RADIATION INDUCED CHANGES IN ELECTRICAL CONDUCTIVITY OF CHEMICAL VAPOR DEPOSITED SILICON CARBIDES UNDER FAST NEUTRON AND GAMMA-RAY IRRADIATIONS

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Silicon carbides (SiCs) are potential candidates as insulating materials in nuclear fusion systems such as separators, between tritium breeding and neutron multiplier materials composing a blanket system. So far, it has been reported that the electrical properties of insulating ceramics are dynamically modified by the so-called dynamic radiation effects [1]. The present work in the Broader Approach activities is to understand fundamental aspects of dynamic radiation effects for SiCs; that is indicative of transportational behaviours of electrical carriers, namely, electronic, ionic, and protonic conductivity, for application of the SiC based ceramics and composites in advanced nuclear systems.

Specimens used in the present study are SiC materials with high purity of 99.9995 % and high density of 3.21 g/cm^3, synthesized by the chemical vapor deposition (CVD) technique by Mitsuizousen Co. The in-situ 14 MeV fast neutron and 1.17 and 1.33 MeV gamma-ray radiation experiments were carried out using a fast neutron source facility and ^{60}Co gamma-ray source, installed in Tokai Research and Development Centre and Takasaki Advanced Radiation Research Institute, respectively, of Japan Atomic Energy Agency (JAEA). Dose rates of the electronic excitation of the fast neutrons and the gamma-rays are approximately 0.01 and 5.9 Gy/s, respectively. The electrical conductivity are in-situ measured at room temperature in air by detecting DC-currents, associated with applying DC-voltages in the range from +30 to -30 V, before, during, and after irradiation, with the electrodes of so-called three terminals configuration .

Figure 1 shows dependence of the electrical conductivities of the SiC on the fast neutron fluence, where filled and opened circles represent data on beam-on (during irradiation) and -off (non-irradiation), respectively. A small amount of radiation induced conductivity (RIC) was observed at the beginning of the irradiation. In addition, the RIC as well as base conductivity without radiation gradually increased with an increase in the fluence. The radiation induced electrical degradation (RIED) may play a role there by breaking the bond between Si and C atoms due to the atomic displacements and by the electronic excitation. Similarly, a larger amount of the RIC occurred under gamma-ray irradiation, which commonly depended on the dose rate. The RIED-like behaviour was also observed, and the degradation saturated at the dose of 50 kGy.

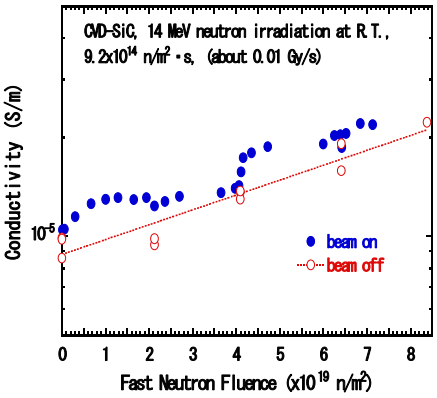

Figure 1: Fast Neutron Fluence dependence of electrical conductivities of SiC before, during, and after fast neutron irradiation.

[1] E. R. Hodgson, Nucl. Instr. and Meth. in Phys. Res. B 191 (2002)