ID de Contribution: **6** Type: **Talk**

Synthesis of (Y, Ti) nano-oxide particles in FeCr alloy by ion implantation

mardi 29 mai 2018 17:40 (20 minutes)

Oxide dispersion strengthened (ODS) ferritic/ martensitic FeCr steels are reinforced by dense and stable metallic (Y,Ti) nano-oxide particles. These ODS steels are known to have very good creep and radiation resistance as well as improved mechanical properties at high temperatures, making them ideal candidates to be used as structural materials for future generation IV (Gen IV) fission and fusion nuclear reactors. Even though significant amount of research has been conducted and continues in the field, the exact mechanism of formation of the nano-particles –important to improve their fabrication, and thus their properties - is yet to be fully established. This study is an attempt at reproducing the various steps and mechanisms of formation of these nano-particles by the use of ion beam synthesis contrary to the conventional ball milling and consolidation techniques used in the industrial fabrication of these steels. The use of ion implantation technique enables to de-correlate the contributions of each of the implantation parameters and if accompanied by appropriate modeling, could provide very useful information to help understand the mechanisms involved in the formation of these nano-oxide particles. At a first step, a high purity FeCr alloy has been sequentially implanted at room temperature with Ti+ and O+ ions at energies of 100 and 37 keV, respectively, and subsequently annealed at various temperatures. The mobility and diffusion of the elements in the matrix has been studied by time-of-flight Secondary Ion Mass Spectroscopy (ToF-SIMS) technique and modeling. The formation of nano-particles has been observed only after annealing at high temperatures. The nature, crystallographic structure and chemical composition have been investigated using conventional and analytical Transmission Electron Microscopy (TEM) techniques. Additional preliminary results also show the formation of nano-particles in (Y,Ti,O)- ion implanted specimens.

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Classification de Session: Nuclear Energy