides good resistance to void swelling and corrosion in the advance nuclear energy systems [4, 5]. As part of the efforts to increase the mechanistic understanding of the radiation effects in this alloy at high dose, heavy ion irradiation experiments were performed on a commercial grade Alloy 800H. This alloy was irradiated with $Fe^{2+}$ ions at energy of 5MeV to doses of 1dpa, 10dpa, and 20dpa, at temperature of 440$^{o}$C using the facility at University of Michigan Ion Beam Laboratory, Ann Arbour, Michigan. In this investigation, a spherical aberration-corrected FEI Titan G2 80-200 with Super X EDX (ChemiSTEM™) operated at 200kV and equipped with a GIF Quantum 965 EELS has been used to provide independent compositional analyses of the nano-scale features that form during ion irradiation.

Scanning transmission electron microscopy (STEM) characterisation revealed the presence of irradiation-induced dislocation loops in Alloy 800H. However, in addition to loop formation, cavities were observed in Alloy 800H after ion irradiation to high dpa, examples of which are shown in Figure 1. These STEM-Electron Energy Loss Spectroscopy (EELS) analyses show that the interface of these cavities and matrix were enriched with Ni, Ti and Si. Qualitative STEM-EELS spectrum imaging shows Ni segregation at dislocations loops and pre-existing dislocations after irradiation, as shown in Figures 2(b), 3(b) and 4(b). Irradiation-induced precipitates were also observed in the STEM-EELS spectrum images. These included Cr-rich carbides (Figures 2, 3, and 4), which were only observed after irradiation to high dpa. The other solute-enriched features detected included Ni-Ti-enriched solute clusters that are believed to form at low dpa and then develop/grow with increasing dpa. The development of these nano-scale irradiation-induced features provides the opportunity for mechanistic studies and modelling to predict long-term microstructural evolution during prolonged irradiation exposure. The quantitative results and the potential phases of these solute clusters and precipitates and the critical role of advanced microstructural analyses will be further discussed.

References:

[1] U.S. DOE Nuclear Energy Research Advisory Committee and the Generation IV International Forum, A Technology Roadmap for Generation IV Nuclear Energy Systems, 2002.
[2] The OECD Nuclear Energy Agency for the Gen IV International Forum, Technology Roadmap Update for Generation IV Nuclear Energy Systems, 2014.
[3] K. Natesan, A. Purohit, S.W. Tam, and C.A. Greene, 2003, “Materials Behavior in HTGR Environments,” ANL-02/37 and NUREG/CR-6824.
[4] F.A. Garner and A.S. Kumar, in: Radition-Induced Changes in Microstructure: 13th International Symposium (part I), in: F.A. Garner, N.H. Packan, A.S. Kumar (Eds.), ASTM STP, 955, ASTM, Philadelphia, 1987, p. 289.
[5] J. Gan and B.A. Hilton, 2007, “TEM Examination of Advanced Alloys Irradiated in ATR”, IN/EXT-07-13306.

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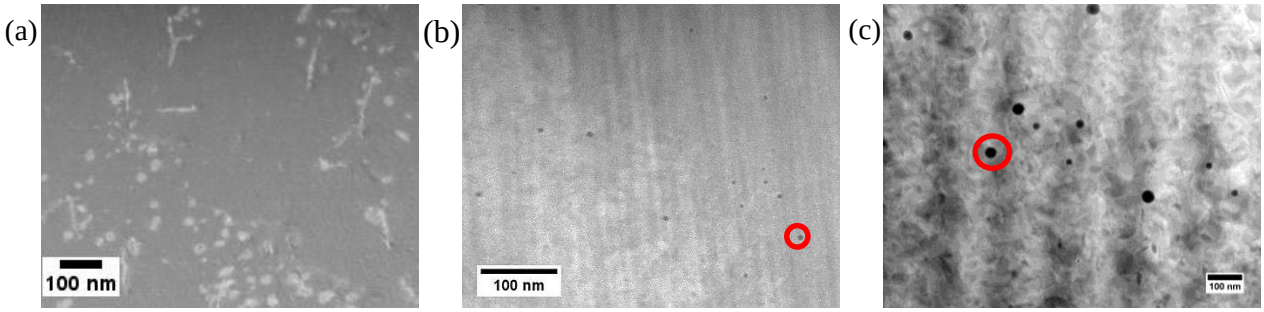


**Figure 1.** MAADF STEM images showing (a) irradiation-induced dislocations/loops in Alloy 800H irradiated to 1dpa, and (b)-(c) cavities, in Alloy 800H irradiated to 10dpa and 20 dpa, respectively.

