

ME/MatE/EE 169 MEMS Fabrication and Design (version 2 – 1/28/2016)

San José State University

Semester: Spring 2016

Section: 01

Class Code: ME: 29366; MatE: 29485; EE: 29484

Credit Units: 1

Class Hours: Thursdays 1330-1615

Class Location: Engineering 311 (microfabrication) or Engineering 213 (design, simulation, etc.)

Instructor: Dr. Evan Green

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Office Hours: Thursdays 12:30-13:00, 16:15-16:45 in Engineering 311.

Course Description <http://info.sjsu.edu/web-dbgen/catalog/courses/ME169.html>

Hands-on design, fabrication, and testing of micro electro-mechanical systems (MEMS). Processes including photolithography, etching, and metal deposition applied to MEMS. Design problems for MEMS components. Introduction to MEMS simulation.

Prerequisites: MatE 25 or MatE 153 or MatE/EE 129.

Required Textbook: *MEMS and Microsystems*, 2nd ed., by T.R. Hsu. Published by John Wiley and Sons, Inc., 2008 (ISBN 978-0-470-08301-7). Multiple copies are on reserve in the SJSU library.

Additional Reading: This class will also require access to published research articles. Each student must be familiar with engineering literature search tools and library access to full-text articles. Tutorials are available at <http://library.sjsu.edu/online-tutorials/>.

Course Website: The course website is maintained using the Canvas learning management system, accessible to enrolled students <http://sjsu.instructure.com>. This course website includes assignment materials, lecture slides, and individual access to grade records. Canvas support is available at <http://www.sjsu.edu/at/ec/canvas/index.html>. Online tools in Canvas will be required for some assignments; hardcopy alternatives to online assignments will be considered only in cases of necessity and if pre-approved in writing with ample time before the deadline (i.e. several days in advance).

Email: Messages regarding this class may be sent to student email addresses listed in MySJSU and/or in Canvas. Each student is required to maintain an up-to-date email address in both.

Workload: Success in this course is based on the expectation that students will spend, for each unit of credit, a MINIMUM of forty-five hours over the length of the course (normally 3 hours per unit per week) for instruction or preparation/studying or course related activities.

Course Goals

1. To learn common processes used in MEMS fabrication via hands-on experience.
2. To develop skill in MEMS design by learning and understanding process capabilities and constraints.
3. To develop teamwork and communication skills in a cross-discipline scenario involving disciplines such as mechanical, electrical, and materials engineering.

Course Learning Outcomes *Upon successful completion of this course, the student should be able to:*

1. Explain the purpose, principle-of-operation, and major execution steps for oxidation, diffusion, photolithography, plasma etching, wet etching, and metal deposition.
 2. Demonstrate under guidance the correct execution of major steps in oxidation, diffusion, photolithography, plasma etching, wet etching, metal deposition, and wafer alignment.
 3. Produce computer-aided design (CAD) geometry suitable for photolithography masks.
 4. Develop a technically feasible MEMS design concept and fabrication process plan for an open-ended design problem involving a microsensor or microactuator.
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Graded Work and Weight Distribution

- 50% for Term Project (Abstract, Mask Set and Poster Presentation)
- 25% for Topic Review Presentation
- 15% for Lab and Reading Quizzes
- 10% for Lab Participation

Grading Basis

Term project and topic review scoring rubrics will be published in *Canvas* no fewer than two weeks prior to each assignment's due date.

Lab and reading quizzes are multiple choice or short answer, within the *Canvas* system, and will be scored according to the grading scale below.

Lab participation measures student interactions with team members, safe and capable operation of lab equipment and extent of engagement in the laboratory activities. These measures apply both to in-lab days and class meetings outside of the MPEL. The detailed scoring rubric for lab participation is posted in *Canvas*.

Grading Scale

The overall course grade is calculated from a weighted sum of all graded components, computed as grade point average (GPA) on a 4.0 scale as follows:

3.85-4.00 A+ | 3.70-3.84 A | 3.50-3.69 A- | 3.15-3.49 B+ | 2.85-3.14 B | 2.50-2.84 B-
2.15-2.50 C+ | 1.85-2.14 C | 1.50-1.84 C- | 1.15-1.50 D+ | 0.85-1.14 D | 0.50-0.84 D- | 0-0.49 F

Work that is evaluated by letter grade receives the following values on 4.0 scale:

A+ = 4.0 | A = 4.0 | A- = 3.7 | B+ = 3.3 | B = 3.0 | B- = 2.7

C+ = 2.3 | C = 2.0 | C- = 1.7 | D+ = 1.3 | D = 1.0 | D- = 0.7 | F = 0.0

Work that is evaluated by percent score is converted to letter grade as follows:

97.0-100 A+ | 93.0-96.9 A | 90.0-92.9 A- | 87.0-89.9 B+ | 83.0-86.9 B | 80.0-82.9 B-
77.0-79.9 C+ | 73.0-76.9 C | 70.0-72.9 C- | 67.0-69.9 D+ | 63.0-66.9 D | 60.0-62.9 D- | 0-59.9 F

Exception Handling

Any grading exceptions or appeals must be resolved promptly in writing. Final evaluation of exceptions will generally not occur until the very end of the semester, so that cases may be compared in fair context with respect to all exceptions class-wide. Late assignments and missed quizzes or exams will normally be recorded with zero credit in the grade roster, unless assignment-specific late policy is stipulated otherwise. Special consideration of truly unavoidable and extenuating circumstances will depend on expeditious timing and supporting documentation (e.g. doctor's note, jury summons, military orders).

