Thin Film
Room 2022 - Session TF2-ThA

Pulsed Laser Deposition of Thin Films
Moderator: S.L. Jones, Norfolk State University

2:00pm **TF2-ThA1 Cathodoluminescence Degradation of Y@sub 2@SiO@sub 5@:Ce Thin Films**, *E. Coetsee,* ***J.J. Terblans,*** *H.C. Swart,* University of the Free State, South Africa

The cathodoluminescence (CL) intensity of cerium-doped yttrium silicate (Y@sub 2@SiO@sub 5@:Ce) phosphor thin films, grown by pulsed laser deposition (PLD), were investigated for possible applications in low voltage field emission displays (FEDs). A thin layer of tin oxide (SnO@sub 2@) was ablated on the surface of some of the films in order to investigate the effect, of the coated layer, on the degradation of the CL intensity. Auger electron spectroscopy (AES), X-ray photo electron spectroscopy (XPS) and CL spectroscopy were used to monitor changes in the surface chemical composition and luminous efficiency of the thin films. AES and CL spectroscopy were done with 2 keV energy electrons and beam current densities between 26.3 mA.cm@super -2@ and 52.6 mA.cm@super -2@, in high vacuum and in oxygen pressures of 1x10@super -8@, 1x10@super -7@ and 1x10@super -6@ Torr. Residual gas mass analysis (RGA) showed that the adventitious C was removed from the surface as volatile gas species which is consistent with the electron stimulated surface chemical reaction (ESSCR) model. Tin oxide (SnO@sub 2@) coated thin films resulted in a lower but more stable CL intensity than the uncoated thin films with light emission from the rare earth, Ce@super 3+@, due to the 5d - 4f transition resulting in the characteristic double shoulder peak of Y@sub 2@SiO@sub 5@:Ce between 400 and 500 nm (blue light).

2:20pm **TF2-ThA2 Computational Study of the Initial Stage of Pulsed Laser Deposition of SrTiO@sub 3@ Thin Films**, ***J.M. McKillip,*** *R.K. Behera, S.R. Phillpot, S.B. Sinnott,* University of Florida

Thin film deposition of SrTiO@sub 3@ is currently a popular area of research due to its widespread use in electronic applications and the motivation to shrink electronic components. Pulsed laser deposition (PLD) is an effective deposition process yielding dense, homogeneous thin films. Here, classical molecular dynamics simulations are used to delve into the initial processes occurring in PLD. The simulations show that collisions between the incident particles and the substrate can induce chemical bonding. This study considers the deposition of SrO and TiO@sub 2@ molecules assigned a kinetic energy of 0.1, 0.5 and 1.0 eV/atom on a (001) surface of SrTiO@sub 3@. The effects of impact energy and surface termination layer (SrO vs. TiO@sub 2@) are examined. The main surface phenomenon of interest is chemical changes that occur at the metal-oxide surface due to the incident particles and structural features of the deposited film. The simulation results are compared to experimental data, where available.

2:40pm **TF2-ThA3 Dynamics of Ultrafast Laser Generated Ablation from Metals and Semiconductors Close to the Ablation Threshold**, ***S.M. Yalisove,*** *J.P. McDonald,* University of Michigan **INVITED**

The evolution of ultrafast laser generated material ejection close to the ablation threshold can studied with a variety of methods. Ultrafast microscopy has been used to study the expulsion of a thin (~40nm) layer of molten material from metals and semiconductors when irradiated with laser pulses of duration less than ~600 femtoseconds and intensity close to the ablation threshold. These methods use pump-probe techniques to construct a series of time resolved images with resolution limited by the duration of the ultrafast laser pulse. We will present results from Si surfaces with a variety of thermal oxide thicknesses that are irradiated with 780 nm laser pulses of duration 150 femtoseconds at normal incidence. The intensities we have studied range from 1-20 times the ablation threshold. Intensities below 10 times of the ablation threshold generally do not produce optically emitting plasmas. We will show that ablation in this regime is fundamentally different that at higher intensities. Three different pump-probe imaging methods will be presented; Newton's ring analysis at normal incidence, side view imaging at grazing incidence, and a new method using a delayed pulse to excite optical emission of the ejected material. While many physical processes occur on the sub picosecond time scale, ejection of material typically occurs about 1-10 picoseconds after ultrafast laser irradiation. The images in this study are acquired every 50 picoseconds up to about 12 nanoseconds after irradiation. Movies made from these images will be shown. Analysis of the results from these studies will be presented including momentum transfer and efficiency of these processes, a physical model to explain phenomena observed with varying oxide thickness and laser fluence, and the different dimensionalities of Sedov-Taylor scaling that are observed. The impact of these studies on ultrafast pulsed laser deposition will be discussed.

