Thin Films
Room 115 - Session TF2-FrM

Thin Films: Characterization
Moderators: Mark Losego, Georgia Institute of Technology, **Virginia Wheeler**, U.S. Naval Research Laboratory

10:30am **TF2-FrM-10 Variable-Angle, Spectroscopic Ellipsometry Studies of the Repeated Application of First Contact Polymers on Optical Surfaces***, **Joshua Vawdrey**,* Brigham Young University*; J. Hamilton,* University of Wisconsin, Platteville*; D. Allred,* Brigham Young University

First Contact Polymer™ (FCP) is an adhesion-based, cleaning polymer that has been shown to remove molecular and particulate contamination from surfaces. Applying, allowing to dry, and then peeling off a layer of FCP from a contaminated surface embeds and removes contaminants. While a single peel-off has been observed to be effective at removing both particulate and molecular contaminants, the effect of consecutive fresh applications and peel-offs on the same surface has not been extensively studied. This is important since FCP is used to protect optical surface in storage. Using variable-angle, spectroscopic ellipsometric (VASE) data, modeled with J.A. Woollam Inc. software, CompleteEase, we addressed the questions: can surfaces be cleaned multiple times recovering the same clean surface each time? And what formulations are suitable for hygroscopic materials like lithium fluoride? One set of thin-film materials studied were three that are important materials in silicon microelectronics: native oxide on "bare" silicon wafer pieces, CVD silicon nitride on silicon wafers, and thermal silicon dioxide on silicon wafers. In addition, surfaces important in thin-film optics including far ultraviolet (FUV) were examined. These were metal fluoride thin films on evaporated aluminum. At each iteration in the study, we removed the layer of FCP coating each sample, measured the surface at several different spots with VASE, reapplied FCP and stored the samples for a designated time. Control samples, which received no FCP but were stored with the others, were also measured iteratively. We observed a reduction in the top-layer thickness of both silicon and CVD silicon nitride on silicon samples after cleaning impure solvent residue off the surface- We interpret this as FCP can effectively remove physisorbed materials from such surfaces yielding atomically clean surface in the absence of can be absorbed layers. We observed that the apparent native oxide layer on both FCP-coated samples and control samples increased with time. This could be due to the deposition of adventitious carbon from the environment. There is a slight increase--about an eighth of an angstrom per repeated peel-off, in the apparent top-layer thickness of the native oxide on Si samples. Cleaning fluorides proved to be more challenging. This is due to affinity of some fluorides particularly LiF to water. We determined condition under which some fluorides can be effectively cleaned without trapping water. Coatings suitable for long-term storage of fluorides are still under investigation.

10:45am **TF2-FrM-11 EnviroMETROS – A Novel Surface and Multilayer Thin Film Analysis Tool***, **Paul Dietrich**, F. Mirabella, S. Boetcher, K. Kunze, O. Schaff, A. Thissen,* SPECS Surface Nano Analysis GmbH, Germany

The new EnviroMETROS series transforms the realm of surface hybrid metrology by employing the key techniques of parallel detection angle resolved XPS (PARXPS) and multi-wavelength excitation. This method utilizes variable photon energies and emission angles operating under diverse environmental conditions for conducting chemical analyses of thin films and bulk materials. LEIS facilitates high surface sensitivity, while electronic characterization can be enhanced with UPS, IPES, and REELS. Integrated Raman and/or IR spectroscopy provide structural information, whereas XPS mapping and SEM/SAM contribute to elemental surface maps correlated with morphology.

The relevance of ultrathin films and 2D materials in modern devices is continuously increasing, prompting a growing interest in the chemical analysis of these multilayer systems and their surfaces. A thorough characterization of stoichiometries, composition, and depth distribution of elements is crucial. The novel EnviroMETROS series serves as an ideal tool for routine analysis in this research and development field. It combines large sample and wafer handling with a photoelectron spectrometer offering variable information depth. When combined with optical and other analytical techniques, it enables depth-dependent composition analysis with unparalleled precision, reliability, and repeatability.

11:00am **TF2-FrM-12 Passivation of Indium Phosphide Substrate Evaluated by Atomic Force Microscopy***, **Fabiano Borges**,* Federal Institute of Sao Paulo, Brazil*; C. Almeida,* PUC-Rio, LabSem, Brazil*; A. Silva,* Unicamp, CCS, Brazil*; O. Berenguel, C. Costa,* CNPEM, LNNano, Brazil*; G. Vieira,* IEAv, Brazil*; J. Diniz,* Unicamp, CCS, Brazil

Passivation involves coating a material to make it passive, i.e., less affected by the environment. In this study, passivation is achieved by depositing an aluminium oxide layer with prior surface treatment. Four surface treatments are considered: oxidation only (O), nitriding only (N), oxidation followed by nitriding (ON), and nitriding followed by oxidation (NO). An InP substrate is heated and exposed to an environment enriched with oxygen and/or nitrogen to form a thin film over the InP surface. Following this, a 20nm thick layer of aluminium oxide is deposited using atomic layer deposition (ALD). Thus, six different samples were generated for analysis: four with surface treatments, one of pure InP without any added thin film, and one of InP with only an aluminium oxide layer as the control sample for reference. This process presumably enables electricity to reliably penetrate the conducting InP below the surface while overcoming the surface states that hinder electrical conduction in the semiconducting layers. Different techniques such as Photoluminescence Spectroscopy, Atomic Force Microscopy, Electrostatic Force Microscopy, and X-ray Photoelectron Spectroscopy can be used for evaluating these treatments' effectiveness. The simplest one, analysing AFM images [1] alongside their RMS roughness values [2], reveals that samples with lower RMS roughness also possess fewer defects at their surfaces [3]. By defining the RMS roughness value of the control sample as the reference, all other values are lower: pure InP has a 15% lower RMS roughness, N has 10%, O has 20%, NO has 15%, and ON 10%. This suggests that the O sample is the smoothest and likely possesses the lowest surface defect density.

References

[1] Klapetek, P. (2006). Quantitative Data Processing in Scanning Probe Microscopy. William Andrew Publishing. 2013.
[2] Nečas, D., Klapetek, P. Gwyddion: an open-source software for SPM data analysis, Cent. Eur. J. Phys. 10(1) (2012). 181-188.
[3] Streetman, B. G., Banerjee, S. (2006). Solid state electronic devices. 6th ed. Pearson/Prentice Hall.

Acknowledgments

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