**Syllabus for Microelectronics Manufacturing – EEE530**

**See also the Syllabus Supplement for the relevant semester(s)**

**Instructor/coordinator**: **Michael N. Kozicki, Ph.D., FNAI**

Professor of Electrical Engineering

Email kozicki@asu.edu Phone 480 965 2572

 Office Engineering Research Center 561 Zoom office: https://asu.zoom.us/j/614272919

Mail *School of Electrical, Computer and Energy Engineering, Goldwater Center 208,*

*650 E. Tyler Mall, Arizona State University, Tempe, AZ 85287-5706*

**Note:** to satisfy the “Instructor Approval” requirements, you must demonstrate that you have the knowledge prerequisites for the course. This is for your own good. To do this, please complete the form at the following link and your request will be reviewed - <https://forms.gle/tscTKG6nnx7uKwz7A>

**Course Description**

Microelectronics is the engine room of the New Economy - industries, such as the internet and artificial intelligence, that are characterized by cutting-edge technology and high growth. Change is endemic. For well over half a century, we have had a continuous improvement in integrated circuit functional capability with smaller size, increased reliability and lower cost. The total available market for semiconductor devices is rapidly approaching a trillion dollars but it is also enabling the growth of the whole computing and electronics segment which is about 10 times larger. This in turn is driving expansion in almost all economic sectors. To make full use of this leverage, a lot of basic features of microelectronics manufacturing, including semiconductor process technology, should be reviewed and understood. That is the goal of this course. We start with the ground rules of “performance, price and physics”, and from there transition to the foundations of unit processes, how these make up whole processes, and end with the limits imposed by nature and the industry.

**Catalog Description**: *Device scaling, integrated circuits in systems, economics of fabrication, silicon, MOS logic and memory devices, yield, physics and chemistry of unit processes (lithography, etching, ion implantation, oxidation, diffusion, CVD/PVD), interconnect, process architecture and control, advanced devices, industry limitations.*

**Prerequisite(s)**: Fulton Engineering graduate student. Introductory course on semiconductor processing such as EEE435 Microelectronics or similar practical or course experience. Knowledge of device operation such as EEE436 Solid State Devices or similar device course.

**Course-level Objectives**

In taking this course, students will:

* Appreciate the role integrated circuits play in the delivery of system solutions.
* Understand the constraints posed by device physics, materials, and the economic framework of the semiconductor industry.
* Comprehend the physics and chemistry foundations of unit processes.
* Be able to show how complete process flows and IC performance are built up from process steps.
* Understand the basic elements of microelectronics manufacturing and thereby become prepared for a professional contribution to a subject that is complex, dynamic and multi-disciplinary.

**Prerequisites by Topic**

* Fundamentals of physics, chemistry, and materials science.
* Fabrication of integrated circuits.
* Basic semiconductor device theory.

**Course Structure**

A. The ground rules - performance, price and physics

1. Introduction - device scaling
2. ICs as systems
3. Economics of fabrication
4. Silicon - physical and electrical characteristics
5. Device sub-structures and interfaces
6. MOS transistor operation

B. Unit processes

1. Unit process steps – goals and strategies
2. Surfaces, cleaning and yield
3. Diffusion
4. Oxidation
5. Chemical vapor deposition
6. Ion implantation
7. Dry etch
8. Sputtering
9. Resist properties
10. Exposure tools
11. Interconnect and wafer finishing
12. Process control

C. Whole processes

1. Process architecture
2. Base CMOS process flow
3. Memory
4. BiCMOS
5. Device models and parameter extraction

D. Limits

1. Process technology limits
2. Rethinking devices for the sub-10 nm regime and wrap-up

**Textbook**

There are **no** **required books** for the course – all examinable matter is supplied in the course materials – but suggested texts, papers, and websites are given in the class website. For those students who prefer the support of a textbook, we recommend Fabrication Engineering at the Micro- and Nanoscale (Fourth Edition), Stephen A. Campbell, The Oxford Series in Electrical and Computer Engineering, ISBN: 9780199861224.

