26aD59P

SiC材料の電気特性に及ぼすマクロ・ミクロ損傷の影響
Effects of macro/micro damages on electrical properties of SiC materials

野澤貴史、大久保成彰、小沢和巳、谷川博康
Takashi NOZAWA, Nariaki OKUBO, Kazumi OZAWA, Hiroyasu TANIGAWA

原子力機構
JAEA

Introduction

A silicon carbide fiber reinforced silicon carbide matrix (SiC/SiC) composite is a promising candidate of the functional structure of the liquid breeding DEMO blanket. Of many functions to realize this concept, electrical insulation is the most essential and it is recognized that damage tolerance of the electrical properties needs to be understood since overall function of the component can be ensured by structural stability. This study therefore aims to identify the effects of macro/micro damages on the electrical properties of various SiC materials.

Effect of macro damage on SiC/SiC composites

SiC/SiC composites inherently have much internal flaws, which are progressively propagated by mechanical loading. The electrical properties are therefore subject to the evolution of these macro cracks. The material tested was highly-crystalline Tyranno-SA3 SiC fiber reinforced chemically vapor infiltrated (CVI) SiC matrix composite with multi-layered SiC/pyrolytic carbon (PyC) interface. The macro damage was induced by tensile loading at different stress levels. The electrical properties were then evaluated by the frequency sweep AC impedance method (DC level: 0 V, amplitude: 100 mV, start and end frequencies: 1 MHz and 1 Hz).

First, we identified that the SiC/SiC composite tested was electrically much conductive (~5 Ohm). This is because PyC as the fiber/matrix (F/M) interface is more conductive than SiC monolith. From this aspect, it is believed that micro-cracking caused electrical disconnection at the F/M interface. However, at least below proportional limit stress (PLS), which is considered as the first fiber sliding stress for the latest composites with high interfacial friction, there was no marked change in the electrical conductivity. Even if the matrix cracking occurred, the conductive PyC interfacial materials still contact to the intact SiC fibers until sliding.

In contrast, above the PLS, the electrical degradation was detected. In this case, fiber sliding and subsequent fiber break progressively occurred until the fracture strength. Physical discontinuity of the fibers finally caused electrical degradation.

Effect of micro damage on SiC ceramics

Due to less resistivity of the composite, it is considered that the high-resistivity SiC over-coating must be effective for the insulator application. Understanding fundamental electrical behavior of SiC itself is therefore more important. In addition, irradiation-induced damage needs to be considered. Of particular emphasis is that identifying the effect of displacement damage as well as the effect of ionization is essential toward the DEMO design.

160 MeV Xe^{14+} ions were irradiated at room temperature with chemical vapor deposited (CVD) SiC by the Tandem accelerator at Tokai, JAEA. The AC impedance was measured by the guard ring method after each irradiation test. Pt electrodes were deposited on both surfaces of the 3 mm-dia. 50 μm-thick small disk specimen.

Some degradation of electrical conductivity of SiC were identified after irradiation. Fig. 1 shows indicative radiation induced electrical degradation (RIED) of CVD SiC. With increasing irradiation fluence, RIED monotonically increased. This trend is qualitatively quite consistent with the previous results by gamma-ray and 14 MeV neutron irradiation experiments.

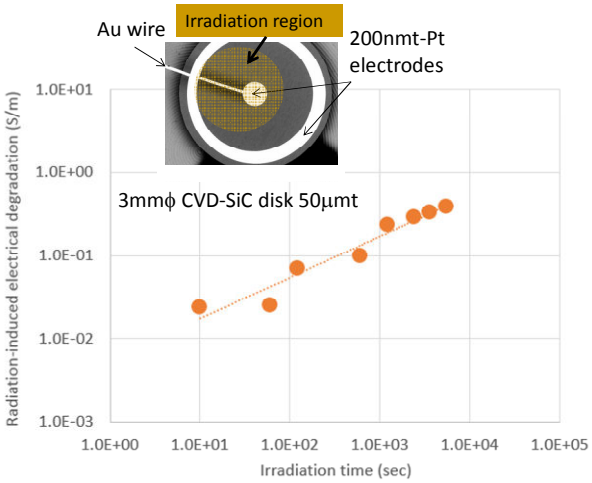

Fig. 1 Effect of Xe^{14+} on electrical conductivity