Analytical and Structural Investigations of the Metal – Enhanced Oxidation of SiC - MOS Structures

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It is well recognized that the operation and reliability of the SiC-based MOSFETs are significantly degraded due to high interfacial charge densities. Recent studies on gate oxides grown via metal enhanced oxidation (MEO), i.e., grown in presence of sintered alumina, had indicated significant reduction of the interface trap density. The results have been correlated with the increased field effect mobilities and small threshold voltage shifts [1]. We have performed detailed studies of the chemical and structural variations across the MEO SiO_2/4H-SiC interfaces in order to correlate those changes with the enhanced performance of the SiC MOS devices.

The MEO SiC-MOS structures were studied via X-ray Photo-Electron Spectroscopy (XPS), Electron Energy Loss Spectroscopy (EELS) and Transmission Electron Microscopy (TEM). Both XPS and EELS analyses indicate that the major elements C, Si and O go through changes of their chemical states in the interface transition regions from SiC to SiO_2. These changes are indicated by variation of the XPS and EELS peak positions, intensities and shapes with depth profiling, as shown in Fig. 1. Further, XPS depth profile studies suggest that these changes have occurred at ~ 200-300 nanometers deep down into the SiC substrate. Also, EELS analysis indicates the local variation in the chemical state of the major elements close to the interface regions. In addition, structural characterization studies with TEM reveal contrast changes at the near interface regions that also indicate local chemical and/or stoichiometric variations. However, there is no indication of structural degradation or amorphization of the top few atomic SiC layers of the MEO processed samples, as shown in Fig. 2, as has been reported previously for the thermally grown oxide films [2].

The results from these investigations correlate with studies done on similar interfaces with characterization techniques, such as spin dependant recombination (SDR) and EELS [3, 4].

References:
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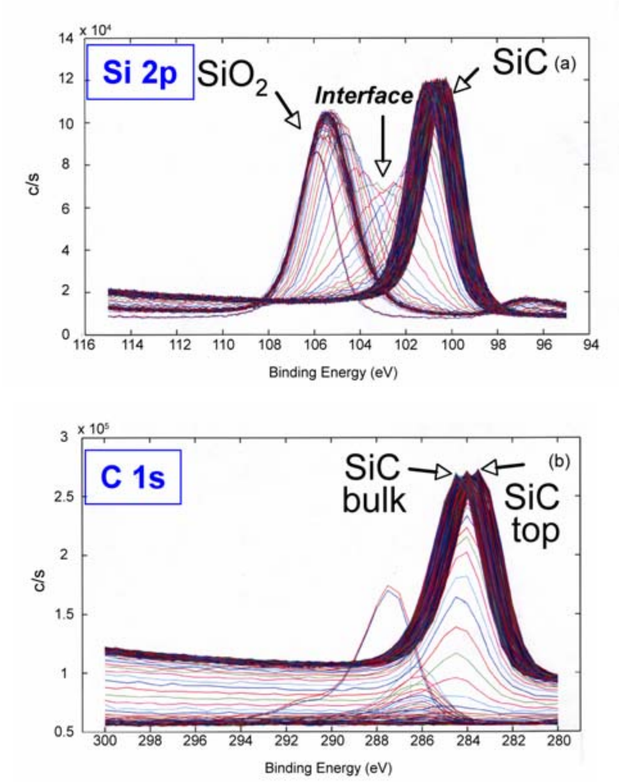

Fig. 1. XPS depth profiles for: (a) Si 2p and (b) C 1s. The changes in the chemical states of the respective peaks persist deep down into the SiC substrate.

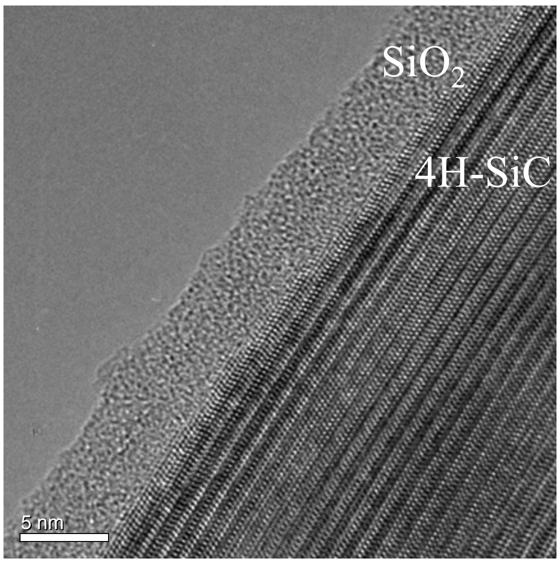

Fig. 2. HRTEM image from the MEO SiO_2/4H-SiC interface revealing abrupt interface without structural degradation of the top 4H-SiC surface.