**Assessment**

* **Module quizzes** – one quiz per module, 25 in total (25% of course grade).
	+ Format is multiple choice or open answer involving a calculation or explanation based on the material in the module.
* **Project** – technology review (20% of course grade).
	+ A review paper requiring literature/web research and analysis of published material.
* **Discussion Board** – Participation in the online forum (5% of course grade).
	+ Requires at least *two original posts per week*. Posts can contain discussion of published articles or news about the semiconductor industry (with links or attachments), comments and questions on class material and related technology, comments on and answers to other Discussion Board posts.
* **Examinations** – one non-comprehensive exam for each half of the course, 2 in total (25% + 25% = 50% of course grade).
	+ The first exam covers “*Introduction - device Scaling”* to *“Ion implantation”* (Modules 1 to 12), the second exam covers “*Dry etch”* to “*Rethinking devices for the sub-10 nm regime and wrap-up”* (Modules 13 to 25).
	+ Students are encouraged to use a one-page (8½ by 11 inch or A4) one-sided *aide-memoire* during exams, as well as a calculator. No internet access is allowed during exams.

**Absence, Make-Up & Hardship Policies**

It is extremely important that the class work is completed according to the assessment schedule given in the Syllabus Supplement for the semester in which you are taking the class. **There is no opportunity for extra credit and make-up material or extra time will only be given following approval by the unit advising team. In the event of hardship such as serious illness or a significant personal or family issue, please contact your academic advisor for guidance**.

Accommodations will be made for religious observances provided that students notify the instructor at the beginning of the semester concerning those dates. Students who expect to miss class due to officially university-sanctioned activities should inform the instructor early in the semester. Alternative arrangements will generally be made for any examinations and other graded in-class work affected by such absences. The preceding policies are based on [ACD 304–04](http://www.asu.edu/aad/manuals/acd/acd304-04.html), “Accommodation for Religious Practices” and [ACD 304–02](http://www.asu.edu/aad/manuals/acd/acd304-02.html), “Missed Classes Due to University-Sanctioned Activities.”

**General Notices**

**Classroom Behavior**

Disruptive behavior of any kind will not be tolerated in the classroom and may result in ejection. Excessively loud talking during lectures, persistent lateness that causes distraction, obnoxious comments directed toward the instructor, teaching assistants, and other students during classes are examples of such prohibited behavior. Cell phones and pagers must be turned off during class to avoid causing distractions. The use of recording devices is not permitted during class unless specifically allowed in writing by the instructor.

**Policy against threatening behavior**

Students, faculty, staff, and other individuals do not have an unqualified right of access to university grounds, property, or services. Interfering with the peaceful conduct of university-related business or activities or remaining on campus grounds after a request to leave may be considered a crime. All incidents and allegations of violent or threatening conduct by an ASU student (whether on- or off-campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students. Consult the Student Services Manual, [SSM 104–02](https://www.asu.edu/aad/manuals/ssm/index.html) for more details.

**Academic Integrity and Copyright Laws**

Students in this class must adhere to ASU’s academic integrity policy, which can be found at <https://provost.asu.edu/academic-integrity/policy> ). Students must review this policy and become familiar with each of the areas in which academic dishonesty can occur. All academic integrity violations will be reported to the Fulton Schools of Engineering Academic Integrity Office (<http://engineering.asu.edu/integrity/>).  The Academic Integrity Office (AIO) maintains record of all violations and has access to academic integrity violations committed in all other ASU college/schools. Course content, including lectures, are copyrighted materials. In addition to ASU’s academic integrity policy, students may not share outside the class, upload, sell, or distribute course content or notes taken during the conduct of the course (see [ACD 304–06](https://www.asu.edu/aad/manuals/acd/acd304-06.html), “Commercial Note Taking Services” for more information).

Students must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the student first complies with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement.

Collaboration on quizzes, homework, and project work is strongly discouraged but the sharing of resources (papers, websites, etc.) is permitted. It is vitally important that you **properly cite all sources** used in homework and project work, otherwise you will not receive credit for the effort (see <https://libguides.asu.edu/citing> for guidance).

**Disability Accommodations**

Suitable accommodations will be made for students having disabilities. Students needing accommodations must register with the ASU disabilities resource Center and provide documentation of that registration to the instructor. Students should communicate the need for an accommodation in sufficient time for it to be properly arranged.

**Harassment and Sexual Discrimination**

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits discrimination, harassment, and retaliation by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information.

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity.  Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited.  An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university.  If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at <https://sexualviolenceprevention.asu.edu/faqs>.  As a mandated reporter, I (the Course Coordinator) am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence.  ASU Counseling Services, <https://eoss.asu.edu/counseling>, is available if you wish to discuss any concerns confidentially and privately.

* **Any information in this syllabus or its supplement may be subject to change with reasonable advance notice.**
* **All contents of the lectures, including written materials distributed to the class, are under copyright protection AND MAY NOT BE SHARED, UPLOADED, SOLD, OR DISTRIBUTED. Notes based on these materials may not be sold or commercialized without the express permission of the instructor.**