Take a quick look - real-time optical characterization of materials and thin films

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Many technical products rely on successful deposition of thin films. Most deposition techniques require real-time control of new layers. Optical spectroscopy is a powerful technique to characterize thin films on a time scale of one second or smaller and is heavily used for thin film production control.

Quantities like color coordinates or integral transmittance values are computed in a straightforward way from measured optical spectra. Sometimes these are sufficient to verify correct product properties. In most cases, however, information about thickness and composition of individual layers must be extracted in order to provide useful operator feedback. Unfortunately, the propagation of light waves through multilayer coatings with thicknesses comparable to (or far below) the vacuum wavelength is not intuitive but rather full of surprises. However, a detailed simulation based on physical modelling is possible and can provide the answers required for running the deposition machinery.

The combination of optical modelling and measurements for thin film analysis is explained. Typical solutions for batch coaters and large area coaters are discussed. Errors of spectrometer systems lead to final errors of the obtained parameters, such as layer thickness or refractive index values. Exploring this relation one can translate wanted thickness accuracy to required spectrometer quality. Based on the accuracy of the wanted information, proper design of measurement systems is discussed, allowing or excluding the use of certain optical components. Recent hardware development trends are presented.

For satisfying final results, measurements should be analyzed by optical models which match the quality of the used hardware components. This means that the modeling software must be able to take into account all effects that lead to significant changes of the spectra, such as surface roughness, penetration of adjacent materials at interfaces or depth gradients of optical constants. Materials with some variability of their optical constants must be handled in a safe way, i.e. the optical constants as well as the layer thickness must be correctly obtained by the fitting algorithm. Software techniques to meet these requirements are discussed.