MSE 2699: Undergraduate Research

Course Description:
Description This course provides undergraduate students with practical and theoretical experience in the epitaxial growth and characterization of Gallium Nitride (GaN) on hexagonal Boron Nitride (h-BN) substrates. Students will gain hands-on training in Metal-Organic Chemical Vapor Deposition (MOCVD), structural characterization using X-ray Diffraction (XRD), and surface/morphology analysis via Scanning Electron Microscopy (SEM). Emphasis is placed on understanding crystal quality, strain, defects, and growth mechanisms in quasi-van der Waals epitaxy.

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Office: GTE 302
Prerequisites: MSE 2001 – Principles & Applications of Engineering Materials

Course Websites:

http://canvas.gatech.edu/

Required Materials:
- No textbook is required; lecture notes and other resources will be provided.

Course Objectives:
By the end of this course, students should be able to:

1. Explain the principles of MOCVD growth for III-nitride semiconductors.
2. Understand quasi-van der Waals epitaxy on layered h-BN substrates.
3. Operate and interpret data from XRD and SEM instruments.
4. Analyze structural and morphological characteristics of GaN thin films.
5. Design and perform experiments, and present results in written and oral formats.

Topics Covered:

Module 1: Introduction and Fundamentals
- Overview of III-nitride semiconductors (GaN, AlN, InN)
- Properties and applications of hexagonal Boron Nitride (h-BN)
- Fundamentals of epitaxial growth: homoepitaxy, heteroepitaxy, and van der Waals epitaxy
- Safety and lab protocols

Module 2: Metal-Organic Chemical Vapor Deposition (MOCVD)
- Principles of MOCVD: precursors, reactors, and growth parameters
- Growth of GaN on h-BN: challenges and strategies
- Substrate preparation and nucleation layers
- Lab: MOCVD reactor operation, growth of GaN thin films on h-BN

Module 3: X-Ray Diffraction (XRD) Analysis
- Principles of XRD and Bragg's law
- Types of scans: θ–2θ, rocking curves, reciprocal space mapping
- Determination of lattice parameters, strain, and crystal quality

- Lab: XRD measurement of GaN/h-BN samples and data analysis

Module 4: Scanning Electron Microscopy (SEM) Analysis

- Principles of SEM imaging and electron-sample interactions
- Surface morphology and defect analysis
- Lab: SEM imaging of GaN films, measurement of surface roughness, grain size, and defects

Module 5: Data Analysis and Research Presentation

- Interpretation of XRD and SEM results
- Correlation between growth parameters and film quality
- Writing a research report and preparing oral presentations
- Group discussion: current literature on GaN on h-BN

Module 6: Final Project and Report

- Individual or small group research project
- Submission of a formal report including introduction, methodology, results, discussion, and conclusion
- Oral presentation and defense of results

Grade Policy:

25% – Lab Performance & Safety
25% – Homework/Reports
25% – Final Research Project
25% – Final Oral Presentation

Attendance Policy:

Attendance is mandatory for this course. Any unexcused absence will result in a grade of zero for both the in-class quiz during that session. In-class quizzes will be administered during the first 10 minutes of the period, and students arriving late will receive a zero for that quiz. Please note that no in-class quizzes will be given during scheduled lab hours to ensure sufficient time for the completion of lab work.

Academic Integrity:

All students enrolled in this course are expected to adhere to the Georgia Tech Honor Code and uphold the highest standards of academic integrity. Any violations or suspicions of academic misconduct will be reported to the Office of Academic Integrity and the Dean of Students for further investigation.

Collaboration:

While students are encouraged to discuss assignments in general terms, all work must be completed individually unless specified otherwise. You may seek help from the course instructors, but it is crucial that each student independently produces their own work. Copying any part of an assignment from another student, or allowing others to copy your work, is considered plagiarism and is strictly prohibited.