Atomic structures and electrical properties of SiO_2/4H-SiC interfaces

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The physical properties of silicon carbide (SiC) have led to the commercialization of high temperature, high frequency, and high voltage power devices. [1] However, the metal/SiO_2/SiC structures exhibit a high gate leakage current and lower channel mobility than bulk mobility. In the present study, we investigated the relationships between atomic structures and electrical properties of SiO_2/4H-SiC interfaces with different crystal orientations of the substrate and thermal oxidation procedures using extended x-ray absorption fine structure (EXAFS) and electrical methods.[2][3]

The dry and wet oxidations were performed on the 4H-SiC (0001) and 4H-SiC (000-1) substrates after performing the standard RCA cleaning, followed by Ar annealing. The SiO_2 layers thus prepared were etched with a diluted HF to obtain SiO_2 with thicknesses of around 3 nm. EXAFS measurements were performed at BL6N1 in the Aichi Synchrotron Radiation Center. The reference samples (bulk 4H-SiC and thick SiO_2) and SiO_2/4H-SiC structures were measured by total electron yield (TEY) and differential electron yield (DEY), [4] respectively.

From EXAFS oscillations, we found the C and Si vacancies formation at the SiC substrate side of SiO_2/4H-SiC (0001) and SiO_2/4H-SiC (000-1) interfaces, respectively. Compressive stresses at the SiC substrate side of SiO_2/4H-SiC (0001) and SiO_2/4H-SiC (000-1) interfaces with the dry thermal oxidation procedure were indicated from reduction of bond lengths in EXAFS. Comparing previous studies with the present study, wet oxidation exhibited less interface stress than dry oxidation. We also found interface stress relaxation by wet oxidation was more effective for 4H-SiC (000-1) substrates than for 4H-SiC (0001) substrates. Relationships between the interfacial atomic structure with the electrical properties were found as follows. A high interface stress related to a high total-density of interface states, while a high interface charge related to a high gate leakage current onset and a high breakdown electric field.

Keywords: EXAFS, interface structure, SiO_2/4H-SiC, thermal oxidation

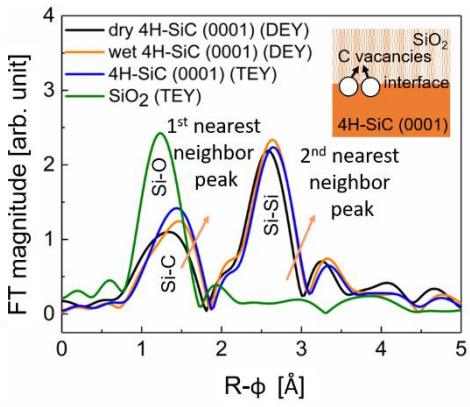

Figure 1. Radial distribution functions of SiO_2/4H-SiC (0001) structures prepared by dry and wet oxidation and the reference samples of bulk 4H-SiC (0001) and thick SiO_2.

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