

Cavity Swelling Behavior in SiC/SiC under Charged Particle Irradiation

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Silicon carbide (SiC) and its composites (SiC/SiC) are attractive structural materials for fusion reactor because of their superior mechanical properties at high temperature and high irradiation resistance. On their performance under fusion nuclear environment, void swelling is one of the important issues to be clarified. As to microstructural evolution, authors have reported that at high dose helium cavities were formed on grain boundaries in both matrix and fiber at 1273 and 1673K. However, the effects of displacement damages and of helium production on microstructural evolutions of matrix, fiber and interface have not been sufficiently investigated yet. The objective of this study is to analyze microstructural evolution in SiC/SiC composites under ion irradiation at high temperature, with the special emphasis on behavior of cavities in SiC/SiC.

The materials used were Tyranno-SATM fiber reinforced SiC/SiC composites, fabricated by chemical vapor infiltration (CVI) method. The ion irradiation was carried out at Dual-Beam Irradiation Experimental Test (DuET) Facility in Institute of Advanced Energy, Kyoto University. In order to induce displacement damages, 5.1MeV Si²⁺ ions were irradiated (single-ion irradiation). And in order to simulate (n, α) reaction, an additional beam of energy-degraded 1.0MeV He⁺ ions was simultaneously implanted (dual-ion irradiation). Displacement damage level was up to 100dpa, irradiation temperature was up to 1673K, He/dpa ratio was 0 or 60appmHe/dpa, respectively. For a microstructural investigation by cross-sectional transmission electron microscopy (XTEM), the irradiated samples were subjected to a thin foil processing using a focused ion beam (FIB) device.

In single-ion irradiation, no void was detected at 1273 and 1673K, 10dpa. But many voids were observed at 1673K, 100dpa. In dual-ion irradiation, three kinds of cavities were observed at 1673K, 100dpa: The first one is helium bubbles (approximately d=5nm) formed densely on (111) faulted planes in the fiber and matrix. The second one is voids (approximately d=20nm) formed on grain boundaries in the fiber and matrix. The third one is large cavities (approximately d=100nm) observed on grain boundaries only in the fiber. The third types were pre-existing pores as intrinsic defects. There are helium bubbles observed densely around such large cavities. As total dose dependence, reduction of helium bubble number density, void growth and localization were detected. The nucleation sites of cavities, grain size and other factors affecting microstructural evolution under single or dual-ion irradiation will be discussed.