Spectroscopic Ellipsometry
Room Ballroom BC - Session EL-ThP

Spectroscopic Ellipsometry Poster Session

EL-ThP-1 ATR-Ellipsometry Using a Custom Liquid Cell*, Madison Coleman,* *Mar Diehl, Madison Meaney, Tyler Adams,* Weber State University*; Jeremy VanDerslice,* J.A. Woollam Co., Inc.*; Alyssa Mock,* Weber State University

A custom multi-bounce, prism-based liquid cell has been developed for use with infrared ellipsometry to enable quantitative analysis of liquids and the species dissolved within them. Traditional optical methods for liquid-phase analysis often rely on attenuated total reflection (ATR), where changes in signal intensity are caused by absorption via interaction between the evanescent wave and the liquid sample. In contrast, this approach leverages ellipsometric polarization measurements, capturing the reflected light's amplitude ratio (Ψ) and phase difference (Δ). These measurements probe molecular vibrations in the fingerprint region, enabling analysis of the chemical composition of liquids.

Conventional optical measurement schemes are limited in the IR spectrum for liquid applications due to strong absorption, particularly in water-based systems. The ATR measurement technique addresses this limitation by coupling light into a prism and probing the sample with the evanescent wave produced by total internal reflections. Our new method combinesthe traditional ATR concept with ellipsometric detection. Multiple internal reflections within a high-index prism produce evanescent waves that repeatedly interact with the liquid sample. The repeated interactions with the liquid enhance sensitivity to small constituent fractions of species within the liquid. By capturing both the intensity and the polarization changes, this configuration extends the sensitivity of ellipsometric measurements to liquid environments.

The prism is housed in a custom-built sealed liquid cell and cut to provide a 45° angle of incidence. Submerged length wise in the liquid, the prism supports multiple internal reflections, with each reflection generating an evanescent field that probes the sample. Our results demonstrate the potential of ellipsometric ATR for concentration-based analysis of complex liquids, with future applications in quality control for the food, beverage, and water industries.

EL-ThP-2 Engineering the Optimal Filter: Quantitative Assessment of Linear and Nonlinear Noise-Reducing Filters in Spectroscopy*, David Aspnes,* North Carolina State University*; Long Le,* Vietnam Academy of Science and Technology, Viet Nam*; Young Kim,* Kyung Hee University, Republic of Korea

The objective of any noise-reduction filter is to preserve information and eliminate noise, both to the maximum extent possible.Up to now filters have been assessed by trial-and-error.Here, we report a cost function that quantifies the action of a filter on information and noise in a spectrum, that is, on distortion and leakage, respectively.For linear filters, which act by direct-space (DS) convolution or (equivalently) by selective attenuation of reciprocal-space (RS) Fourier coefficients, the expression is exact.Consequently, optimal parameters for any linear filter operating on any spectrum can now be determined unambiguously.We find that the best practical linear filter is the Gauss-Hermite filter introduced by Hoffman and co-workers in 2002 [1].

Nonlinear filters operate differently, retaining low-order Fourier coefficients exactly up to the white-noise cutoff and replacing those in the white-noise region with model-independent most-probable analytic extrapolations.With distortion nominally eliminated and noise input limited to retained coefficients, these should outperform any linear filter.However, the only known example, the corrected-maximum-entropy(CME) approach [2], can be used only with positive-definite spectra consisting of superpositions of Lorentzian absorption lines.Here, we report a forward-prediction approach with performance equivalent to the CME, but one that is based on physical principles and is completely general.Examples dealing with spectroscopic-ellipsometric and other types of data, for instance X-ray photoelectron and Auger electron spectra, will be presented.

[1] D. K. Hoffman, D. J. Kouri, and E. Pollak, Computer Phys. Commun. **147** (2002) 759-769.

[2] L. V. Le, Y. D. Kim, and D. E. Aspnes, Thin Solid Films **761** (2022) 139515.

Author Index

Bold page numbers indicate presenter