Local Valence Electronic States of SiO₂ Ultrathin Films Grown on Si(100) Studied Using Auger Photoelectron Coincidence Spectroscopy (APECS): Observation of Upward Shift of Valence-Band Maximum as a Function of SiO₂ Thickness

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Introduction

The local valence electronic states of SiO₂ ultrathin films grown on a Si(100)-2×1 surface (SiO₂/Si(100)) have been studied extensively because (1) in-depth understanding of the electronic properties of surfaces and interfaces from an atomic point of view is of fundamental importance in science, and (2) these films play dominant roles in metal-oxide-semiconductor field-effect transistors (MOS-FETs). Therefore we investigate the local valence electronic states of the surface of the SiO₂/Si(100) ultrathin films by using Si-L₂³VV Auger electron – Si⁴⁺-2p photoelectron coincidence spectroscopy (Si-L₂³VV-Si⁴⁺-2p APECS), the oxidation number represents the number of oxygen bonding to Si [1].

Results and Discussions

Figure 1 shows the Si-2p photoelectron spectrum of SiO₂/Si(100) with a thickness of 2.8 Å (≈2 ML, 2.8-Å SiO₂/Si(100)). The Si-2p peaks are decomposed into the Siⁿ⁺-2p photoelectron components (n = 0, 1, 2, 3, 4). The straight dashed line at +4.1 eV represents the Si⁴⁺-2p photoelectron kinetic energy (PeKE) position taken as the trigger signals for the Si-L₂³VV-Si⁴⁺-2p APECS measurements.

Figure 2 shows a series of Si-L₂³VV-Si-2p APECS spectra for 13-, 2.8-, 1.7-, and 1.5-Å SiO₂/Si(100). The Si⁴⁺-2p PeKE positions taken as trigger signals of these APECS were set to the same value. Every wide-scan Si-L₂³VV-Si⁴⁺-2p APECS spectrum in Fig. 2(a) shows clear five peaks (P₁–P₅). In Fig. 2(b), we show the enlarged Si-L₂³VV-Si⁴⁺-2p APECS spectra. The intense peaks shift by ≈1 eV to the higher-AeKE side, while the cut-offs shift by ≈4 eV to the higher-AeKE side as the SiO₂ thickness decreases. These results indicate that the binding energies of valence band maximum of 1.5- and 1.7-Å SiO₂/Si(100) are shifted upwards by ~1.6 eV (toward the Fermi level) in comparison with that of 13-Å SiO₂/Si(100) [1].

References


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