

**ECE 544 Microfabrication/MEMS Laboratory**  
**Fall 2022**

**Catalog Data**

Laboratory to illustrate microfabrication processes, semiconductor measurement techniques, MEMS microstructure fabrication, and MEMS testing. Cleanroom activity required.

**Prerequisites**

ECE 543 (or concurrent)

**Important Comments and Special Instructions**

This lab represents a unique opportunity for students due to the Class100/1000 cleanroom facility available for teaching and research. This opportunity has responsibilities and restrictions, with expectations to follow all safety and operational rules of the cleanroom as imposed by the MNTC manager and engineering personnel. Lack of following rules and restrictions can result in expulsion from the lab and a lack of completion for the lab. Personal safety and safe operation of the instruments within the facility are paramount to ensure a safe environment for fellow students, researchers, and the facility. A cleanroom lab notebook will be provided, and you are encouraged to maintain notes with material from the MNTC's website to during the labs (SOPs, etch rates, etc.). Cleanroom safety training will be conducted the 1<sup>st</sup> week of the lab. Below are additional items in preparation for the first class.

**SOME IMPORTANT CLEANROOM RULES**

- 1) Pencils are not allowed in the cleanroom. Pens only.**
- 2) Electronics must be wiped down with isopropyl alcohol (IPA).**
- 3) Dress code – A long or short sleeved top, with pants and closed toe shoes.  
(NOT allowed: Tank tops, shorts and open-toed shoes.)**
- 4) No smoking 30 minutes prior to entering the cleanroom.**
- 5) No running in the cleanroom.**
- 6) Backpacks are to be placed in the lockers of the gowning room.**

**Goals**

This course is designed to provide a valuable hands-on laboratory cleanroom experience in the areas of microfabrication and MEMS technology. During the semester, a MEMS device will be designed, fabricated, packaged, and tested using the MNTC's resources. Computer design tools for MEMS devices will also be utilized.

**Laboratory Instructor/ MNTC Process Engineer**

Jasmin Beharic, Ph.D.

Shumaker Research Building, Room 110

jasmin.beharic@louisville.edu

### **MNTC Process Engineers**

Curt McKenna, [curtis.mckenna@louisville.edu](mailto:curtis.mckenna@louisville.edu)

Mike Martin, Ph.D., [michael.martin@louisville.edu](mailto:michael.martin@louisville.edu)

Evgeniya Moiseeva, Ph.D., [evgenia.moiseeva@louisville.edu](mailto:evgenia.moiseeva@louisville.edu)

### **MNTC Manager**

Julia Aebersold, Ph.D.

Shumaker Research Building, Room 233

[julia.aebersold@louisville.edu](mailto:julia.aebersold@louisville.edu)

### **Laboratory Sessions**

Section 001 – Tuesday, 1:00 pm - 3:45 pm (can extend past 3:45pm)

Section 002 - Thursday, 1:00 pm - 3:45 pm (can extend past 3:45pm)

Meet outside of the Cleanroom (room 122) unless otherwise notified.

### **Textbook**

Richard Jaeger, Introduction to Microelectronic Fabrication, Second Edition, Addison Wesley, 2002

### **Class Information Website**

<https://louisville.edu/micronano>

### **Other References**

#### **Prerequisites/co-requisites by Topic**

1. Basic microfabrication processes
2. MEMS technology and applications
3. Basic concepts of college chemistry
4. Basic concepts of college calculus
5. Chemistry and physics laboratory experience

#### **Topics**

1. Cleanroom principles and safety issues (1 lab)
2. Microfabrication/MEMS processes (9 classes)
3. Photomask Design (1 lab)
4. MEMS Packaging, Imaging & Testing (2 labs)

#### **Computer Usage**

Microsoft Office, L-EDIT

### Laboratory Projects

A MEMS device will be designed, fabricated, packaged, and tested using the MNTC's resources in and outside of the cleanroom. Devices will use stress mismatched materials to create unique out-of-plane structures.

### Graduate Requirements

There are no additional graduate requirements for this 1-hour laboratory course. The additional graduate requirements have been addressed in the accompanying lecture course (ECE 543).

