Experimental study of microstructure evolution under irradiation of zirconium alloys. Towards a better understanding of irradiation induced growth.

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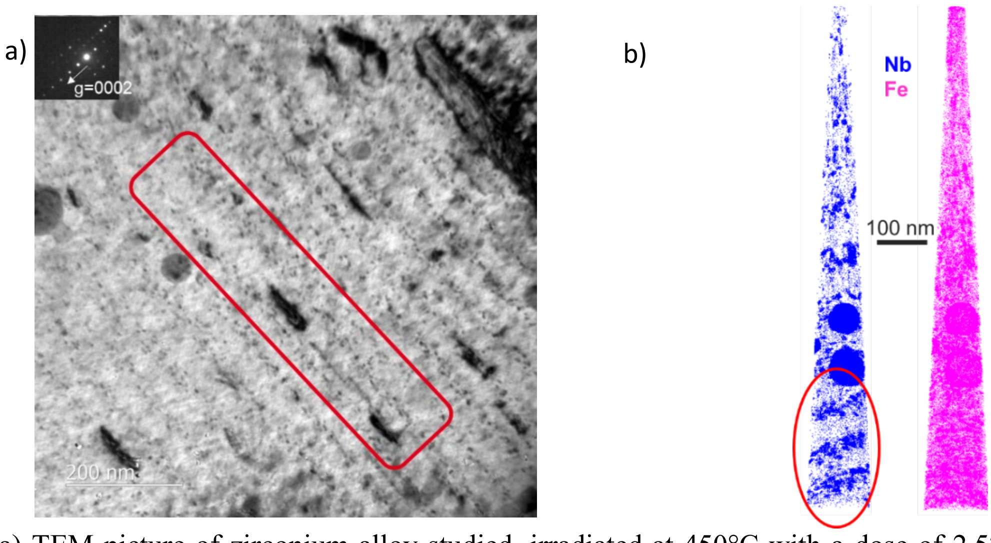
Zirconium alloys are widely used as a cladding material for nuclear fuel in Pressurized-Water Reactors (PWR). They have been chosen for their very low thermal neutron absorption cross-section, their good corrosion resistance and good mechanical properties. Under irradiation these materials exhibit a deformation phenomenon called “stress free growth”, that occurs without applied stress. At higher doses, a growth acceleration occurs [1]. Many authors have attributed this acceleration to the formation of specific irradiation defects known as the c-component loops, but the detailed mechanism that relates the dislocation loop evolution to the growth acceleration is still unclear [2–4]. Furthermore, the alloying elements seem to have an effect on the c-loops formation and thus on the growth deformation [5].

We used EMIR platforms to irradiate a zirconium alloy, containing 1% niobium and several hundred ppm of iron, with heavy ions. Different temperatures and doses have been chosen to investigate whether the microstructure (dislocation loops and segregations) obtained is similar to those of neutron-irradiated specimens. Irradiated samples are characterized using two advanced techniques: Transmission Electron Microscopy (Figure a) and Atom Probe Tomography (Figure b) in order to analyze both the microstructure and the microchemistry, thus having a complete understanding of the material after irradiation. The first results obtained show the formation of c-loops and the formation of Nb-rich precipitates under irradiation.



a) TEM picture of zirconium alloy studied, irradiated at 450°C with a dose of 2.52x10^{15} ions/cm^2 (Au^{5+} ions, E =12 MeV) and Au ions, grain oriented with diffraction vector g=0002 ; b) APT atom maps of Nb and Fe of a sample taken from the same specimen – Nb-rich segregations induced by irradiation are circled in red.

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