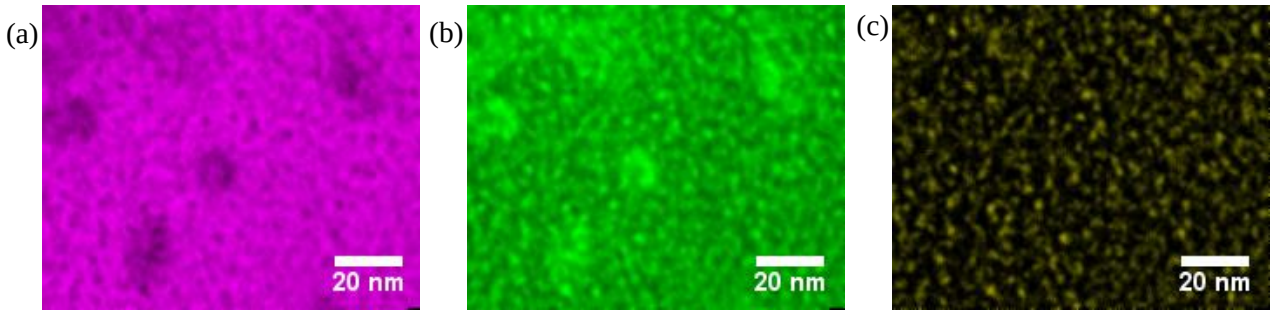


**Figure 2.** EELS MSA reconstructed spectrum images of (a) Cr L-edge, (b) Ni L-edge, and (c) Ti L-edge showing Ni-Ti-enriched solute clusters and Ni segregation to dislocation loops in Alloy 800H irradiated to 1dpa.

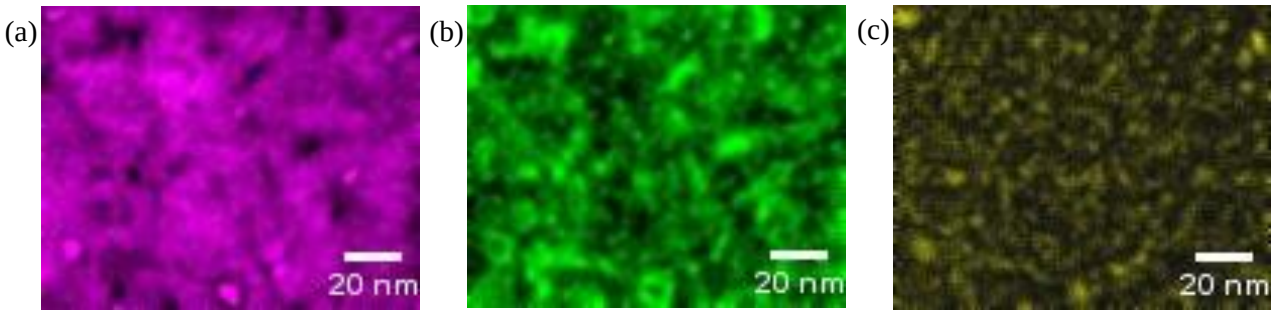


**Figure 3.** EELS MSA reconstructed spectrum images of (a) Cr L-edge, (b) Ni L-edge, and (c) Ti L-edge showing irradiation-induced Cr-rich precipitates, Ni, Ti-rich solute clusters and Ni segregation to dislocation loops as well as pre-existing dislocation lines in the Alloy 800H irradiated to 10dpa.

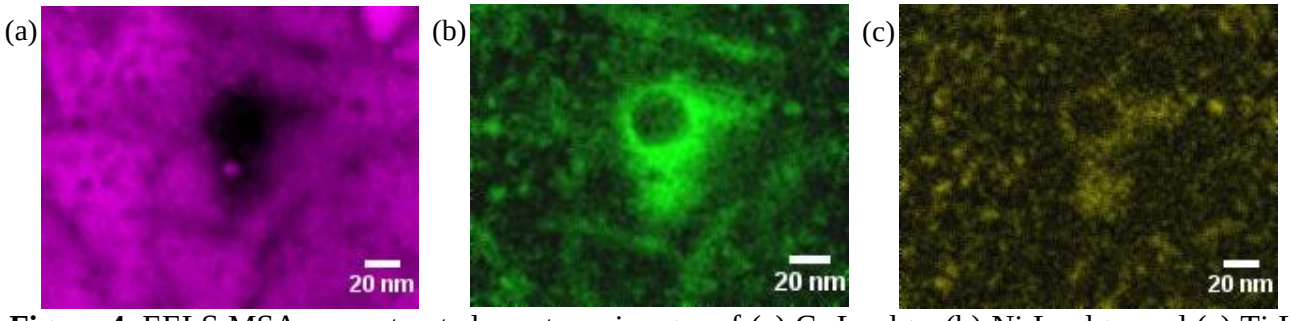


**Figure 4.** EELS MSA reconstructed spectrum images of (a) Cr L-edge, (b) Ni L-edge, and (c) Ti L-edge showing Cr-rich carbides, Ni, Ti-rich solute clusters and Ni segregation to dislocation loops and dislocations in Alloy 800H irradiated to 20dpa. Note the Ti and Ni segregation around cavities.

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