Effect of ion irradiation on austenitic stainless steel at low temperatures

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Ti stabilized austenitic steels are prime candidate materials for fuel cladding in the first cores of future liquid metal cooled fast reactors. 15-15Ti grades have been succesfully applied for this purpose in sodium cooled fast reactors such as Phénix and Super Phénix in France. Elevated temperatures and high fluxes of fast neutrons can cause rapid degradation to mechanical properties and volumetric swelling in reactor core materials. Ti combines with C in the steel to form TiC nanoprecipitates, which act as point defect sinks and recombination centers. These delay some of the adverse effects of radiaiton, thereby increase the lifetime of the component and the fuel burn-up. Lead or lead bismuth cooled fast reactors are envisioned to operate at lower temperatures than sodium cooled reactors. The relevant irradiation temperature domain is still largeley unexplored for this class of steels

In this work, a new heat of DIN 1.4970 steel of the 15-15Ti family was subjected to heat treatment and Fe^{2+} ion irradiations at different temperatures between 300 and 600 °C. The resulting microstructure was studied by TEM and APT, as well as nanoindentation. It was found that at low irradiation temperatures (<450 °C), TiC nanoprecipitates tended to become unstable and completely redissolve. At 600 °C, Si and Ni segregated to the precipitate interface and Ti tends to cluster with Si and Ni to form G phase and γ' phase. Frank loop populations were also studied in the different irradiated layers. The results indicate that at lower irradiation temperatures TiC precipitates may not help against the adverse effects of radiation.

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