MEMS 5801 Micro-Electro-Mechanical Systems I
Fall 2018 (updated 04/18/2018, subject to change)

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Teaching Assistants:

Course Information

Lecture: M 2:30–4:00 pm
Lab (one of): Tuesday 1:00–4:00 pm
IMSE Cleanroom, Rudolph Hall L35
F 9:00 am–12:00 pm
F 1:00–4:00 pm

Catalog Description: Microelectromechanical systems (MEMS) are ubiquitous in chemical, biomedical, and industrial (e.g., automotive, aerospace, printing) applications. This course will cover important topics in MEMS design, micro-/nanofabrication, and their implementation in real-world devices. The course will include discussion of fabrication and measurement technologies (e.g., physical/chemical deposition, lithography, wet/dry etching, and packaging), as well as application of MEMS theory to design/fabrication of devices in a cleanroom. The laboratory component will allow students to investigate those processes first-hand by fabricating simple MEMS devices. No prerequisites or final exam.

Philosophy/Learning Objectives: This course is primarily a laboratory course with supplementary lectures that cover the theory underlying the lab work, in addition to providing context for and applications of the various fabrication processes. You will work through the initial lab modules in TEAMS OF THREE before designing, fabricating, testing, and reporting on performance of your own microfluidic device.

Students will learn basic micro-/nanofabrication techniques and their implementation in MEMS devices. Topics will include:

- Photolithography (positive/negative), multi-layer alignment, and pattern transfer
- Soft lithography (microreplica molding), characterization, and microfluidic design concepts
- Thermal oxidation and film characterization (ellipsometry)
- Etching of dielectrics (dry/wet), glass (wet), and silicon (wet/dry), and characterization of resulting structures

Students are expected to be active participants in lecture and lab through:

- Interdisciplinary teamwork in small groups
- Creative approaches to problem-solving
- Communication and presentations
- Scientific writing
• Applying fabrication/device knowledge to design custom microfluidic devices

Student grades are based primarily on module reports; however, pre-lab and in-lab worksheets will be collected and graded to assure individual students are keeping up with reading and lab/lecture discussion. Lecture and lab are tightly integrated, and lab worksheets cover knowledge gained during both components of the class. There may be class participation quizzes.

**Texts:** Required reading will be provided as handouts; however, a number of additional resources are available online and through the WUSTL library as noted.

Most course-related information will be communicated to you via Blackboard. Uploaded documents will include reading material, lab worksheets, and some processing data. Students are expected to read required material BEFORE coming to lecture or laboratory. MEMS is an expansive field, and there is not enough lecture time to cover all topics of importance. Being well-prepared (e.g., reading material offline) will help you better conduct experiments in the cleanroom.

**Course Grading:**

<table>
<thead>
<tr>
<th>Material</th>
<th>% of Course Grade</th>
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<tbody>
<tr>
<td>Pre-lab and in-lab worksheets</td>
<td>10%</td>
</tr>
<tr>
<td>Project report on module 1</td>
<td>20%</td>
</tr>
<tr>
<td>Project report on module 2</td>
<td>25%</td>
</tr>
<tr>
<td>Research project</td>
<td>40%</td>
</tr>
<tr>
<td>Class participation/quizzes</td>
<td>5%</td>
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**Pre-lab and In-lab Worksheets**

1. Most weeks, a pre-lab worksheet will be posted to or e-mailed from Blackboard one (1) week prior to the corresponding lab. Pre-lab worksheets cover material from lecture, reading, and previous labs. Each individual student will submit the pre-lab worksheet AT THE BEGINNING OF THE LAB PERIOD LISTED ON THE PRE-LAB.

2. In-lab worksheets will be handed out at the beginning of each lab. In-lab worksheets cover material to be discussed that day and should be completed during the lab period. Each individual student will submit the in-lab worksheet AT THE BEGINNING OF THE LAB PERIOD FOLLOWING THAT LISTED ON THE IN-LAB WORKSHEET.

3. Both pre-lab and in-lab worksheets will be returned to students and discussed at the beginning of lecture following their due dates to aid in preparation of module reports.

**Group Modules/Projects and Reports**

1. Most of the course grade is based on group performance on three lab modules (2 structured modules, and 1 less-structured project). Students will have different groups for each module. I will select groups for all three modules early in the semester based on the lab sections.

2. Module reports for the two structured modules will be due after completion of associated lab tasks for each module, specifically: 1) soft lithography and PDMS microfluidics, and 2) fabrication of acoustic microfluidic channels in silicon. During laboratory, you will perform a number of
fabrication and metrology tasks, some of which build upon previous weeks’ work and some that are meant to demonstrate how various parameters affect a given process. You will be given worksheets to guide your learning in the lab. All of this information will be helpful in preparing your reports, but note that you are responsible for recording the information on the worksheets. In general, the project reports will follow a “journal article” format, e.g., with introduction, background theory, methods, results, and discussion sections. I will provide examples of what I expect, but also note that structure, grammar, and clarity will count in addition to technical content.

3. The final module is an open-ended research project on a process/device of your choosing. Students may have a chance to participate in active research projects at WashU. While largely student-driven, there are limitations on what can be fabricated and tested: (1) only processes that have been covered in class can be used (unless given prior approval), and (2) availability of device testing instrument. The format should be similar to that of the module reports, though the final report is more heavily weighted.

4. The final project includes two presentations (literature review/design/process review (10%) and final (10%)), as well as a final project report (20%).

**Participation Policy**

1. All students are expected to participate in lecture discussions, particularly in the latter part of the semester when groups are presenting on various aspects of their research projects.

2. Again, you are expected to read assigned material BEFORE coming to lecture.

3. Students will give two 15-18 minute (13-15 minute body + 3-5 minutes for questions) presentations during the last half of the semester. These will cover 1) a literature review supporting your project topic and fabrication process flow development, and 2) testing/analysis and final outcomes of your project.

4. There may be periodic quizzes that count toward your participation grade.

**LAB SAFETY TRAINING**

In addition to the lab-specific safety training given during the first lab period of the semester, students must take the EHS – Initial Lab Safety Training online. The course must be completed through the WUSTL SABACloud (Learn@Work) interface:

1. Go to: [http://learnatwork.wustl.edu/training/](http://learnatwork.wustl.edu/training/)
2. Click on “Login to Learn@Work” link on the right side of the page
3. Enter your Wash U credentials and you will be taken to the SABACloud interface
4. Click in the search bar at the top of the page and type “EHS – Initial Lab Safety Training”
5. Click on the first linked result, and then click on the words “EHS – Initial Lab Safety Training,” which will open a new window that runs through the actual training module
6. Complete the training module and print your certificate
7. Return your certificate at the first lab meeting (cleanroom lab specific training the week of 8/27/18)