Hard X-ray photoelectron spectroscopy study on buried interfaces in next generation CMOS devices

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The gate insulators having high dielectric constants, high chemical reaction barriers at interfaces of the gate insulator with Si substrate and gate metal, and large conduction and valence band offsets at these interfaces are strongly anticipated for the metal-oxide-semiconductor field effect transistors (MOSFETs) used in the next generation complementary MOS (CMOS) devices. These buried interfaces for CMOS devices has been successfully characterized non-destructively by newly developed hard X-ray excited photoelectron spectroscopy having extremely large probing depth of more than 10 nm. In this review we will discuss the composition and chemical structures and their thermal stability at these buried interfaces in gate metal (NiSi, TiN, etc.)/gate insulator(HfO_2, HfON, PrSiO, La_2O_3, etc.)/silicon structures, conduction and valence band offsets at these interfaces, and the interface layers used as chemical barriers between gate insulators and Si substrate, etc. In addition, we will discuss on the dielectric constants of ultrathin silicon oxide films determined from the measurement of the oxidation-induced chemical shifts in Si 1s and Si 2p photoelectron spectra.