3:20pm **TF2-ThA5 Electrical Conduction in Pulsed-Laser Deposited As- and Ga-doped ZnO Films**, ***A.K. Pradhan,*** *K. Lord, D. Hunter, T.M. Williams, S. Cherry, S.L. Jones,* Norfolk State University

The increasing demand for transparent conducting oxides and p-n junction based-short wavelength light emitting diodes has created a lot of research interest. We report the synthesis of epitaxial As-doped ZnO and Mn-doped (ZnAs)O films by pulsed-laser deposition (PLD) technique. The grain size in (ZnAs)O films decreases from 40 nm to less than 10 nm upon Mn doping, illustrating that Mn acts a potential catalyst creating nanosize grains. Temperature dependent electrical resistance shows metal-insulator (MIT) and metal-semiconductor transitions (MST) at 165 and 115K, respectively, in (ZnAs)O, although Mn-doping suppresses MST completely. Both ionization efficiency of oxygen vacancies and percolation of charge carriers may be responsible for such transitions. In addition, electrical conduction is these films show strong ageing effects related to the conductivity instability in the film. We have also synthesized highly epitaxial conducting Ga-doped ZnO system by the PLD techniques. The films show transmittance more than 85% in the visible region. The films show very high electrical conductivity. The temperature dependent resistivity measurements of these highly conducting and transparent films show several transitions. The extensive results will be presented.

3:40pm **TF2-ThA6 Nanoscale Laser Processing and Micromachining of Biomaterials and Biological Components**, ***D.B. Chrisey,*** Rensselaer Polytechnic Institute **INVITED**

Lasers are increasingly proving to be an enabling approach to process biomaterials and biological components on the nanometer length scale. While nanotechnology encompasses an array of enabling technologies that utilize the fact that matter at length scales less than 100 nanometers have distinctly different physical and chemical properties than the same matter at larger length scales, biology and biological components are a special subset since the fundamental building blocks are almost all less than 100 nanometers in size, i.e., biological molecules are constantly being used in a directed self-assembly manner to communicate and build new materials. There are already several successful examples of nanotechnology starting from the somewhat mundane sharper scalpels and protective sunscreens, to more effective drug delivery, and even biomolecular motors, gene therapeutics, tissue engineering and improved medical diagnostics. The unique capabilities of laser processing for these applications is based on tuning the laser-material interaction to create novel structures, i.e., the laser wavelength, pulse width and power can be varied over a wide range as can the composition and state of the material. This presentation will summarize several successful examples of the laser processing of biomaterials and biological components.

4:20pm **TF2-ThA8 Laser Desorption from Polytetrafluoroethylene at 157 nm -- A Possible Reactant Source for Thin Film Growth**, ***S. John,*** *S.C. Langford, J.T. Dickinson,* Washington State University

Thin film growth of a number of polymers, including polytetrafluoroethylene (PTFE -- Teflon), has been achieved using pulsed laser deposition (PLD). Past studies have also shown that 157 nm Excimer (nanosecond) pulsed laser irradiation is uniquely clean and efficient in etching PTFE. We characterize the resulting neutral and charged products accompanying this exposure using time resolved mass spectroscopy as a function of laser fluence. We find that photochemical release of neutral species of the form (CF@sub 2@)@sub n@, where n = 1,2,3, and possibly 4 occurs with non-thermal kinetic energies (~0.8 eV). A slow component is also observed attributed to an un-zipping reaction with a lifetime of 180 μs. We also observe both positive and negative ions with kinetic energies of a few eV. Mechanisms for the formation of these ions is under study; electrons emitted during the laser pulse are likely involved in the formation of negative ions. We examine possible scenerios to maximize PTFE film growth in light of our measurements.

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