Spectroscopic Ellipsometry Focus Topic
Room Hall B - Session EL-TuP

Spectroscopic Ellipsometry Focus Topic Poster Session

Moderator: Tino Hofmann, University of North Carolina at Charlotte

EL-TuP1 An In situ Spectroscopic Ellipsometry Study of Cerium Oxidation, ***Wayne Lake***, *P. Roussel,* AWE, UK

Cerium is an electropositive metal and will be covered by an oxide film. X-ray Photoelectron Spectroscopy (XPS) measurements have shown the oxide film to be composed of the trivalent oxide at the metal interface and the tetravalent dioxide at the oxide gas interface. Furthermore, in ultra high vacuum the dioxide film is thermodynamically unstable with respect to the cerium metal substrate and reduces to the trivalent oxide. The XPS technique is limited due to the small depth probed, therefore, to follow cerium oxidation reaction with oxide films greater than 10 nm spectroscopic ellipsometry offers a better technique of choice. At the AWE the spectroscopic ellipsometer is attached to an in situ film growth chamber on the XPS spectrometer. The problem with spectroscopic ellipsometry arises from the data interpretation. Spectroscopic ellipsometry modelling of a substrate with a single oxide film is easily achieved. However, when two oxides of different oxidation state are formed this presents a more difficult challenge to model.

Starting from sputter cleaned cerium substrate, the sample is heated and exposed to oxygen and the reaction is followed by using in situ spectroscopic ellipsometry. The substrate model is determined from the first data points in the data set prior to exposing the sample to oxygen. This work addresses how we determine a suitable model to interpret the spectroscopic ellipsometry data where two oxides are present.

EL-TuP2 In-situ Multi-wavelength Ellipsometric Monitoring of the Reactive Sputter Deposition of WO_x Films, ***Ned Ianno***, *G. Kaufman, C. Luth,* University of Nebraska-Lincoln*; C. Exstrom, S.A. Darveau,* University of Nebraska at Kearney*; B. Johs,* Film Sense

Thin films of WO_x where x<3 have a range of applications as sensors, while amorphous WO_3 thin films have been employed as the precursor films for the growth of WSe_2 and WS_2 films. The WO_x films have been deposited by reactive sputtering in an Oxygen/Ar ambient, while the WO_3 films have primarily deposited by thermal evaporation although reactive sputter deposition has also been reported. Based on the literature and the work reported here the reactive sputter deposition of WO_x is very dependent on plasma bombardment during growth, and the voltage applied to the sputter gun, as well as the more straightforward parameters such as pressure, flow rate and substrate temperature. In view of this we have performed a 2-level factorial survey of the deposition parameter space associated with the reactive sputter deposition of WO_x films where we varied the O/Ar flow rate ratio, total chamber pressure, substrate temperature and sputter gun magnetic configuration to provide a more fundamental understanding of the deposition of WO_x films. A critical part of this work is the use of in-situ multi-wavelength ellipsometry (data acquired at 4 wavelengths in the visible spectrum: blue, green, yellow, and red) to monitor the growth process where we will show the sensitivity of the ellipsometric data to stoichiometry of the film, both during deposition and post deposition annealing.

EL-TuP3 Mid-infrared Optical Constants of InAsSb Alloys and Bulk GaSb, ***Pablo Paradis***, *S. Zollner, R. Carrasco,* New Mexico State University, Department of Physics*; J. Carlin, V. Dahiya, A. Kazemi, S. Krishna,* The Ohio State University, Department of Electrical and Computer Engineering

Antimonides are attractive materials for mid-infrared detectors and emitters, because they form a direct band gap, which can be tuned from 0.1 to 0.7 eV. For the design and modeling of such devices, the optical constants of these materials must be known. We present results of Fourier-transform infrared (FTIR) ellipsometry measurements of bulk GaSb and doped and undoped InAsSb alloys with different compositions. Doped and undoped layers of InAsSb alloys were grown on GaSb substrates by MOCVD. Their optical constants were determined using two different methods. First, we fitted the data as a sum of oscillators representing the free-carrier and interband optical response, which allows a physical interpretation of the results. Second, we expanded the dielectric function into a sum of Kramers-Kronig consistent B-spline polynomials, assuming thicknesses obtained from the growth parameters. In the doped layers, a free-carrier reflectance band can clearly be seen in the spectra, while the undoped layers show an absorption increase at the band gap. The 10% Sb samples are lattice matched and the 44% Sb samples are lattice mismatched leading to some strain inhomogeneity in the samples. This can be seen in the dielectric function of these samples. In the doped samples, we analyze the optical conductivity obtained from parametric oscillator fit. We pay attention to the plasma frequency term in our parameters to describe the behavior of the conductivity in doped vs undoped layers.

EL-TuP4 Temperature-dependent Ellipsometry and Thermal Stability of $Ge_2Sb_2Te_5$:C Phase Change Memory Alloys, ***Cesy Zamarripa***, *N. Samarasingha, F. Abadizaman, R. Carrasco, S. Zollner,* New Mexico State University

$Ge_2Sb_2Te_5$ (GST) compounds are phase change memory alloys. At temperatures above 425 K, they are crystalline, forming a metastable rocksalt (T>425 K) or a stable hexagonal crystal structure (T>525 K). Heating the alloys above their melting point, followed by rapid cooling to room temperature (on a nanosecond time scale) forms an amorphous phase, where the resistivity is at least three orders of magnitude higher than in the crystalline phase.1 This enables their use as rewritable optical recording media. Carbon doping allows tuning of the amorphous to crystalline transition temperature. In this work, we performed temperature-dependent spectroscopic ellipsometry measurements of as-deposited (amorphous) GST alloys in high vacuum from 300 to 800 K in 25 K steps, at an incidence angle of 70°. The samples were held approximately three hours at each temperature. We used two different instruments, a J.A. Woollam Fourier-transform infrared ellipsometer with ZnSe windows from 0.07 to 0.7 eV and a J.A. Woollam VASE ellipsometer with quartz windows from 0.5 to 6 eV. The GST layers were about 750 nm thick and deposited on singleside polished Si wafers covered with 400 nm of SiO2. The original room-temperature measurements show two sets of interference fringes below 1 eV, due to the two different films present on the wafer. The SiO2 absorption bands at 0.15 eV are clearly visible. The GST layers are transparent in the infrared without any lattice vibration features, due to the large mass of the constituent atoms. The absorption rises rapidly at 1 eV towards a broad maximum at 1.7 eV and then drops smoothly towards the UV. The dielectric function of the as-deposited films is featureless, as expected for an amorphous layer. The ellipsometric spectra are essentially unchanged between 300 and 400 K, showing an absorption threshold near 1.1 eV. At 425 K, this threshold suddenly drops to 0.7-0.8 eV, where it remains constant up to 675 K. The dielectric function is featureless at all energies and never displays any sharp features expected for a crystalline material. No amorphous to crystalline phase transition can be observed in the optical spectra. Spectra above 700 K show only the interference oscillations from the SiO2 oxide layer. Apparently, the GST film has evaporated.

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1. E.M. Vinood, K. Ramesh, and K.S. Sangunni, Sci. Rep. 5, 8050 (2015).

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