Microstructural Response of C/BN Particle Dispersed SiC Materials to Ion Irradiation

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Abstract

The precise control and weakness against environmental corrosion of the fiber/matrix interphase are bothering the SiC composite industry. To overcome these problems, the C/BN particle dispersed SiC composites without interphase have been developed and displayed promising prospect in nuclear applications. Here in this study the ion irradiation response in microstructure of C/BN particle dispersed SiC materials will be explored by AFM and Raman spectroscopy.

Keywords: silicon carbide, irradiation, C/BN particle, swelling, microstructure, raman spectroscopy.

1. Introduction

Basically weak fiber/matrix interphase materials such as carbon (C) or boron nitride (BN) is required for SiCf/SiC composites. Precise control of the interphase material, however, is a critical issue in terms of large scale production and material cost. In addition, the interphase material is the weakest point for the environmental effects. To overcome these problems, the C/BN particle dispersed SiC composites without interphase materials have been developed and have displayed promising mechanical properties and oxidation resistance [1]. The objective of this study is to investigate the irradiation response in swelling of C/BN particle dispersed SiC matrices, which is critical for the C/BN particle dispersed SiC composites to be used in nuclear applications.

2. Experiments

SiC-20vol% BN and SiC-20vol% C materials were fabricated by liquid-phase sintering (LPS) using hot press for consolidation. CVD-SiC and LPS-SiC with same amount of sintering additives as SiC-20vol% BN and SiC-20vol% C were used for comparison. These samples were polished to be mirror-like and then irradiated to 0.1/1/3/100 dpa by 5.1 MeV Si^{2+} ions at 300 ℃ in the DuET facility, Kyoto University. The surface morphology was observed by AFM and the swelling induced by irradiation was calculated from the AFM data. The specimens were excited by the 532 nm line of an argon ion laser focused to an area about 140×15 μm^2 in size on the specimen, using a 50× microscope objective lens.

3. Results

The swelling of CVD SiC saturated at 1 dpa, to a value of 2.1%, while the swelling of the LPS-SiC specimens didn't saturate at 300 ℃ at least up to 3 dpa, with a value of 3.1%, and reached to a value of 9.67% at damage of 100 dpa. Addition of C/BN particle didn't influence the swelling of the SiC materials, because the swelling behavior of SiC-20vol% BN and SiC-20vol% C is quite similar to LPS-SiC at every damage level. According to the correlation between the swelling and the wavenumber of the Raman peaks, it's inferred that SiC saturated between 0.1 dpa and 1 dpa, BN saturated at below 0.1 dpa, and C didn't get stable at least up to 3 dpa. Raman spectroscopy also showed that a small fraction of cubic BN formed from the main hexagonal BN phase.

4. Conclusion

These data indicate that the C/BN particle dispersed SiC composites fabricated by LPS can be applied at irradiation damage up to 3 dpa but not 100 dpa, at 300 ℃. The temperature-dependence of the swelling of sintering additives needs to be further confirmed to verify the feasibility of using these LPS-SiC composites in other temperatures.

References

[1] Tatsuya Hinoki, Kanjiro Kawasaki, Fujio Shinoda, and Kazuya Shimoda, "High temperature mechanical properties of BN particle dispersion SiC composites" in "Composites at Lake Louise 2017", ECI Symposium Series, (2017).