Spectroscopic Ellipsometry
Room 116 - Session EL2-ThA

Evolving Methodology and Analytical Methods of Ellipsometry

Moderators: Nikolas Podraza, University of Toledo, **Mathias Schubert**, University of Nebraska - Lincoln

3:30pm **EL2-ThA-6 Dirty Ellipsometry: Finding Success with Nonideal Samples and Nonideal Data in a Nonideal World***, **Maxwell Junda**, A. Green, X. Li,* Covalent Metrology **INVITED**

Ellipsometry has tremendous utility in commercial pursuits of science and engineering across a range of industries. One of the missions of Covalent Metrology is to make ellipsometry available to as broad a range of applications and users as possible. While much of the industrial scale ellipsometry used in production process monitoring involves repeated measurements of similar samples, Covalent's ellipsometry projects typically have an R&D flavor and are often one-time experiments meant to answer a specific question. Consequently, unavoidable constraints can sometimes lead to data or results that are hampered by nonidealities, and the overall project falls short of the clean results showcased in much of published literature (or at least the vision in our minds upon conceiving the experiments). Several common nonidealities can be understood strictly from a technical perspective: samples are not flat or too rough, films are too thin or inhomogeneous, or a multilayer structure has too many unknown layers. However, there are multiple other less obvious or less visible challenges to be navigated in providing primarily industry-focused ellipsometry measurement services. One example is that it's common to have incomplete information about test samples while planning an experiment, either due to intellectual property-related secrecy, or sometimes a simple lack of knowledge. Budget constraints are another typical nonideality where practicality dictates finding ways to obtain the best possible results to challenging, sometimes open-ended questions within a limited amount of time.

Covalent Metrology has worked on numerous projects in recent years wherein spectroscopic ellipsometry has produced useful results, despite "ugly" optical models, largely unknown samples, or rushed timelines. Specific examples will be described including: (1) optical models for highly inhomogeneous films that have quantitatively poor fits to noisy data yet can still provide key results, (2) use of spectroscopic ellipsometry to monitor the mechanical lapping of layered samples to thin the surface layer to submicron thickness and (3) pairing ellipsometry with other metrologies (such as TEM or XPS) to reverse engineer multi-layer optical filter stacks, the details of which were completely unknown at the project start. Lessons in evaluating the feasibility of hypothetical experiments will also be discussed, focusing on key descriptive factors of sample and experiment that gate project success, and on the value of ellipsometric simulations to both test measurement viability and tune experiment parameters prior to sample measurement.

4:00pm **EL2-ThA-8 Numerical Ellipsometry: AI for Real-Time, in situ Process Control for Absorbing Films Growing on Unknown Transparent Substrates***, **Frank Urban**, D. Barton,* Florida International University

Ellipsometry is an optical analytical method in which desired reflecting surface parameters are related to measurements by mathematical models. Recent work has shown that using AI methods can result in predicting reflecting surface parameters faster and more easily than by using iterative methods. This prior AI work used artificial neural networks applied to a growing absorbing film on a known substrate. Each different substrate required a set of separately trained networks across the wavelength spectrum thus necessitating training a new set of networks for each new substrate. The work presented here does not require substrate optical property data. Thus one set of spectroscopic networks can serve a large number of different substrates. This becomes possible by increasing the number of measurements per wavelength from two to three. For now we consider transparent substrates for which k2 = 0 or near zero. As before the non-iterative, stable, and fast performance lends itself to real-time, in situ monitoring of thin film growth. Examples for such growth of an absorbing metal film, chromium, will be given using two different substrates as proof of concept. The multilayer perceptron configuration consists of 6 input and 6 output neurons with two hidden layers of 80 neurons each. Solutions are performed at each wavelength independently and do not rely on fitting functions for optical properties.

4:15pm **EL2-ThA-9 Gaining Insight Into InAs Plasma Treatments and Passivation via *in situ* Spectroscopic Ellipsometry***, **John Murphy**, G. Jeringan, J. Nolde,* Naval Research Laboratory

Indium Arsenide (InAs) is a crucial material for infrared photodiode fabrication. However, its performance is severely hindered by the spontaneous formation of a complex native oxide on its surface, which leads to a high surface state density. This density pins the Fermi level within the conduction band, promoting the formation of shunt paths and increasing the surface recombination velocity. Consequently, these effects contribute to increased dark current and degraded detector performance in InAs-based devices.

To improve the performance of InAs-based devices, a suitable passivation of these dangling bonds must be developed. Atomic layer processing techniques, including remote plasma treatments and self-cleaning processes involving metalorganic precursors, have been explored as possible solutions. These methods aim to control and improve the InAs surface by removing the native oxide and subsequently passivating it with wide-gap oxides using plasma-enhanced or thermal atomic layer deposition (PE-ALD).

When utilized in conjunction with ALD, in situ spectroscopic ellipsometry has proven invaluable to study ALD oxide growth; however, it can also be utilized to assess the quality of the InAs surface during plasma treatments. In this study, we employ *in situ* critical point analysis of pseudo-dielectric functions to evaluate the efficacy of remote plasma treatments in cleaning InAs (100) surfaces. We will correlate changes in the pseudo-dielectric function with alterations in surface morphology, as measured by atomic force microscopy, and surface chemistry, assessed via x-ray photoelectron spectroscopy. An air-free transfer apparatus will be used to prevent re-oxidation of the surface. Finally, we will characterize the surface state density of plasma-treated and Al_2O_3-passivated InAs surfaces using capacitance-voltage measurements.

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