Radiation damage suppression in AISI-316 steel nanoparticles: implications for the design of future nuclear materials

Self-healing capability of point and extended defects that are introduced by energetic particle irradiation is a desired behaviour to be attained in the design and selection in potential materials for application in extreme environments. Nanoporous materials have potential for achieving higher radiation tolerance due to the presence of many active unsaturable surfaces to which defects may diffuse and thus be effectively annihilated. The effects of heavy ion collisions in the lattice of functional AISI-316 steel nanoparticles (NPs)-which serve as a model for the ligaments in a nanoporous–, are herein investigated in-situ within a transmission electron microscope. Comparisons are made directly with AISI-316 steel in the form of foils and the results show that the fewer radiation-induced defect clusters form in the NPs and that small NPs ($r < 50$ nm) were observed to accumulate fewer defects when compared to larger NPs. Post-irradiation analytical characterisation within a scanning transmission electron microscope (STEM) revealed that the AISI-316 steel NPs may develop a radiation-induced self-passivation (RISP) driven by a solute-drag mechanism: an effect that can potentially enhance their radiation corrosion resistance in the expected extreme conditions of a reactor. The capability of a NP to self-heal irradiation-induced point defects is investigated using the cellular model for active internal and surface sinks. The design of functional nanoscale materials for extreme environments is discussed.