

§28. Evaluation of the Stability of SiC/SiC Composites for Inertial Fusion Dry Wall Chamber to High Temperature Irradiation and Design Study Based on the Material Properties

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INTRODUCTION

The first wall of an Inertial Fusion Energy (IFE) chamber will suffer serious damage from intense pulsed neutrons and other energetic particles. Due to excellent mechanical properties at high temperatures, chemical stability and low activation following neutron irradiation, SiC/SiC composites is attractive for Tokamak fusion reactors. The knowledge about irradiation resistance at high temperature over 1773 K is indispensable, in particular for designing dry wall chamber of IFE in spite of technical difficulty.

The objective of this work is to understand the stability of SiC/SiC composites to high temperature irradiation over 1500 °C to establish design window for IFE dry wall chamber.

EXPERIMENTAL PROCEDURE

A high purity polycrystalline 3C-SiC produced through chemical vapor deposition process were irradiated with 5.1MeV Si²⁺ for inducing displacement damage at DuET facility, Kyoto University. The damage level was up to 3 dpa (displacement per atom), and irradiation temperature was up to 1873 K. The magnitude of swelling and microstructure were examined at MUSTER (Multi-scale testing and evaluation research) facility. The surface height change as a consequence of irradiation-induced swelling was measured with Micromap™ interferometric optical surface profiling system. For a microstructural examination, the irradiated specimens were subjected to a thin-foil processing using a focused ion beam (FIB) micro-processing device. The microstructural was examined with cross-sectional transmission electron microscopy (XTEM).

RESULTS AND DISCUSSION

In figure 1, the swelling of SiC irradiated at 3dpa is plotted as a function of irradiation temperature, along with reported neutron irradiation data [1]. Considering the outstanding controllability of irradiation conditions in the present ion irradiation experiment, we suspect that part of neutron data have been affected by irradiation

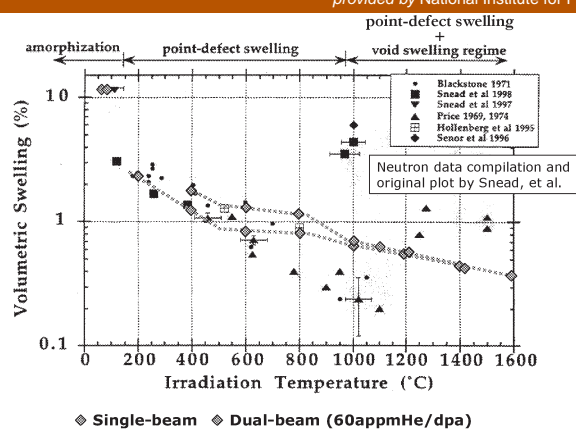


Figure 1. Temperature dependence of swelling of SiC induced by irradiation.

temperature uncertainty and/or unintentional transient low temperature neutron exposure that is peculiar to the irradiation in fission reactor cores [2]. In addition, some of the neutron data might have been affected by transmutation of boron, which had been added as a sintering aid to produce dense materials.

Void formation at high temperature ($T_{irr} > 1273$ K) has been concerned about severe increase in swelling. The trend curve of swelling shown in figure 1 indicates that the void formation have little influence on the swelling value below 1873 K. It was also confirmed by TEM examination.

Nano-powder Infiltration and Transient Eutectic Phase (NITE) Process developed at Kyoto Univ. is the most promising process to fabricate SiC/SiC composites for nuclear application [3]. The NITE-SiC/SiC composites consist of high purity 3C-SiC fiber and 3C-SiC matrix. The dimensional stability in the NITE-SiC/SiC composites is expected to be close to monolithic SiC studied here. The results in the present study indicate that the NITE-SiC/SiC is applicable to the first wall without severe swelling at high temperature.

REFERENCES

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