Electronic Materials and Photonics
Room 303 - Session EM-WeA

Wide Bandgap Materials and Devices

Moderators: Daniel Pennachio, Naval Research Laboratory, **Haozhe "Harry" Wang**, Duke University

2:15pm **EM-WeA-1 High-Temperature Stability of Contacts to β-Ga2O3*, Donivan Mouck*[1]*,* ARL/PSU*; Paul Kelemen, Sohyun Lee, Nathan S. Banner, Chan-Wen Chiu, Suzanne E. Mohney,* Pennsylvania State University*; Luke A. M. Lyle,* ARL/PSU

β-Ga_2O_3 is among the most promising candidates to replace Si in power electronics as it features an ultrawide band gap, shallow n-type dopants, and a large Baliga's figure of merit. It has the potential to surpass both SiC and GaN as a material for high power electronics due to the above considerations and presents the potential for scaling up manufacturing due to its ability to be grown in large areas from the melt. Wide and ultra-wide band gap semiconductors, like β-Ga_2O_3, offer the ability to operate at high voltages, high power, and high temperatures (> 300 °C). However, these aspects of β-Ga_2O_3 can be limited due to the metal/semiconductor interface when high operating temperatures are required. The work examines the metallurgical stability of contact metallizations at elevated temperatures up to 700 °C.

This work explores the typical Ti/Au 20/100 nm and new Ti/$TaSi_2$/Ti/Pt 20/150/5/100 nm ohmic contacts for high-temperature applications. Ohmic contacts are annealed for 60 s at 100 °C increments in a rapid thermal annealing furnace, starting at 300 °C and increasing until failure. As deposited and annealed contacts are probed to determine specific contact resistances using the Cox-Strack method. In this work we demonstrated that by using the new Ti/$TaSi_2$/Ti/Pt ohmic contact, we can achieve a lower specific contact resistance by more than a factor of two after annealing at 500 °C. Furthermore, the ohmic contacts using the Ti/$TaSi_2$/Ti/Pt experience less deviation in the measurements than the contacts using the popular Ti/Au ohmic contact. In addition to offering lower specific contact resistances and less deviation, the Ti/$TaSi_2$/Ti/Pt ohmic contact continues to improve upon further annealing up to 700 °C, while the Ti/Au contact is no longer usable. We think that the failure mechanism of the Ti/Au, at 700 °C, may in part be caused by agglomeration of the Au layer. In addition, we will also present work on high-temperature stability of Schottky diodes to β-Ga_2O_3.

2:30pm **EM-WeA-2 Franz-Keldysh Effect in Al-rich AlGaN*, Yashas Satapathy*,** North Carolina State University*; Pramod Reddy, Will Mecouch, Ronny Kirste, Seiji Mita,* Adroit Materials*; Zlatko Sitar, Ramon Collazo, Spyridon Pavlidis,* North Carolina State University

Aluminum gallium nitride (AlGaN) has become a major focus in the area of ultra-wide bandgap (UWBG) semiconductor technology due to its ability to modulate its electronic and optical properties by changing the Al-content. A wide range of devices can be developed by the community including but not limited to solar-blind photodetectors, small wavelength LEDs, and vertical power devices. When a semiconductor device is applied under high voltages (resulting in high internal electric fields) the absorption edge of the material shifts such that sub-bandgap photons can be absorbed in the material and lead to the production of electron-hole pairs. This phenomenon, known as the Franz-Keldysh effect (FKE), has been studied more recently in wide bandgap semiconductors such as SiC and GaN. Understanding this effect can not only be used to predict the device performance under illumination but also give insight into the fundamental material properties of AlGaN which is currently not well established. In this study, the FKE in $Al_{0.7}Ga_{0.3}N$ was observed and a similar approach reported in literature was used to develop a model with high accuracy. The model considers the optical transitions from each valence subband (heavy-hole band (HHB), light-hole band (LHB), and split-off (SO) band) towards the conduction band. Two different models were calculated. The first model, the 1-hole band model, assumes that the dominating optical transition is between the LHB and CB (this assumes that the incoming light is not normally incident on the c-axis of the crystal). The second model, the 2-hole band model, assumes that the dominating optical transitions are between the HHB and CB and the SO and CB (this assumes that the incoming light is normally incident on the c-axis of the crystal). 252 nm light (sub-bandgap energy) and 244 nm light (above bandgap energy) was illuminated on a quasi-vertical $Al_{0.7}Ga_{0.3}N$ PiN diode and the measured photocurrents were investigated. The presented model gives insights into various material properties including the electron effective mass, the hole effective mass, and the optical momentum matrix element. According to the measured I-V characteristics and the calculated absorption coefficients due to the proposed model, the diode exhibited absorption of photons with sub-bandgap energy, therefore showing FKE. This work was supported in part by the US Army Research Office under grant W911NF-22-2-0158 (Program Manager: T. Oder) and the National Science Foundation under grant ECCS-2145340.

