CREOL, The College of Optics & Photonics

OSE-6615 Optoelectronic Device Fabrication Laboratory

Date and Time: Wednesday 3:00 – 5:00 PM – **Lecture** / Device Fab **Lab** (TBD)
Location: CREOL Room 266 & Nano-Photonics Device Fabrication Facility
Credit Hours: 3.0
Prerequisite: None
Instructors: **Prof. Debashis Chanda**
NSTC 417, CREOL A310
Office: 407-823-4575
Email: debashis.chanda@creol.ucf.edu
Office Hours: TBD – Door is always "open". Just email in case you don't find me.

Required References:

Class Notes/Handouts (provided by instructor)

Course Description:

This is a single semester course designed to strengthen the knowledge base of graduate students in the fabrication methods of modern optoelectronic semiconductor devices. Hands-on fabrication of several optoelectronic devices will be accompanied by classroom lectures designed to provide necessary background knowledge of the fabrication process. Students are expected to gain the general skill set needed to fabricate many of the modern semiconductor devices that are commercially manufactured today.

Grading Policy:

- (4 Lab Reports – **Each 20% of Final Grade**)

Your grade in the course is directly related to your participation in the Lab Segments (the Lab Segments are listed in Course Outline below). The Lab Segments will conclude with a Lab Report that is to be independently written by each student. The Lab Report should include all generated data/information that you gather during your Lab Segment efforts and are expected to be substantially different to show independent work. There are a total of 4 Lab Reports that will each constitute 20% of your final grade. Due date for each Lab Report will be announced well in advance – Lab Reports turned in after the due date may not be accepted by the Instructor.

-Quiz 1 (**10% of Final Grade**)
-Quiz 2 (**10% of Final Grade**)

<u>Lab 1</u>: Spin Processing (1 Week)

- Operating the Spin Coater Tool
- Operating the Hotplate
- Photoresist and Thickness (Photolithography, dry etching, passive optoelectronics devices)
- Scratch Test
- **Generate Spin Vs. Thickness Curve**
- Cleaning the Fume Hood
- Solvent Disposal

<u>Lab 2</u>: Photolithography (1 Week)

- S1813 Photoresist (Material datasheet, positive/negative photoresist, etc)
- Aligner Operation (Lamp, min. feature size, measuring lamp power, calculating exposure time, etc)
- Mask
- 351 Developer (Over/under development)
- Photolithography Steps (Spin, soft bake, exposure, PEB, developing, hard bake)
- Operating the Profilometer
- **Generate Depth Vs. Exposure Time Curve**

********* <u>LAB REPORT #1</u> *********

<u>Lab 3</u>: Etch (2 Week)

- Wet vs. Dry Etch
- Sidewalls (Isotropic, anisotropic, directional)
- Chemical Safety and Acids (MSDS review, special protective apparel)
- Mixing chemicals (Order, percentage, molarity)
- Etching
- **Generate Etch Rate Vs. Time (Dry Etch)**
- **Generate Etch Rate Vs. Acid Concentration Curve (Wet Etch)**
- Acid Disposal

<u>Lab 4</u>: Metal Deposition & Contact Annealing (2 Weeks)

- Contacts (n/p contacts, substrate dependence, transparency in optoelectronics, ohmic vs. schottky)
- Review of Metal Deposition Techniques
- Operating the Temescal (E-beam Evaporator)
- Contact annealing
- Operating the RTA
- **Generate Contact Resistance Vs. Temp (or Time) Curve**

********* <u>LAB REPORT #2</u> *********

<u>Lab 5</u>: GaAs LED (5 Weeks)

- Imprinting/etching (1 week)
- n-metal deposition, contact annealing and photolithography for p-contact (1 week)
- p-contact lift-off and contact annealing, SEM (1 week)
- Manual wafer probe testing (**L-I-V curve and Frequency spectrum measurement**) (1 week)
- Light output measurements using integrating sphere (1 week)

********* <u>LAB REPORT #3</u> *********

<u>Lab 6</u>: Infrared Detector (2 Weeks)

- Nanoimprint to form periodic **nano-array metamaterial** on photoresist
- Scanning Electron Microscope (**<u>SEM</u>**) characterization of nanoimprinted patterns
- Detector formation : UV lithography, metal deposition
- Optical and electronic characterization

********* <u>LAB REPORT #4</u> *********

OSE 6615 – LAB REPORT FORMAT GUIDE

This document provides the general guidelines for elaborating the Lab Report document that you are expected to turn in following completion of the lab segments of the course. Although these are only guidelines – you can depart from the listed content when appropriate but not the format. If any questions arise, please consult the Graduate Lab Assistant or the Instructor for the course.

