

Effect of Optical Constants on Measurements of Thin Gate Dielectric Materials

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Introduction: We wish to test the accuracy of published optical constants used for thickness measurements of oxide and other dielectric layers used on Si for CMOS devices. We do this by performing thickness and composition measurements using grazing incidence x-ray photoemission spectroscopy (GIXPS) above and below the Si K-edge, where the optical constants go through large changes. The thickness measured for a surface oxide should remain the same, although the data will look appreciably different.

Methods and Materials: XPS spectra were taken of a sample of native oxide SiO_2/Si over a series of angles between 0° and 1.5° . The work is performed using a double-crystal monochromator using an InSb(111)/KDP(200) crystal pair and toroidal mirror focussing. The integrated yields of photoemission peaks for the Si 2p lines in the substrate and oxide layer, the O 1s in the oxide layer, and the C 1s surface contamination were all fitted for the thickness and content of a multilayer solution.

Results: Spectra were obtained at 1822 eV (Fig. 1), which is immediately below the Si K-edge (1839 eV), and at 1844 eV (Fig. 2), which is immediately above the edge.

Conclusions: The large changes in the real and imaginary parts of the index of refraction are immediately evident in the spectra, for which all the other parameters remain the same. Fits to the integrated photoemission yields as a function of angle give an oxide thickness of 1.08 nm measured below the edge and 0.86 nm above the edge. This indicates some discrepancy in the calculated index of refraction about the Si K-edge.

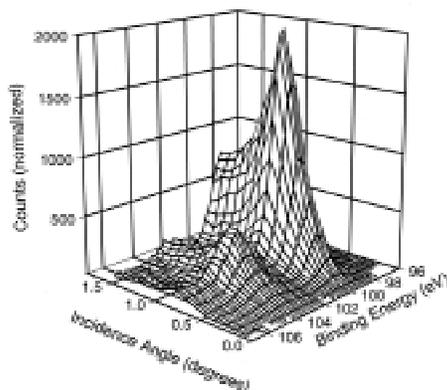


Figure 1. GIXPS Si 2p photoemission spectra showing bulk (lower BE) and oxide (higher BE) peaks. $E_0=1822$ eV.

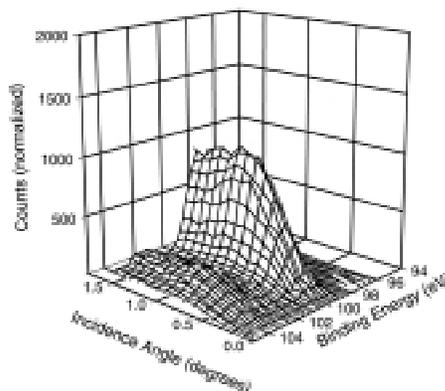


Figure 2. GIXPS Si 2p photoemission spectra from the same sample at $E_0=1844$ eV.