Potts Model for Simulating Main Characteristics of High Burnup Structure in UO_2 Nuclear Fuels

Jae-Yong Oh*, Yang-Hyun Koo, Byung-Ho Lee
Korea Atomic Energy Research Institute
1045 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea

* Corresponding Author
Tel. : +) 82-42-868-2944
Fax : +) 82-42-864-1089
E-mail : tylor@kaeri.re.kr

Abstract

A high burnup structure (HBS) is observed in the periphery of a high burnup UO_2 fuel. It has very unique characteristics: The HBS microstructure consists of very small sub-μm sized grains and large 1μm sized bubbles instead of original 10μm sized UO_2 grains, and the threshold burnup and temperature for the HBS evolution exist.

Since the HBS evolution in UO_2 fuel resembles recrystallization phenomena in materials from the aspect of forming new small defect-free grains, some HBS models adopted a basic concept that the driving force for the HBS evolution is the stored energy in the UO_2 grains due to an irradiation. In the paper, the Potts model, based on the kinetic Monte Carlo method, was implemented to simulate a HBS evolution instead of an analytical solution. We adopt the Potts model for the HBS evolution from simulating a recrystallization phenomenon. We consider only energy stability instead of considering detailed HBS evolution mechanisms. It generated detailed snapshots of the evolving HBS microstructure with time, which could explain some controversial experimental observations on the HBS evolution. The threshold burnup and temperature for the HBS evolution were also simulated by the Potts model.