Lab Report Components

Cover Page

The cover page should indicate the Course and Lab Segment Number (ex. OSE 6615L: Lab Segment #1), the term (ex. Fall 2006), the instructor (ex. Prof. Debashis Chanda), your name, and the date. The Cover Page should not contain any other Lab Report Components and should take up only a single page. If you wish you may add an image or figure from the lab to add some "flair" to the cover page.

Report Format

The report format will follow the general guidelines of *Applied Optics* (https://www.osapublishing.org/ao/submit/templates/default.cfm). Only pdf versions are accepted.

Abstract

The abstract should be a self-contained paragraph that describes the purpose of the lab and the results obtained. The key to a good abstract is to be very concise. You should limit the abstract to a 300 word maximum.

Introduction

The introduction provides the reader with an understanding of the purpose of the work in the report, i.e. what you are reporting. For example, if you were creating spin curves for a photoresist, you would explain that photoresist is an essential element of photolithography and that precision in the targeted photoresist thickness requires one to generate such curves. Any useful background literature or information is also included in this section. Essential elements of the Introduction are the purpose and associated background.

Procedure

The procedure gives details on the methodology you used and the steps therein that were followed during the lab. Use figures or schematics where useful, and include information about the equipment or materials you used. For example, if you were processing a photodetector, you would want to include a schematic of the epitaxial wafer layers and perhaps a flow diagram of the lithography and testing steps that were followed. Do not bullet-point your procedure. Instead, describe it in a paragraph as if you were writing a journal paper.

Results and Discussion

This is where the nice data you took goes. You should put some thought into the best method to present the data. Avoid duplicating data in table and figure form, chose one method as you consider appropriate. Figures should be properly labeled and numbered. The discussion of the results should be integrated such that as results are presented a discussion of their meaning and the associated conclusions are made. When appropriate, you may want to become familiar with the data from other groups in case there are some additional conclusions that can be made. An example might be that different lab groups annealed contacts at different temperatures in an effort to determine the best Ohmic contact annealing conditions or two groups performing different etching recipes. You may in this case want to make a statement about how you think your conditions compare to those of the others. You also may want to look in the literature to see how your contact resistance numbers match up with those that are typically achieved.

Conclusions

In this section you want to quickly state the purpose, what you did in the lab, and what the results and associated conclusions were. It can be considered as an expanded abstract that emphasizes the conclusions that were reached during the lab segment.

References

If you used any references in the Lab Report, you should include them in this section in numbered format for cross-reference to the text.

Additional Notes

<u>Page Requirements</u> – There is no page minimum or maximum, use your own judgment.

<u>Figures</u> – All figures should be properly labeled and numbered using figure captions. You should consider using the automatic Figure Caption and Figure Reference tools of you word processing software (it will make your life a lot easier when you write your dissertation). Use fonts size in captions and inset that are readable in the final report compilation.

*Some comments on individual sections (additional to the note above):

Introduction: Start with the purpose and importance of the work. Not just that you're learning it for the requirements of a course, but the larger impacts to research, industry and society. Remember, all of these seemingly basic techniques enabled a technological revolution. Explore the fundamental concepts related to the project and elaborate on the ones you find particularly interesting. I also find the history behind the science fascinating. Lastly, the course handouts are to be used only as a guide. **Do not**

regurgitate the background information within them. Use your own thought process and images/figures.

Procedure: Write out your steps and **give the reasons behind each one**. Ask yourself “why” and “what if” and address them as best you can. We will use many techniques continuously throughout the semester and I do not expect you to repeat yourself for every report. Elaborate only on new portions of the procedure, which for this first report means everything. We don’t want to see a bulleted list of steps without any context.

Results: Present your data in the most efficient manner and make figures/graphs easy to read with sensible legends, axes and labels. Discuss the conclusions, if any, that can be drawn from your data. If possible, compare your results with those from the other lab group, product data sheets and/or journal publications. Do not duplicate data in table and figure form, use the most appropriate.