ECE 792 Syllabus  Spring 2019
Wide Bandgap Semiconductor Device Microfabrication Laboratory

Lectures (TBC):  Mon. and Wed.  8:30 AM - 9:45 AM  1212 EB2
Laboratory (TBC): Fri.  9:35 AM-12:20 PM  1020 EB2

Prerequisite Courses:
ECE-404 Introduction to Solid-State Devices (or equivalent)
ECE-538 Integrated Circuit Technology and Fabrication

Recommended Sister Courses:
The following courses are not required to successfully navigate ECE792, however they will provide students with the necessary theoretical background to design and analyze semiconductor power devices, which will be the core application of this course. We will cover the basics of power devices in this course, but will not dig deeply into the theoretical background. Therefore, it is recommended that students enroll in at least one the courses below:

ECE-553 Semiconductor Power Devices
ECE-792-003 Wide Bandgap Semiconductor Power Devices

Course Goals:
The course aims to provide students with hands-on experience designing, fabricating and electrically testing wide bandgap semiconductor devices. Wide bandgap semiconductors are used in a variety of applications, including high-frequency electronics, sensors and lighting. This course will focus on their use in power electronics to demonstrate their exemplary high power handling and high-speed switching capabilities. The theory that is taught in class will be supplemented by practical experiences, including exposure to process modeling, hands-on microfabrication in the NNF cleanroom, on-wafer and packaged electrical characterization, as well as occasional guest lectures from industry.

Instructor Information:
Dr. Spyridon Pavlidis
E-Mail: spavlidis@ncsu.edu  Phone: 919-513-3018
Office: MRC 436

Textbook:
Required:
- Cleanroom notebook/paper (found in bookstore or online)

This course will not have a required textbook, besides the acquisition of a cleanroom notebook. The material presented in the lectures will be drawn from a variety of scientific publications, including the following textbooks:
Supporting Texts:

  ○ Free electronic versions available through:
    ■ NCSU Library - Proquest EBook Central:
      https://ebookcentral.proquest.com/lib/ncsu/detail.action?docID=275904
    ■ IEEE Xplore:

Grading:

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<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Lab Reports/Homework</td>
<td>35%</td>
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<tr>
<td>Participation/Lab Practices</td>
<td>5%</td>
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<tr>
<td>Term Project</td>
<td>40%</td>
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<tr>
<td>Final Exam</td>
<td>20%</td>
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Course Website:

TBD

Term Project:

Students will undertake the design, fabrication and characterization of a GaN Power HEMT. You will be provided with performance specifications (e.g., breakdown voltage, etc.) that your device must achieve, as well as design constraints (e.g., epitaxial film stack-up, lithography node, etc.) that you must adhere to. This exercise is intended to demonstrate the life cycle of development for semiconductor devices.

After the design phase, you will be expected to submit a proposal report, which is less than 10 pages long. Along with the proposal report, each student must submit their CAD files for their lithography masks. The report must describe your approach to the design, including calculations and simulations that you have conducted to justify the proposed device layout. Your proposed process flow must also be described. The report will be assessed based on the ability to meet the performance specifications, and the clarity of the justifications provided.

Once the fabrication and characterization phases have been completed, a written final report will need to be submitted, along with an oral presentation. The final report must be less than 15 pages, while the oral presentation must be less than 20 minutes. These will be largely assessed on the quality of your reporting (attention to detail, investigation of measured results,
troubleshooting, comparison with initial simulations, etc.). The ability to meet the performance specifications will also be evaluated.

Students with the Top 3 measured device performance will receive extra credit towards their project grade as follows:

1st Place  +20%
2nd Place +10%
3rd Place +5%

Project Grading Rubric:
Written Proposal Report  30%
Written Final Report  30%
Oral Presentation Presentation  40%

Useful Links:
NCSU Nanofabrication Facility: https://nnf.ncsu.edu

Additional Notes:
Communication about the class will conducted via email and the class web page. The web page will give you access to the syllabus, calendar, grades, labs, and lecture notes. Each lecture/laboratory covers a unique topic and attendance is required. Please notify the instructor in advance of absences.

