

ECE 5037 (Approved): Solid State Electronics and Photonics Laboratory

Course Description

Introduction to laboratory techniques for semiconductor device fabrication including photolithography, oxidation, diffusion, chemical processes, reactive ion etching, and metallization; fabrication and measurements of visible light emitting diodes (LED) and GaN High Electron Mobility Transistor (HEMT).

Prior Course Number: 5037

Transcript Abbreviation: Sld St Micro Lab

Grading Plan: Letter Grade

Course Deliveries: Classroom

Course Levels: Undergrad, Graduate

Student Ranks: Junior, Senior, Masters, Doctoral

Course Offerings: Autumn

Flex Scheduled Course: Never

Course Frequency: Every Year

Course Length: 14 Week

Credits: 4.0

Repeatable: No

Time Distribution: 2.0 hr Lec, 4.0 hr Lab

Expected out-of-class hours per week: 6.0

Graded Component: Laboratory

Credit by Examination: No

Admission Condition: No

Off Campus: Never

Campus Locations: Columbus

Prerequisites and Co-requisites: Prereq or concur: 3030 (432), and acceptance in ECE, MSE or EngPhysics major; or Grad standing in Engineering, Biological Sciences, or Math and Physical Sciences.

Exclusions: None

Cross-Listings:

Course Rationale: Existing course. It is being upgraded to include new content.

The course is required for this unit's degrees, majors, and/or minors: No

The course is a GEC: No

The course is an elective (for this or other units) or is a service course for other units: Yes

Subject/CIP Code: 14.1001

Subsidy Level: Doctoral Course

Programs

Abbreviation	Description
CpE	Computer Engineering
EE	Electrical Engineering

Course Goals

Be competent with the basic techniques for fabrication of LEDs and GaN HEMTs

Be competent in applying knowledge learned in prerequisite semiconductor devices courses to fabrication of LEDs and GaN transistors, other semiconductor devices, and test structures
Be competent in performing current-voltage characterization of semiconductor devices and test structures fabricated in lab
Be competent in performing optical characterization of semiconductor devices and test structures fabricated in lab
Be competent in extraction of device parameters from and analysis and interpretation of test results
Be familiar with cleanroom procedures, and with safe use of the hazardous materials and equipment used in semiconductor device fabrication

Course Topics

Topic	Lec	Rec	Lab	Cli	IS	Sem	FE	Wor
Lab safety, overview of class	1.0							
Theory of LEDs and process overview	3.0							
Epitaxial Growth	2.0							
Theory of XRD and PL Characterization	2.0							
LED L-I optical characterization	2.0							
Wafer Cleaning	1.0							
Photolithography; photomask alignment, tolerances and layout	2.0							
Reactive ion etching	2.0							
Metal contact deposition - evaporation and sputter deposition	2.0							
Sheet resistance, four-point probe	1.0							
Rapid Thermal Anneal	1.0							
Overview of GaN HEMT Theory and Process	3.0							
Gate dielectrics and passivation	2.0							
Ion implantation	2.0							
Electrical testing of I-V characteristics	1.0							
Introduction to working in a cleanroom, initial silicon wafer characterization, wafer cleaning			4.0					
LED Processing and characterization			19.0					
GaN HEMT processing and characterization			19.0					

Representative Assignments

Weekly pre-lab assignments that are predictive of outcomes to expect for that lab session
Weekly post-lab assignments that analyze results of measurements and observation in lab, with comparison to pre-lab expectations.
A formal final report on the results of device characterization.
Several homework assignments on the theory underlying the processes and measurements being performed in lab, and design of unit processes such as oxidation and diffusion.

Grades

Aspect	Percent
Homework	25%
Device Testing Lab Report	40%
Lab Rules and Participation 10%	10%
Pre-lab Assignments	10%

Aspect	Percent
Post-Lab Assignments	10%
Process Simulation Assignments	5%

Representative Textbooks and Other Course Materials

Title	Author
<i>Light Emitting Diodes</i>	E. Fred Schubert
<i>Gallium Nitride (GaN): Physics, Devices, and Technology (Devices, Circuits, and Systems)</i>	Farid Medjdoub

ABET-EAC Criterion 3 Outcomes

Course Contribution	College Outcome
***	a An ability to apply knowledge of mathematics, science, and engineering.
***	b An ability to design and conduct experiments, as well as to analyze and interpret data.
**	c An ability to design a system, component, or process to meet desired needs.
	d An ability to function on multi-disciplinary teams.
**	e An ability to identify, formulate, and solve engineering problems.
*	f An understanding of professional and ethical responsibility.
**	g An ability to communicate effectively.
	h The broad education necessary to understand the impact of engineering solutions in a global and societal context.
*	i A recognition of the need for, and an ability to engage in life-long learning.
*	j A knowledge of contemporary issues.
**	k An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Additional Notes or Comments

Laboratory Schedule:

LEDs

- .. Week 1: Observe the LED wafers being grown by our Nanotech West MOCVD.
- .. Week 2: Perform XRD & PL characterization on 3rd floor Caldwell (part of the open SEAL lab).
- .. Week 3: Perform lithography of top mesa. Etch mesa in Dreese ICP-RIE (else wet etch).
- .. Week 4: Perform lithography of top ohmic contact. Metalize. Liftoff.
- .. Week 5: Perform lithography of bottom electrode. Metalize. Liftoff.
- .. Week 6: RTA anneal ohmic contacts and perform TLM ohmic contact resistance measurements
- .. Week 7: Perform full I-V diode electrical and LED L-I optical characterization

GaN HEMTs

- .. Week 8: Perform lithography for Source and Drain
- .. Week 9: Evaporate Ti/Al/Ni/Au metal stack and lift off
- .. Week 10: Clean and RTA anneal to form source and drain contacts
- .. Week 11: Perform lithography of top mesa. Etch mesa in Dreese ICP-RIE and remove PR

- .. Week 12: Perform TLM ohmic contact resistance measurements
- .. Week 13: Perform lithography of Schottky Gate contact. Metalize Ni/Au/Ni.
Liftoff. Clean
- .. Week 14: Perform full I-V electrical characterization

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