Reliable In-Line Metrology Based On The Combination Of X-Ray Reflectometry And Spectroscopic Ellipsometry

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ABSTRACT

The demand for accurate and highly reliable in-fab characterization of thin layers included in advanced CMOS and MEMS stacks has placed stringent requests on in-line optical metrology methodology and protocols. This paper will report on the interest of a lab-to-fab characterization protocol based on the combination of X-ray reflectometry (XRR), variable-angle spectroscopic ellipsometry (VASE) and in-line micro-spot ellipsometry (µ-SE). First, X-ray reflectometry (XRR) provides unambiguous thickness information of the thin layers of interest. Then, VASE analysis is run based on XRR-deduced thickness, which permits to determine the dispersion laws of the materials of interest will low correlation concern when compared with SE-only analysis. Finally, these dispersion laws are implemented on µ-SE tool so as to run automated measurements on product wafers. Based on numerous examples (semiconductors, dielectrics, transparent conductive oxides, anisotropic materials), we will evaluate the performances and limitations of this characterization protocol. We will demonstrate that, as far as key parameters (e.g. interfacial and top oxide layers, airborne molecular contamination, surface and interfacial roughnesses, etc) are taken into account, systematic combination of XRR and SE permits to accelerate the development of new processes and to increase the reliability of in-fab process monitoring.

FIGURE 1. VASE raw data and best-model calculation based on isotropic assumption relating to a sample made of 63nm-thick hydrogenated amorphous carbon layer grown by PECVD at 400°C on a silicon wafer. Though the isotropic model appears to properly depict the raw data, it leads to a thickness error in the 10% range. Appropriate lab-to-fab protocol, based on XRR-deduced thickness revealed the slight uniaxial anisotropy of the a-C:H layer and improved the fitting quality.