Application of X-ray Photoelectron Spectroscopy in Semiconductor Industry

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Over several decades, X-ray Photoelectron Spectroscopy (XPS) has been widely used for surface issues in chemistry-based industries. It was limited in its application for semiconductors due to film thickness and chemical change of material during the Ar+ sputtering process. Over the past ~15 years, things have slowly changed as the semiconductor industry has evolved. There has been a steady decrease in the thickness of many layers of the "thin film" structure down to the sub nanometer. This has made XPS a highly suitable technique for material characterization of the whole film, because of the correlation in film thickness to XPS probing depth (~10nm). In addition, surface and interfacial layers on the nanometer scale were technologically irrelevant when thin thickness approached micrometer (μm) dimension. Today, as films go down to a few nanometers; the interface reaction might consume a considerable fraction of overall film thickness and strongly affect many film properties. In this presentation, several case studies in semiconductor industries will be investigated, like High K materials – HfO_2, SiN_xO_y, ultra-low K materials, metal gate material (TiN and TiAlN) work function control, and contamination analysis on small pads on patterned wafers. Opportunities and challenge for XPS application in the semiconductor world will be discussed.