In-situ ion irradiation of Ni-based austenitic model alloys

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The swelling of austenitic stainless steels (ASSs) under irradiation is a complex phenomenon. It starts with an incubation regime and is followed by a steady state regime where the swelling rate is 1%/displacement per atom (dpa). The steel composition does not seem to influence the swelling rate in the steady state but solute elements, such as Cr and Ti, play a major role on the incubation dose [Garner2012, Benkaddour1994]. To increase the swelling threshold, 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 face-centered cubic (f.c.c.) structure on the incubation period. Pure nickel and two binary alloys (Ni-0.4wt%Ti and Ni0.4wt%Cr) were studied as f.c.c. model alloys. Samples were irradiated at 510°C by 2 MeV Ni2+ ions with a flux of 4 ± 0.8 x1011 ions/cm2/s in a TEM using the JANNuS-Orsay facility. The fluence was up to 9 ± 1.8 x1013 ions/cm2 (0.06 dpa by SRIM-2018 at 200 nm thickness).

The microstructure evolution of three samples was analyzed. In all the samples, dislocation loops were formed and grew during the irradiation. However a great difference among samples was shown. Loops in Ni were formed intensively, grew very quickly and were quite mobile. In Ni-Ti, the nucleation was the densest but the loop growth the slowest. The growth rate in Ni-Cr was twice as low as Ni but ten times higher than in Ni-Ti. Another interesting phenomenon is the internal contrast change of the loops during irradiation. It is probably due to the unfaulting of faulted loops into perfect loops. After irradiation, the loops (size, density, Burgers vectors) were characterized by TEM versus the sample thickness. A stronger effect of sample thickness was found in Ni than in Ni-Ti. Results will be presented in details and discussed during the presentation.

References

[Garner2012] F.A.Garner, Radiation Damage in Austenitic Steels , volume 4, p. 33 (2012).
[Benkaddour1994] A. Benkaddour et al. J Nucl. Mater. 217 (118-26). (1994).