Prior to working the cleanroom, a safety test must be passed. The information on the test is located in the Safety Manual link on the NNF web page. Additional information is can be found on the NCSU Nanofabrication Facility web page. You must get at least an 85% on the safety test.

The length of the labs may vary slightly depending on the experiment. You will be expected to submit an individual lab report after each lab session. These reports are your homework and will therefore form a large part of your grade because of their importance. The content/expectations of the lab reports will be discussed.

This course will only have one exam:
- Final: FINALS WEEK (TBD)

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at:
1900 Student Health Center, Campus Box 7509, 515-7653.
http://dso.dasa.ncsu.edu/
For more information on NC State's policy on working with students with disabilities, please see http://policies.ncsu.edu/regulation/reg-02-20-01
All the provisions of the code of academic integrity apply to this course.
http://policies.ncsu.edu/policy/pol-11-35-01
## Class Schedule

GL: Guest Lecture  
SIM: Simulation or CAD Lab  
NNF: Cleanroom Lab  
CHAR: Characterization Lab  

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<th>Monday Lecture</th>
<th>Wednesday Lecture</th>
<th>Lab/Activity</th>
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<td>1</td>
<td>1/7</td>
<td>Introduction to WBG Semiconductors</td>
<td>WBG Crystals and Substrates</td>
<td>GL: WBG Market</td>
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<tr>
<td>2</td>
<td>1/14</td>
<td>WBG Epitaxial Film Growth</td>
<td>Defect Characterization</td>
<td>GL: IQE</td>
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<tr>
<td>3</td>
<td>1/21</td>
<td>No Class (MLK)</td>
<td>Comparison of SiC Device</td>
<td>SIM: Introduction to Device</td>
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<tr>
<td>4</td>
<td>1/28</td>
<td>Comparison of GaN Device Topologies</td>
<td>Doping</td>
<td>SIM: Doping</td>
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<tr>
<td>5</td>
<td>2/4</td>
<td>Etching</td>
<td>Metallization and Contacts</td>
<td>NNF: Etching</td>
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<tr>
<td>6</td>
<td>2/11</td>
<td>Dielectrics on WBGs</td>
<td>High-Voltage Design</td>
<td>NNF: Contacts and Metallization</td>
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<tr>
<td>7</td>
<td>2/18</td>
<td>Switching and Pulsed Characteristics</td>
<td>Thermal Engineering</td>
<td>SIM: Breakdown Voltage</td>
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<td>8</td>
<td>2/25</td>
<td>Term Project Introduction</td>
<td>Power Device Characterization</td>
<td>SIM: Project</td>
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<td>9</td>
<td>3/4</td>
<td>GL: Reliability</td>
<td>NNF: Mask Review</td>
<td>SIM: Project Proposal Due</td>
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<td>10</td>
<td>3/11</td>
<td>No Class (Spring Break)</td>
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<td>11</td>
<td>3/18</td>
<td>NNF: GaN HEMT Fabrication</td>
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<td>12</td>
<td>3/25</td>
<td>NNF: GaN HEMT Fabrication</td>
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<td>CHAR: On-Wafer Measurements</td>
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<td>13</td>
<td>4/1</td>
<td>GL: WBG Foundry Services</td>
<td>Lab: PowerAmerica/Baliga Probe Station</td>
<td>CHAR: Project Measurements</td>
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<tr>
<td>14</td>
<td>4/8</td>
<td>Evaluation Boards and Modules</td>
<td>WBGs: Optoelectronics</td>
<td>CHAR: Transient Measurements</td>
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<td>15</td>
<td>4/15</td>
<td>WBGs for RF Electronics</td>
<td>Ultra Wide Bandgap Materials</td>
<td>No Class (Spring Holiday)</td>
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<td>16</td>
<td>4/22</td>
<td>Presentations</td>
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<td>TBC</td>
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