Mesoscale Modeling of High Burn-up Structure (HBS) Formation and Evolution in U-Mo alloy

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U-Mo and other nuclear fuels develop a unique microstructure under irradiation usually known as the High Burn-up Structure (HBS). Recrystallization was proposed as a mechanism that facilitates HBS formation, where the increases in the free energy due to the formation of new grain boundaries is offset by the reduction in the free energy caused by creating dislocation-free grains at the expense of the deformed grains. A phase field model was utilized to study irradiation-induced recrystallization. The model takes into consideration the chemical energy of gas atoms, interfacial energies of grain boundaries and bubble surfaces and strain energy associated with dislocations. This renders the model capable of simulating the formation and growth of sub-grains and bubbles concurrently. The model predicts a strong effect of magnitude and distribution of dislocation density, grain boundary energy, and bubble surface energy on the formation of sub-grains. A systematic study of the effects of temperature, grain size, dislocation density/burn-up, bubble size and fraction on the overall kinetics of HBS formation and evolution was conducted. The model predictions agree well with reported data in literature.