Boston University
College of Engineering

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

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

Instructor: Dan Cole
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Office: Mechanical Engineering Department, Rm. 133, 15 Saint Mary's Street
(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 2015 semester will be **Tu and Th, 2-4 pm, Rm 105, EMB**, 15 Saint Mary's Street. Go in at 15 Saint Mary's St., bear to the right, and the classroom is the very first room on the left.

There are a few exceptions on class days being held, such as there is not class on Tu 10/13/2015. To keep track of exceptions, plus when the final exam period begins, when the earlier study period is, etc., please go to the link at:

http://www.bu.edu/reg/files/2015/07/Academic-calendar-2015-2016.pdf

I will also remind you (and you can help remind me!) of these exceptions, as we proceed through the semester.

My **office hours** will be 9-10:30 am on Tuesday and 10-11 on Thursday, except for holidays of course. See above for directions to my office. If you cannot make those hours, please feel free to contact me by email to arrange another time, or, just stop by and see if I am free. Again, my email is dccole@bu.edu.

Please note: This course is often taken by students in all three departments in BU's College of Engineering, since micro and nano electronic technology has come to be used in so very many fields. For example, take 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.

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.

Prerequisite Course(s): Senior or graduate standing in engineering, or consent of instructor.

Textbooks:

(1) Main material will be from class notes. If you would like additional background material, here are several fine sources:

(2)

- "Fundamentals of Semiconductor Devices," by Betty Anderson and Richard Anderson.
- "Fundamentals of Modern VLSI Devices," by Yuan Taur and Tak H. Ning, 2009.
- "Fundamentals of Microelectronics," Behzad Razav, 2008.

Alternatively, for just general good background, the following advanced undergrad book is very helpful:

- Solid State Electronic Devices (6th Edition) by Ben G. Streetman.

(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) "Whither Moore's Law: The Future of Semiconductors," by Clayton M. Christensen, Scott D. Anthony, Erik A. Roth , date 2004, 25p, product #1751BC.
(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 microelectronics industry, emphasizing semiconductor processing, device design, device operation, and circuit integration, all from the perspective of obtaining an improved manufacturable product. Most semiconductor related courses focus on one of these aspects, without aiming for a full integration of the technology development to enable high yield, fast devices, and low priced products to be

obtained. A key emphasis now being recognized in the microelectronics industry is the need to "design for manufacturability" right from the very beginning of the 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 emphasize the change in business practices now taking place in the microelectronics industry to incorporate this new attitude. 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. Embracing solid manufacturing practices will be essential for these new and exciting technologies to reach their full potential in the rapidly changing technology business market.

Grading:

Homework	10%
Midterm	30%
Final	30%
Project	30%

Lectures and class activities will require 4 hours per week.

Topics **Rough % of course emphasis in a Fall/Spring semester of 14 weeks, 2 classes per week**

(1) Initial overview of key components in nano/micro electronics industry (1 week)
(2) Silicon processing (2 weeks)
(3) Device operation (3 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 (3 weeks)
(9) Presentations by students on special topics agreed upon with instructor by middle of semester (1 week)

Other helpful books:

(1) "Introduction to Micro Fabrication," by Sami Franssila, Wiley, 2004, ISBN 0-470-85106-6.
(2) "Advanced Semiconductor Fundamentals," 2nd ed., by Robert Pierret, Prentice-Hall, 2002, ISBN 013061792X.