Tuesday Morning, November 5, 2024

Thin Films
Room 115 - Session TF2-TuM
Thin Films for Extreme Environments

Moderators: April Jewell, Jet Propulsion Laboratory, **Lauren Garten**, Georgia Institute of Technology

11:00am **TF2-TuM-13 Nanoscale Metasurfaces for UV Spectropolarimetric Applications***, **Tobias Wenger**, D. Nemchick, D. Wilson, R. Muller, K. Manatt, F. Winiberg, W. Johnson,* Jet Propulsion Laboratory (NASA/JPL)*; H. Hsiao,* National Taiwan University, Taiwan*; B. Drouin,* Jet Propulsion Laboratory (NASA/JPL) **INVITED**

In this talk I will describe our efforts to develop optical metasurfaces for applications in the ultraviolet part of the spectrum. Metasurfaces are made from subwavelength elements that can be thought of as imprinting a phase on incident wavefronts, thereby allowing precise control over light by use of micro-fabrication methods. Here, I will focus on our work on UV spectropolarimetric gratings intended for vertical ozone profiling within Earth's planetary boundary layer. Particular emphasis will be on the fabrication of metasurface nanostructures with high aspect ratios and feature sizes well below 100 nm. To accomplish this, we utilize low-temperature atomic layer deposition on resist preform structures fabricated using electron-beam lithography. To date we have used this method to fabricate metasurfaces from a variety of materials, e.g., hafnium oxide.

11:30am **TF2-TuM-15 Amorphous Boron Carbide-Amorphous Silicon Heterojunction Devices for Neutron Voltaic Application***, **Vojislav Medic**, N. Ianno,* University of Nebraska - Lincoln

Amorphous hydrogenated boron carbide (a-BC:H) has been extensively researched as a semiconductor for neutron voltaic device fabrication. Previous work on a-BC:H devices investigated the fabrication of homojunction, heterojunction and heteroisomeric devices from the polymeric precursors ortho-carborane (p-type) and meta-carborane (n-type) using plasma enhanced chemical vapor deposition (PECVD).

The p-type single crystal silicon (c-Si) with n-type a-BC:H grown from meta-carborane has been previously studied and shown to produce the most optimal device performance compared to different a-BC:H device structures (Figure 1). However, as c-Si degrades over time due to radiation induced damage to its crystalline structure, p+ type hydrogenated amorphous silicon (a-Si:H) was identified as a viable layer for development of the a-BC:H heterojunction device.

Characterization via 4-wire current-voltage measurements, X-ray Photoelectron Spectroscopy (XPS) and ellipsometry of a-BC:H/c-Si and a-BC:H/a-Si:H devices was done, and the a-BC:H/a-Si:H device shows potential in fabricating a novel neutron voltaic device. Utilizing well known material and electronic properties of c-Si, Kraut's method for calculating valence band offset (VBO) at the interface junction via XPS (Equation 1) was used to produce a band structure of both c-Si/a-BC:H and a-Si:H/a-BC:H p-n heterojunction devices (Figures 2-5).

Equation 1: $VBO = \Delta E_v = (CL\text{-}VBM)_{Si} - (CL\text{-}VBM)_{BC} + (CL_{BC}\text{-}CL_{Si})_{int}$

Additionally, the metal contact formation with a-BC:H has not been previously studied with respect to its possible effects on device performance. The metal/a-BC:H contact investigation was performed, identifying Ti as an Ohmic contact with n-type a-BC:H (Figure 3).

11:45am **TF2-TuM-16 Investigating the Practical Limits of Delta Doping by Low-temperature Silicon Molecular Beam Epitaxy***, **April Jewell**, M. Hoenk,* Jet Propulsion Laboratory

Silicon-based photodetectors and imaging arrays are used in nearly every space-based mission, including those for astrophysics, heliophysics, planetary science, and Earth science. In order to achieve the highest sensitivity and stability, silicon detectors must be properly passivated; JPL's approach to surface passivation uses low-temperature molecular beam epitaxy (MBE) to embed an atomically thin (i.e. <monolayer) delta layer of dopant atoms with nanometers of the silicon surface. The delta doping process allows for nanometer-scale control of the near surface band structure, which can be fine-tuned through dopant concentration, number of delta layers, layer separation, and depth. Most scientific silicon imaging arrays—including charge coupled devices (CCDs) and complementary metal oxide semiconductor (CMOS) image sensors—are backside illuminated to maximize efficiency, and the delta-doped layers are deposited on the back surface. In all of JPL's work on development and deployment of delta-doped detectors, our fabrication process has required heating the substrate surface to at least 400 °C to prepare the hydrogen-terminated surface for epitaxial growth. However, the same hydrogen chemistry that enables epitaxial growth can also lead to depassivation of the Si-SiO_2 interface in frontside MOS gate structures; furthermore, the 400°C temperature may result in thermal stresses at the interfaces or through-silicon-vias in 3D stacked detectors. Here we report on recent work to investigate the practical limits of low temperature MBE in an effort reduce the minimum substrate temperature required to achieve epitaxial growth and good dopant activation in delta-doped detectors.

12:00pm **TF2-TuM-17 Improvement of Coating Uniformity on Non-Planar, Non-Stationary Substrates Through a Combined Experiment-Simulation Approach***, **Sean Hayes**, S. Baxamusa, J. Biener, X. Lepro-Chavez, J. Forien, T. Parham, T. Braun, L. Sohngen,* Lawrence Livermore National Laboratory*; C. Wild, T. Fehrenbach,* Diamond Materials GmbH, Germany

Laser inertial confinement fusion (ICF) has come into worldwide focus after the historic experiment on December 4th, 2022 which achieved a target gain >1 for the first time at the National Ignition Facility.ICF experiments on NIF utilize ultrathick(~80-95µm) hollow spherical CVD diamond capsules that must have a coating with >99.8% thickness uniformity to efficiently convert laser energy to compression energy. The CVD diamond is coated on a spherical substrate that is agitated during deposition to ensure even coating. This work provides a framework for understanding the combined effects of instantaneous coating non-uniformity (ICNU) and substrate reorientation on coating uniformity.ICNU measurements on characteristic ensembles of shells in controlled settings were used to understand the effect of the number of nearest neighbors (coordination number, CN). These measurements were used as inputs for Monte Carlo simulations and tested against dynamic batch coatings to determine the effects of CN and FWHM of overall coating non-uniformity, and to infer reorientation times. Such an approach allows us to connect physical processes and dynamics to coater hardware configurations.

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