Boston University
College of Engineering

Course #: **me-ec579** (cross-listed in ME and EC departments), usually taught each fall.

Course title: **Nano/microelectronic Device Technology**

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(Directions to office: Go in at 15 Saint Mary's, bear right, go down the long narrow corridor, with the glass walls on the left, through the double doors, and my office is on the left, Rm. 133. My office is very close to the ECL computer lab.)

The classes during the Fall semester in 2022, will be held **Tu & Th, 1:30-3:15pm, in Room 105, EMB, 15 Saint Mary's Street.** (Go in at 15 Saint Mary's Street, bear to the right; our classroom, Rm #105, is the first one on the left.) Classes start on Tu, 9-6-2022.

My **office hours** will be 1pm to 2pm on Mondays and Wednesdays, via zoom, except for holidays of course. If you cannot make those hours, please feel free to contact me by email to arrange another time. Please use the following Zoom contact: Meeting ID 8205304635
https://bostonu.zoom.us/j/8205304635

Please note: This course is often taken by students in all three departments in BU's College of Engineering, plus the material science division, since micro and nano electronic technology has come to be used in so very many fields. For example, consider bioengineering: much of the advanced imaging, surgical methods, instrumentation, and analysis in this area would not be possible without microelectronics.

Prerequisites: You need the usual set of undergraduate math, and undergraduate physics. You do not need to know semiconductor physics. This material will be taught as part of the course. You will learn about the engineering and science end, as well as the business end. The course greatly illustrates the use of innovation, since this field of micro and now nanoelectronics has continued to prosper by repeated new innovative methods to overcome barriers. Students should be of graduate or senior standing in engineering, or consent of instructor.

Course Description/Catalog Data:
Physical processes and manufacturing strategies for the fabrication and manufacture of more conventional nano/microelectronic devices will be emphasized. Processing and device aspects instrumental in silicon, including the fabrication of doping distributions, etching, photolithography, interconnect construction, and packaging, will be covered. Future directions and connections to novel devices, MEMS, photonics, and unusual nanoscale structures will be made. Emphasis will be placed on designing these novel structures for manufacturability purposes if they are to replace the versatility of more conventional devices like FETs and BJTs. The overall integration with methods and tools employed by device and circuit designers will be covered.

Textbooks:

(1) The main material will be from class/lecture notes. **You do not need to buy a textbook.** If you would like additional background material, here are several fine sources:

- Solid State Electronic Devices by Ben G. Streetman.
- "Advanced Semiconductor Fundamentals," 2nd ed., by Robert Pierret, Prentice-Hall, 2002, ISBN 013061792X.
- "Fundamentals of Semiconductor Devices," by Betty Anderson and Richard Anderson.
- "Fundamentals of Modern VLSI Devices," by Yuan Taur and Tak H. Ning.
- "Fundamentals of Microelectronics," Behzad Razav, 2008.

(2) Microelectronic business case studies, possibly including some of the following:

(1) "Reversal of Fortune? The Recovery of the U.S. Semiconductor Industry," by Jeffrey T. Macher, D. Mowery and D. Hodges, 1998, 29 pages, HBSP, Case CMR138.
(2) "Managing Intellectual Capital: Licensing and Cross-Licensing in Semiconductors and Electronics," by Peter C. Grindley, David J. Teece, date 1997, 35p, product number CMR074.
(3) "Science and Engineering Beyond Moore's Law," by Ralph K. Cavin, III, Paolo Lugli, and Victor V. Zhirnov, Proc. of IEEE, 5/13/2012.
(4) "Taiwan Semiconductor Manufacturing Co.: The Semiconductor Services Company," by Hau Lee, Seungjin Whang, Shiri Shneorson, date 2006, 27p Product # GS40.
(5) "The "Non-Globalization" of Innovation in the Semiconductor Industry," by Jeffrey T. Macher, David C. Mowery, Alberto Di Minin, Date: Nov 1, 2007 Product Number: CMR387 Length: 27p

(3) Current news articles on microelectronic technology developments, such as new devices and new business directions. These news articles will be covered as they happen, to help foster interest and awareness of the rapidly changing microelectronics industry.

Goals:

The intent of this course is to provide an overall view of the physical processes and steps that are key to the nano/microelectronics industry. In particular, the course will emphasize electron-hole transport to a large extent, plus semiconductor processing, device design, device operation, and circuit integration, all from the perspective of obtaining an improved manufacturable product. A strong effort will be made to connect deeper theoretical ideas to the level of, hopefully, insightful and intuitive physical understanding, particularly regarding the important behavior of the transport of electron and holes, but also key physical processes like diffusion, oxidation, and photolithography.

During this process, an emphasis will be made to cover the integration of technology development to enable both high yield and fast devices. A key emphasis recognized in the microelectronics industry is the need to "design for manufacturability" right from the very beginning development of a new technology generation, rather than designing first, and later worrying about this important aspect later. A number of examples will be discussed that illustrate this point. Connections will be made throughout the course on how the microelectronics industry is evolving, with directions and connections to new innovative technologies, including novel semiconductor devices, MEMS, photonics, and nanoscale devices.

Below are the grading topics and due dates for the four main items in this course. Regarding the percentages, they reflect the weight of that item in the final course grade.

Topic	Grading	Date
Homework	10%	4 HWs, dates to be announced.
Midterm	30%	10/25/22 (Tu) (14th class)
Class project	30%	12/6/22 & 12/8/22 (Tu & Th) (last classes)
Final	30%	TBD (Finals held 12/15-12/21.)

The midterm exam will be held on Tu 10/25/22 (class #14). Project presentations will be on Tu & Th (classes #25 & 26), 12/6 & 12/8, and the final exam will be held during the university's final exam period between 12/15 and 12/21. Usually we learn the date, time, and place for our course's final exam during the first month of class; I will announce the time and place as soon as I learn them from the registrar.

Topics **Rough % of course emphasis in a Fall/Spring semester of 13.5 weeks, 2 classes per week**

(1) Initial overview of key components in nano/micro electronics industry (1/2 week)
(2) Silicon processing (2 weeks)
(3) Electron-hole transport and device operation (4 weeks)
(3) Photolithography processing (1 & 1/2 weeks)
(4) Interconnect processing (1/2 week)
(5) Connections to device and circuit design (1/2 week)
(6) Packaging (1/2 week)
(7) Testing and reliability (1/2 week)
(8) Future technologies attempting to be incorporated into manufacturable schemes, including novel 3D device, quantum mechanical devices, other related areas of nanoelectronics, and optoelectronics (2.5 weeks)
(9) Presentations by students on special topics agreed upon with instructor by middle of semester (1 week)