Reordering of Cr atoms during proton irradiation in a Fe-5 at.% Cr alloy

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The Fe-Cr alloy system is the base of ferritic/martensitic steels with a Cr concentration up to 15 at.%. Because of their low activation, resistance to radiation damage accumulation and good mechanical properties, Fe-Cr alloys are considered as prime candidates for the internal structure of future Fusion Power Plants. However, the behaviour and the evolution of their microstructure under irradiation is not yet fully understood. One of the greatest obstacles in understanding both thermodynamic and kinetic properties of Fe-Cr under irradiation is the uncertainty relating to the low temperature equilibrium state (T<700 K). Currently the low temperature part of the Fe-Cr phase diagram is derived only from high-temperature experiments.

In an effort to elucidate the existence of solute ordering effects during irradiation, which may affect phase stability and microstructure evolution, proton irradiations were performed at the NCSR "Demokritos" 10MV TANDEM accelerator at a temperature of 400 K. It was shown that atomic migration is still possible even at such a low temperature, enabled by the energy imparted to the lattice atoms during collisions with the irradiating particles. The radiation-enhanced diffusion constant associated with this effect has been estimated by performing experiments at different proton fluxes. Irradiation induced modifications were detected by means of in-situ measurements of the electrical resistivity, which is sensitive to solute ordering in alloys. It was found that significant re-ordering of Cr atoms takes place during irradiation of Fe-5 at.% Cr alloys, leading to enhanced short-range order.

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