Simulation of Inert Fission Product Gas Effects to the Inner Surface of the Fast SCWR Cladding

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Introduction

•The inner cladding surface of the SCWR undergoes bombardment from energetic Xe and Kr noble gas fission products.

•Surface damage effects from this phenomenon are unknown, but may result in appreciable degradation of the cladding over reactor lifetime.

• The UW IEC (Inertial Electrostatic Confinement) device uses 10 – 100 keV helium ions to simulate the damage caused by these energetic Xe and Kr fission products

• Preliminary experiments tested two candidate Ferritic-Martensitic steels slated for use in the fast SCWR – HT9 and T91

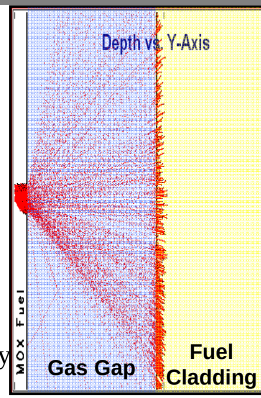
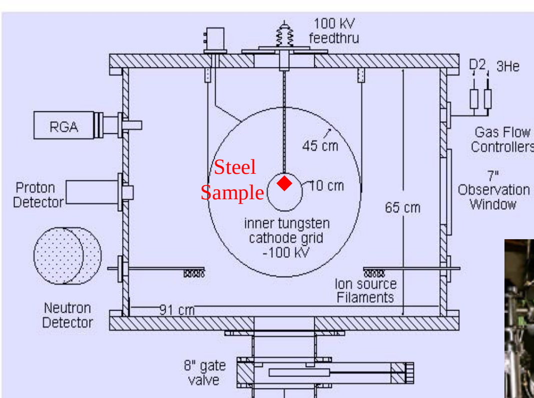


Figure 1: Schematic of Fuel Pin and Cladding

Experimental Setup

• Ferritic-Martensitic steel samples are mounted in the IEC and negative potentials of 10-100 kV are applied



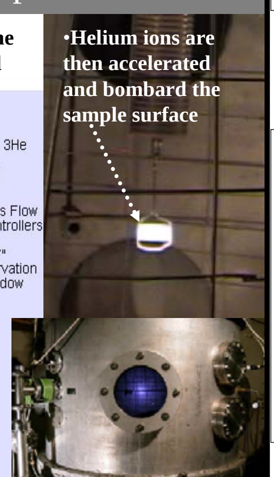


Figure 2: IEC Device and Sample During Irradiation

Modeling Xe, Kr, and He Range Using SRIM©

•The SRIM program was used to model the comparative range of IEC ions in the cladding to that of the energetic Xe and Kr fission gases.

•The gas gap pressure in the fuel pin was modeled using the FRAPCON code (developed at PNNL) to determine if a significant amount of Xe and Kr fluence is lost to collisions in the gas gap.

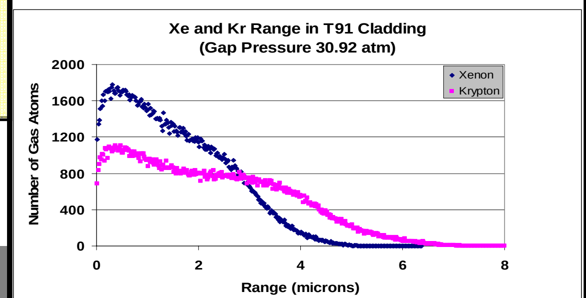


Figure 3

•Results show that irradiation using 100 keV He^+ in the IEC device effectively simulates low energy Xe and Kr bombardment of the cladding.

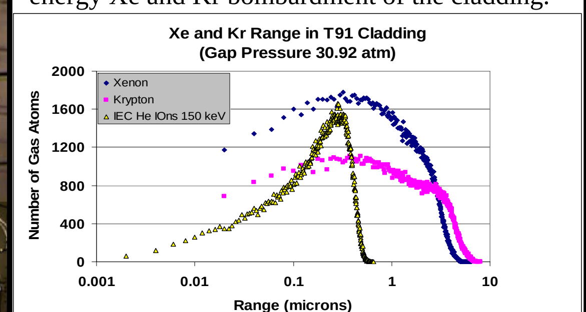


Figure 4

Special Thanks To: AFCI and the University Fellowship Alliance
Kenneth Geelhood at PNNL

Preliminary Results

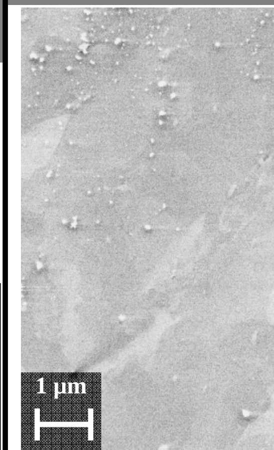


Figure 5: T91 Steel Unirradiated

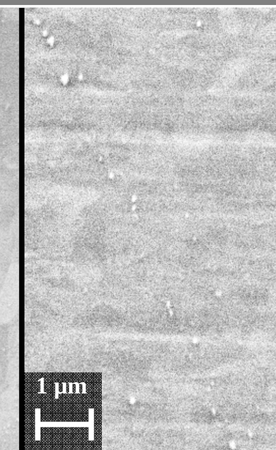


Figure 6: HT9 Steel Unirradiated

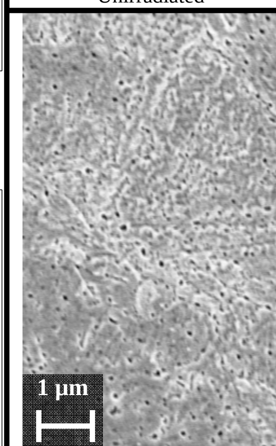


Figure 8: T91 irradiated to ~5×10^{17} He^+/cm^2 at 550°C. SEM analysis illustrates substantial pore formation over the sample surface.

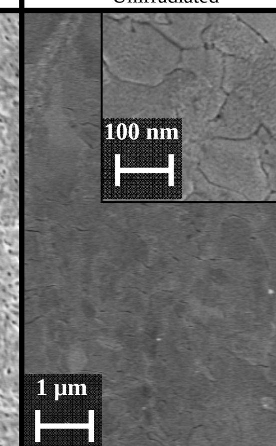


Figure 9: HT9 irradiated to ~3×10^{17} He^+/cm^2 at 625°C. Post irradiation analysis reveals grain boundary segregation on sample surface.