### Evaluation Methods

Lab Assignments - 40%

Mask Files – 20%

Class Participation, Behavior, and Overall Technical Competence in Cleanroom - 10%

Final Report (2 pages) - 30%

### Course Grade

A+	97 – 100
A	90 – 97
B+	87 – 89
B	80 – 87
C+	77 – 79
C	70 – 77
D+	67 – 69
D	60 – 67
F	< 59.99

**NOTE: After missing one lab, a loss in letter grade will result for each additional lab session missed. Cheating or Plagiarizing will result in a failing grade (F).**

### Estimated ABET Category Content

Engineering science: 0.5 credits or 50%, Engineering design: 0.5 credits or 50%

### UofL's ADA (Americans with Disabilities Act) Services

<https://catalog.louisville.edu/undergraduate/about/americans-disabilities-act/>

**ACADEMIC and PROFESSIONAL INTEGRITY:** You are expected to act professionally and ethically, in accordance with the **Code of Student Rights and Responsibilities**

<https://louisville.edu/dos/students/studentrightsandresponsibilities>

Cheating of any form, including plagiarism can result in disciplinary action, including a resulting grade of an F in the course. Cases involving cheating will be dealt with in accordance with the **Code of Student Rights and Responsibilities**.

### **Title IX/Clery Act Notification**

Sexual misconduct (including sexual harassment, sexual assault, and any other nonconsensual behavior of a sexual nature) and sex discrimination violate University policies. Students experiencing such behavior may obtain confidential support from the PEACC Program (852-2663), Counseling Center (852-6585), and Campus Health Services (852-6479). To report sexual misconduct or sex discrimination, contact the Dean of Students (852-5787) or University of Louisville Police (852-6111).

Disclosure to University faculty or instructors of sexual misconduct, domestic violence, dating violence, or sex discrimination occurring on campus, in a University-sponsored program, or involving a campus visitor or University student or employee (whether current or former) is not confidential under Title IX. Faculty and instructors must forward such reports, including names and circumstances, to the University's Title IX officer.

### **ABET COURSE OUTCOMES:**

At the completion of ECE544, the student should be able to accomplish the following.

1. Be able to answer short qualitative questions about semiconductor fabrication techniques and the equipment used for those processes.
2. Be able to demonstrate to the Laboratory Instructor their ability to perform various microfabrication processes in the cleanroom.
3. Be aware of safety issues and demonstrate an ability to function in the cleanroom in a safe and deliberate manner.
4. Be able to maintain a lab notebook and record observations/results both clearly and effectively.
5. Be able to summarize their lab experience by writing an effective final laboratory report.

**ECE 544: Microfabrication/MEMS Lab Schedule – FALL 2022 (Tentative)**

1:00-3:45 PM

Week #	Date	Activities	Location	Assignment Due
1	08/23 08/25	Lab 0 - Introduction, Orientation & Safety Training & Cleanroom Tour	<b>WS 226</b>	
2	08/30 09/01	Lab 1 – Photolithography with Mask 1	Cleanroom	Safety Quiz
3	09/06 09/08	Lab 2 – Sputter Deposition & Liftoff	Cleanroom	Lab Assignment #1
4	09/13 09/15	Lab 3 - Photolithography with Mask 2	Cleanroom	Lab Assignment #2
5	09/20 09/22	Lab 4 – Dicing & XeF <sub>2</sub> Etching	Cleanroom	Lab Assignment #3
6	09/27 09/29	Lab 5 – Device Packaging, Imaging & Testing	Cleanroom	Lab Assignment #4
7	10/04 10/06	<b>Mid-Term Break</b> Lab 6 – L-Edit Training		Lab Assignment #5
8	10/11 10/13	Lab 6 – L-Edit Training Lab 7 – Photomask Generation	Cleanroom	Lab Assignment #5
9	10/18 10/20	Lab 7 – Photomask Generation Lab 8 – Photolithography Mask 1	Cleanroom	Mask Files due by 10/19
10	10/25 10/27	Lab 8 – Photolithography Mask 1 Lab 9 – Sputter Deposition & Liftoff	Cleanroom	Mask Files due by 10/24
11	11/01 11/03	Lab 9 - Sputter Deposition & Liftoff Lab 10 - Photolithography with Mask 2	Cleanroom	
12	11/08 11/10	Lab 10 - Photolithography with Mask 2 Lab 11 - Dicing & XeF <sub>2</sub> Etching	Cleanroom	
13	11/15 11/17	Lab 11 - Dicing & XeF <sub>2</sub> Etching Lab 12 - Device Packaging, Imaging & Testing	Cleanroom	
14	11/22 11/24	Lab 12 - Device Packaging, Imaging & Testing <b>Thanksgiving Break</b>	Cleanroom	
15	11/29 12/01	Lab 13 – Other Cleanroom Processes	Cleanroom	
16	12/07	Final Reports are Due	Cleanroom	Final Report Due

**Labor Day Holiday: Monday, September 5th, 2022****Mid-term Break: Monday & Tuesday, October 3<sup>rd</sup> & 4<sup>th</sup>, 2022****Thanksgiving Break: Wednesday – Friday, November 23<sup>rd</sup> – 25<sup>th</sup>, 2022**