**Name of the module: Semiconductor Devices**

**Number of module: 365-1-4141**

BGU Credits 3.5

ECTS credits: 5.5

Academic year: every year

Semester: Spring semester

Hours of instruction 2013: Wednesday 16-18, Thursday 10-12

Location of instruction: Will be defined

Language of instruction: Hebrew (or English if requested by students)

Cycle: B.Sc.

Position: Compulsory course for Materials Engineering students in the Electronic Materials, and Physics-Materials programs. Advanced elective course for Materials Engineering students in the Structural Materials and Materials-Mechanical Engineering program.

Field of Education: Materials Engineering

Responsible department: Materials Engineering

General prerequisites: Students should complete the following courses before their registration to the module: Physics 3 (203-1-2421), Electronic Properties of Materials (365-1-3141), and Introduction to Electrical Engineering (361-1-5000)

Grading scale: the grading scale would be determined on a scale of 0 – 100 (0 would indicate failure and 100 complete success 0 to 100), passing grade is 56.

Course Description: The course teaches the physical processes related to the behavior of semiconductor devices and obtained device characteristics. In this framework basic principles of pn junction and metal semiconductor junction, MOS capacitor and filed effect transistor will be addressed . Toward the end of the course will discuss the bases of railway integrated circuits.

The course materials will be practiced by analytical exercises and computer modelling.

Aims of the module: Introduce the basic physical principles of semiconductor devices and the factors controlling their performance.

Objectives of the module: Introduce the basic principles of the semiconductor devices including pn diode and field effect transistor. Beyond understanding the basic principles the student should know how to calculate the working curve of these devices and analyze and judge the validity of device models from a device physics point of view.

Learning outcomes of the module: On successful completion of the course, the student should be able to:

1. Account for and calculate how the electrical conductivity varies with temperature and doping concentration for the semiconductors Si and GaAs.
2. Analyze and describe the charge distribution in pn diode and MOS transistor for different bias voltages.
3. Analyze how different physical phenomena influence the current in semiconductor devices
4. Calculate the current in the pn diode and MOS transistor using simplified device models based on the physical phenomena that influence the current.
5. Exemplify how the simplified device models can be developed to more complex models that deviate less from experimental data
6. Implement device model in a computer simulation.

Lecturer: Professor Nurit Ashkenasy

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Office hours:

Lecturer:

Sunday 15:00-16:00,

Thursday 15:00-16:00

TA: will be announced.

Module evaluation: at the end of the semester the students will evaluate the module, in order to draw conclusions, and for the university's internal needs.

Confirmation: the syllabus was confirmed by the faculty academic advisory committee to be valid on 2012-2013.

Last update: January 24, 2013

Attendance regulation: Attendance in class is not mandatory

Teaching arrangement and method of instruction: Lectures and exercises.

Assessment:

1. Final Exam 65%
2. Midterm exam 20%
3. Exercises 5%
4. Computer exercises 10%

100%

Work and assignments: The students are expected to follow classes and lecture notes, and supplement by reading in the text –book of the course, as well as complementary literature**.** The students will receive exercises every 2 or 3 weeks, and in addition 3-4 computer exercises during the semester. Their solutions will be examined and will be used to access their marks in the course as described above.

Time required for individual work: in addition to attendance in class, the students are expected to do their assignment and individual work: at least 3 hours per week.

Module Content\ schedule and outlines:

1. Introduction: [energy bands of semiconductors](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_3.htm#2_3_3), [density of states](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_4.htm), [carrier distribution functions](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_5.htm), [carrier densities](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_6.htm) (3h).
2. [Carrier transport](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_7.htm): [mobility, carrier drift](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_7.htm#2_7_1) and diffusion, velocity saturation, (2h).
3. [Carrier recombination and generation](http://ecee.colorado.edu/~bart/book/book/chapter2/ch2_8.htm): quasi-Fermi levels, the continuity equation and the diffusion equation (2h).
4. [p-n junction](http://ecee.colorado.edu/~bart/book/book/content4.htm) [at](http://ecee.colorado.edu/~bart/book/book/chapter4/ch4_2.htm) equilibrium: band diagram and built in potential, the depletion approximation (3h).
5. [The p-n diode current](http://ecee.colorado.edu/~bart/book/book/chapter4/ch4_4.htm): [the ideal diode current](http://ecee.colorado.edu/~bart/book/book/chapter4/ch4_4.htm#4_4_2), deviation from ideality, reverse bias breakdown, the junction capacitance (7h).
6. [Metal-Semiconductor junctions:](http://ecee.colorado.edu/~bart/book/book/content3.htm) [structure and principle of operation](http://ecee.colorado.edu/~bart/book/book/chapter3/ch3_2.htm), [thermal equilibrium](http://ecee.colorado.edu/~bart/book/book/chapter3/ch3_2.htm#3_2_3), [forward and reverse bias](http://ecee.colorado.edu/~bart/book/book/chapter3/ch3_2.htm#3_2_4), metal semiconductor contacts (4h).
7. [Metal-Oxide-Silicon capacitors:](http://ecee.colorado.edu/~bart/book/book/content6.htm) [structure and principle of operation](http://ecee.colorado.edu/~bart/book/book/chapter6/ch6_2.htm), [MOS capacitor analysis](http://ecee.colorado.edu/~bart/book/book/chapter6/ch6_3.htm) (6h)
8. [MOS Field Effect Transistors:](http://ecee.colorado.edu/~bart/book/book/content7.htm) [structure and principle of operation](http://ecee.colorado.edu/~bart/book/book/chapter7/ch7_2.htm), [MOSFET analysis](http://ecee.colorado.edu/~bart/book/book/chapter7/ch7_3.htm), threshold voltage, advanced MOSFET issues, CMOS, MOSFET memory (12h)

Required reading: "Solid State Electronic Devices” by B. G. Streetman and S. K. Banerjee.

Additional literature: "Physics of Semiconductor Devices" S.M. Sze and K. Ng. Kwok

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\* Learning material will be available to the students on the module's website (high-learn)/ library/ electronic documents available to BGU students.