University Policies

General Expectations, Rights and Responsibilities of the Student

1. As members of the academic community, students accept both the rights and responsibilities incumbent upon all members of the institution. Students are encouraged to familiarize themselves with SJSU's policies and practices pertaining to the procedures to follow if and when questions or concerns about a class arises. See University Policy S90-5 at <http://www.sjsu.edu/senate/docs/S90-5.pdf>. More detailed information on a variety of related topics is available in the SJSU catalog, at <http://info.sjsu.edu/web-dbgen/narr/catalog/>. In general, it is recommended that students begin by seeking clarification or discussing concerns with their instructor. If such conversation is not possible, or if it does not serve to address the issue, it is recommended that the student contact the Department Chair as a next step.

Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc. Refer to the current semester's Catalog Policies section at <http://info.sjsu.edu/static/catalog/policies.html>. Add/drop deadlines can be found on the current academic year calendars document on the Academic Calendars webpage at http://www.sjsu.edu/provost/services/academic_calendars/. The Late Drop Policy is available at <http://www.sjsu.edu/aars/policies/latedrops/policy/>. Students should be aware of the current deadlines and penalties for dropping classes.

Information about the latest changes and news is available at the Advising Hub at <http://www.sjsu.edu/advising/>.

Consent for Recording of Class and Public Sharing of Instructor Material

University Policy S12-7, <http://www.sjsu.edu/senate/docs/S12-7.pdf>, requires students to obtain instructor's permission to record the course and the following items to be included in the syllabus:

- "Common courtesy and professional behavior dictate that you notify someone when you are recording him/her. You must obtain the instructor's permission to make audio or video recordings in this class. Such permission allows the recordings to be used for your private, study purposes only. The recordings are the intellectual property of the instructor; you have not been given any rights to reproduce or distribute the material."
- "Course material developed by the instructor is the intellectual property of the instructor and cannot be shared publicly without his/her approval. You may not publicly share or upload instructor generated

material for this course such as exam questions, lecture notes, or homework solutions without instructor consent.”

Academic integrity

Your commitment, as a student, to learning is evidenced by your enrollment at San Jose State University. The University Academic Integrity Policy S07-2 at <http://www.sjsu.edu/senate/docs/S07-2.pdf> requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at <http://www.sjsu.edu/studentconduct/>.

Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please inform me in writing as soon as possible (email acceptable). Presidential Directive 97-03 at http://www.sjsu.edu/president/docs/directives/PD_1997-03.pdf requires that students with disabilities requesting accommodations must register with the Accessible Education Center (AEC) at <http://www.sjsu.edu/aec> to establish a record of their disability.

Student Technology Resources

Computer labs for student use are available in the Academic Success Center at <http://www.sjsu.edu/at/asc/> located on the 1st floor of Clark Hall and in the Associated Students Lab on the 2nd floor of the Student Union. Additional computer labs may be available in your department/college. Computers are also available in the Martin Luther King Library. A wide variety of audio-visual equipment is available for student checkout from Media Services located in IRC 112. These items include DV and HD digital camcorders; digital still cameras; video, slide and overhead projectors; DVD, CD, and audiotape players; sound systems, wireless microphones, projection screens and monitors.

SJSU Writing Center

The SJSU Writing Center is located in Clark Hall, Suite 126. All Writing Specialists have gone through a rigorous hiring process, and they are well trained to assist all students at all levels within all disciplines to become better writers. In addition to one-on-one tutoring services, the Writing Center also offers workshops every semester on a variety of writing topics. To make an appointment or to refer to the numerous online resources offered through the Writing Center, please see <http://www.sjsu.edu/writingcenter>.

Class Meeting Schedule

Dates and deadlines are subject to change with fair notice by in-class and online announcement. In order to avoid crowding in the lab, the class will be divided into two rotation groups (A and B), with only one group working in the lab at a given time. Reading and quiz assignments will be posted in Canvas.

	A GROUPS	B GROUPS
Week 1 (Jan 28):	Course Introduction, MEMS Overview, MEMS Processes; Safety, Formation of Project Teams	
Week 2 (Feb 04):	Process development: lithography	Term project discussion MEMS design rules and CAD
Week 3 (Feb 11):	Term project discussion MEMS design rules and CAD	Process development: lithography
Week 4 (Feb 18):	Process development: Metal deposition TERM PROJECT SELECTION DUE	Process and mask design TERM PROJECT SELECTION DUE
Week 5 (Feb 25):	Process and mask design	Process development: Metal deposition
Week 6 (Mar 3):	Term project fabrication start MASKS DUE	Topic review research MASKS DUE
Week 7 (Mar 10):	Topic review research	Term project fabrication start
Week 8 (Mar 17):	Term project fabrication TOPIC REVIEW SELECTION DUE	Topic review research TOPIC REVIEW SELECTION DUE
Week 9 (Mar 24):	Topic review research	Term project fabrication
Week 10 (Mar 31):	<i>Spring recess (no class)</i>	
Week 11 (Apr 7):	Term project fabrication	Topic review research
Week 12 (Apr 14):	Topic review research TOPIC REVIEW DUE	Term project fabrication TOPIC REVIEW DUE
Week 13 (Apr 21):	Term project testing	Term project simulation Term project report
Week 14 (Apr 28):	Term project simulation Term project report	Term project testing
Week 15 (May 5):	Term project testing	Term project simulation Term project report
Week 16 (May 12):	Term project simulation Term project report	Term project testing
FINAL EXAM PERIOD (May 19)	TERM PROJECT POSTER PRESENTATION Thursday, May 19, 1215-1430	