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Reduction of Defects at the SiO_2/SiC Interface by MeV Electron Beam Irradiation

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Among wide-band gap semiconductors, SiC has attracted interests in part because a stable native oxide SiO_2 can be grown only on SiC. However, metal-oxide-semiconductor field effect transistors (MOSFETs) based on SiC have shown lower electric performance than expected from bulk SiC properties. The low electrical performance has been known to be related to defects at the SiO_2/SiC interface. The defects produce fixed charges and interface trap states lowering electric performance. Several experiments using x-ray photoelectron spectroscopy have shown that the defects are Si suboxides (Si^{3+}, Si^{2+}, and Si^{1+}) and Si oxycarbides (Si-C-O). Therefore, the reduction of defect density at the SiO_2/SiC interface is one of crucial issues for device applications of the promising wide-band gap SiC. In this study, 1 MeV electron beam was irradiated on a SiO_2/SiC wafer at room temperature and ambient condition to reduce the defect density at a SiO_2/SiC interface, where a native SiO_2 film with a thickness below 1 nm was naturally grown on a 6H-SiC(0001) wafer in air. The effect of the irradiation on the SiO_2/SiC interface was investigated schematically by using synchrotron radiation scanning photoelectron microscopy with various incident photon energies (hν's). This makes it possible to measure spatially-resolved core-level spectra along directions parallel and perpendicular to a surface. Spatially-resolved Si 2p spectra show that 1 MeV electron beam irradiation reduces inevitable defects, Si suboxides (Si^{3+}, Si^{2+}, and Si^{1+}) and Si oxycarbides (Si-O-C), at the SiO_2/SiC interface with an ultrathin SiO_2 film leaving an abrupt SiO_2/SiC interface. It is meaningful that the defect reduction by the irradiation succeeds at room temperature and ambient condition. Therefore, MeV electron beam irradiation is a promising method in producing a high quality SiO_2 and an abrupt SiO_2/SiC interface.