2:45pm **EM-WeA-3 Controlled Growth and Automated Thickness Estimation of Wide-Bandgap Perovskites*, Shadmani Shamim,*** *Sanchaya Pandit, Jack Gude,* University of Nebraska-Lincoln, USA*; Catherine Puckett,* Dickinson College*; Yanan (Laura) Wang,* University of Nebraska-Lincoln, USA

Lead-halide perovskites have gained importance because of strong light-matter interactions, including room-temperature excitonic effects and bandgap tunability, and have been explored in applications such as light-emitting devices, photodetectors, photovoltaics, and optical sensing. Layered and low-dimensional lead-halide perovskite materials offer additional degrees of freedom to control these properties through morphology and thickness, which prompts the need for efficient thickness-determination techniques. In our work, we demonstrated a controlled hydrothermal procedure for synthesizing cesium lead bromide ($CsPb_2Br_5$) single crystals with thicknesses below 100 nm, along with a non-destructive approach for thickness estimation based on reflection measurements. We developed an automated thickness-estimation model by comparing experimental reflectance spectra with calculated spectra obtained from Frensel equation and further calibrating it with atomic force microscopy (AFM) measurements. The reliability of the estimated thickness was evaluated through a quantitative error analysis using root mean square (RMSE) and the coefficient of determination (R^2) with matching of spectral features. The combination of controlled synthesis and reflection measurements provides a practical framework for thickness-dependent characterization of $CsPb_2Br_5$ flakes, enabling rapid thickness screening for subsequent development of perovskite-based nanophotonic and optoelectronic devices.

3:00pm **EM-WeA-4 Stabilizing the Bright Charge State of Silicon Vacancy in 4H-SiC using Phosphorus Dopant*, Suryakanti Debata,*** Laboratory for Physical Sciences*; Sai Krishna Narayanan,* University of Maryland College Park*; Pratibha Dev,* Laboratory for Physical Sciences

Silicon carbide (SiC) has emerged as a testbed for designing defect-based qubits for quantum technologies. In particular, the negatively-charged silicon vacancy in SiC is being explored as a solid-state spin qubit due to its long spin coherence time at room temperature and near-telecom range emission energies. To ensure that the bright negative charge state of this defect remains stable, SiC is often doped with nitrogen [1], although it can form unwanted complexes [1,2]. In our first-principles based study, we investigate the effect of phosphorus doping on the quantum emission properties of the silicon vacancyin SiC. We show that phosphorus is an efficient donor and stabilizes the bright charge state of the monovacancy, resulting in the desirable spin-3/2 bright ground state. We further establish its influence on the excited-state properties, paving way for experimental development of defects with desired properties.

[1] Carter et al. "Influence of nitrogen doping and annealing on the silicon vacancy in 4H-SiC" Phys. Rev. B **112**, 085209 (2025)

[2] Rauls et al. "The different behavior of nitrogen and phosphorus as n-type dopants in SiC" Physica B **340–342,** 184–189 (2003)

3:15pm **EM-WeA-5 Optimization of Silicon Oxynitride Buffer Layers for Highly Textured Sputtered Aluminum Nitride Films on SiO_2*, Spencer Gellerup,*** *Kyle Kelley,* Oak Ridge National Laboratory*; Zhaosen Qu,* John Hopkins University*; Matthew Brahlek, Bogdan Dryzhakov,* Oak Ridge National Laboratory

Plasma treating SiO_2 coated wafers to nitride the surface into amorphous silicon oxynitride provides a buffer layer for highly oriented AlN sputtered films. In this work, nitrogen plasma treatment conditions were varied to investigate the effect on subsequent AlN depositions. X-ray reflection measurements were used to investigate film density and thickness of both as-treated SiO_xN_y and SiO_2/SiO_xN_y/AlN stacks. X-ray diffraction was used to confirm single-axis (0002) AlN growth, and rocking curves measured c-axis mosaicity. Roughness of as-treated SiO_xN_y and as-deposited AlN were evaluated by atomic force microscopy. The effect of heat treating SiO_2

[1] **JVST Highlighted Talk**

directly preceding silicon oxynitride formation was assessed. Thin films (<100 nm) of AlN yielded ~2° full-width-half-maximum (FWHM) rocking curves, and thicker films were grown with rocking curve FWHM of ~1°. Direct deposition of strong (0002) fiber texture is possible without the use of single crystal substrates, and sputtering AlN on plasma treating SiO_2 coated wafers allows for CMOS compatible device fabrication and integration with other material platforms.

3:30pm **EM-WeA-6 Growth and Characterization of Highly c Axis-Oriented Aln Thin Films on Diamond (001) via RF Magnetron Sputtering**, *Raman Devi, Aman Malasi, Ananya Choudhary,* ***Ramesh Chandra****,* Indian Institute of Technology Roorkee, India

A novel fabrication process for hexagonal aluminum nitride (AlN) thin films on diamond (001) substrates was fabricated using RF magnetron sputtering at elevated temperatures. Highly crystalline c-axis-oriented AlN films were successfully grown, exhibiting a diffraction full width at half maximum (FWHM) of 928.8 arcsec, which is significantly lower than the previously reported value for sputtered AlN films on diamond, indicating a substantial improvement in crystalline quality and c-axis alignment. The nucleation and initial growth stages of AlN at the interface were found to play a crucial role in determining the final film quality, where a transition zone from randomly oriented AlN grains to highly c-axis-oriented grains was observed. The microstructure and surface morphology of the films were investigated using field-emission scanning electron microscopy (FESEM) and atomic force microscopy (AFM), respectively. X-ray photoelectron spectroscopy (XPS) was employed to analyze the chemical composition and bonding states of the films. Furthermore, the film thickness and optical constants were determined using spectroscopic ellipsometry.

Keywords: Magnetron sputtering, hexagonal aluminium nitrite, Surface roughness, thin film.

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