Influence of irradiation conditions on precipitation behavior in Fe-Cr and Ni alloys

E. Reese[1], L.-J. Yu[1], N. Almirall[2], K. Hattar[3], T. Yamamoto[2], G.R. Odette[2], J. Tucker[4], M.G. Burke[5], and E.A. Marquis[1]

[1]University of Michigan, Ann Arbor, MI, USA
[2]University of California, Santa Barbara, CA USA
[3]Sandia National Laboratory, Alburquerque, NM USA
[4]Oregon State University, Corvallis, Or, USA
[5]University of Manchester, Manchester, UK

The use of heavy ions, protons, or electrons to understand the effect of irradiation on microstructures and therefore materials properties presents many experimental benefits over the use neutrons. However, extrapolating the laboratory observations to behaviors found under neutron irradiation in reactor conditions is not a straightforward process. In particular, dose rates that are orders of magnitude apart and can play a significant role on the development of microstructures, through mechanisms that include higher point defect production and cascade mixing effects.

Here, we will discuss the behaviors under ion, proton, and neutron irradiation of alloys that would normally phase decompose under thermal conditions. Specifically, using atom probe tomography to characterize microstructures at high spatial and chemical resolution, the evolution of microstructures in model ferritic Fe-Cr alloys and austenitic Ni alloys was quantified as a function of dose and dose rates. In Fe-Cr alloys, precipitation of the α' phase is expected under long thermal annealing times. In the selected commercial Ni alloys (625, 625 Plus, and 690), the γ" phase, an ordered Pt_2Mo-type phase, and in some cases the γ' phase are expected to precipitate. Under irradiation conditions, both alloy systems exhibit different precipitation regimes that are dependent on dose rate. Generally, accelerated precipitation by radiation-enhanced diffusion is observed at lower dose rates, establishment of a steady state regime occurs at intermediate dose rates, and precipitation is entirely suppressed at higher dose rate.