Spectroscopic Ellipsometry for Thin Film Characterization: a Tutorial

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Spectroscopic ellipsometry (SE) is a very powerful technique for the characterization of thin films, in that it is sensitive to many properties of the film that directly impact its quality, such as film thickness, film surface and interface roughness, and spectroscopic refractive indices and extinction coefficients. In addition, very accurate SE measurements can be easily made over a wide range of wavelengths from the UV to the near-IR, and the measurements can be carried out in any transparent ambient. Unfortunately, SE is not a direct technique in that the interesting parameters (such as film, surface roughness, and interface thicknesses, and film refractive indices) are not obtained directly. To obtain these parameters from SE measurements, the near-surface region of the sample must be modeled, and the data fit using an appropriate non-linear algorithm.

In this tutorial, starting with single-wavelength nulling ellipsometry, various ways of making ellipsometry measurements will be discussed and evaluated. It will be shown that all methods for performing ellipsometry measurements are not equal, and that some methods leave very important parameters unmeasured, or measured very inaccurately. The analysis of the SE data is as important as the acquisition of very accurate data, and will be discussed in detail. Several models of the refractive index and extinction coefficient as a function of wavelength will be discussed, including their range of applicability. Finally, several common examples will be discussed.