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Irradiation behavior of austenitic binary model alloys: Ni, Ni-Ti and Ni-Cr

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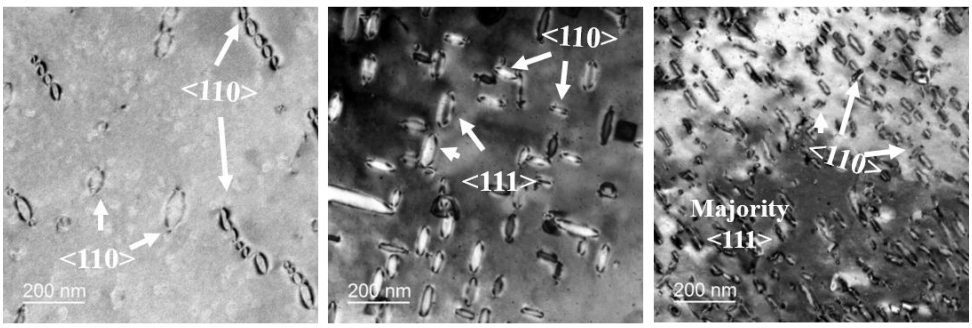
Austenitic stainless steels are foreseen as cladding and structural materials for future generation IV reactors. However, their swelling under irradiation favored by their Face Centered Cubic (FCC) structure limits their lifetime in reactors and therefore the fuel burn-up. Austenitic steel swelling is a complex phenomenon. It starts with an incubation regime with no macroscopic deformation and is followed by a steady state regime where the swelling rate is about 1%/displacement per atom (dpa). The steel composition does not influence the swelling rate in the steady state regime but thermomechanical treatments, major and minor elements, such as chromium (Cr) and titanium (Ti), play a major role on the incubation dose [2-3]. In order to increase the incubation time of austenitic steels, it is utmost important to get a better understanding of the mechanisms involved.

This study focuses on the effect of Ti and Cr on the microstructure evolution of FCC structure on the incubation period during irradiation. Pure nickel and two binary alloys (Ni-0.4wt%Ti and Ni-0.4wt%Cr) were studied as FCC model alloys of austenitic steels. In a first step, the effect of an addition of Ti or Cr on the nature, size and density of dislocation loops was studied with an ex-situ irradiation experiment on JANNuS-Saclay platform. The samples were irradiated at 450 °C with Ni ions up to 0.5 dpa and characterized by Transmission Electron Microscopy (TEM). Microstructures after irradiation are showed in Fig.1. It suggested that Ti and Cr could delay the transition from Frank loops to perfect loops either by increasing the stacking fault energy or by reducing the defect mobility or the dislocation bias. Therefore, in a second step, the influence of Ti and Cr on the dislocation bias and the loop growth was investigated by electron and ion in-situ experiments at 450°C. Electron irradiations were performed on the High Tension TEM of CEA/SRMA and the Ni ion irradiation on JANNuS-Orsay platform. Results will be presented and discussed during the presentation.



(a) (b) (c)

Figure 1: Irradiated microstructure of: (a) pure Ni; (b) Ni-0.4Cr; (c) Ni-0.4Ti with <110> noted as perfect loop and <111> as Frank loop.

References

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