《Semiconductor Device Physics》Syllabus

Course Number: NANA2068
Course Name: Semiconductor Device Physics
Course Category: Compulsory Course (Nano Devices Stream)
Credits/Contact Hours: 3 Credits / 54 Hours
Evaluation Method: Class Discussion + Short Presentation + Final Examination
Semester: 5th Semester
Prerequisites: NANA2051 and NANA2060
Follow-Up: NANA2073
Lecturer: Sui-Dong Wang
Syllabus Author: Sui-Dong Wang
Syllabus Reviewer: Zhao-Kui Wang
Textbook: S. M. Sze and Kwok K. Ng, 《Physics of Semiconductor Devices》, Wiley-Interscience, 2007; and Lecture Notes.

(1) Specific Goals for the Course

The course objective is to obtain practical knowledge in semiconductor physics and semiconductor devices. Students will acquire knowledge in crystal structures and bonding, orbital hybridization of semiconductor materials, and fundamental physics of semiconductors that includes energy bands, calculation of carrier density using Fermi-Dirac distribution and density of states, drift and diffusion current, transport mechanism of charge carriers in organic and inorganic semiconductors. Students will learn phenomena of doping, photoexcitation and thermal excitation of carriers, and the recombination of excited carriers in semiconductors. Based on fundamental semiconductor physics, students will build knowledge in semiconductor devices that comprise diodes, transistors and memories, as well as their typical applications.

By the end of the course, students should be able to:

(I) Use knowledge in semiconductor physics and semiconductor devices to analyze and quantify complex problems in the field of nanotechnology. (Support Graduation Requirements Indicator 1-2)

(II) Conduct effective analysis and literature review to address complex problems related to semiconductor physics and semiconductor devices. (Support Graduation Requirements Indicator 2-2)

(2) Topics for the Course

- Students can discuss semiconductor materials for construction of semiconductor electronic devices.
- Students can recognize different crystalline structures of semiconductors, and their effects on macroscopic properties of semiconductors.
- Students can resolve and describe different bonding configurations of semiconductors, and their effects on macroscopic properties of semiconductors.
- Students can explain the orbital hybridization, and its effects on macroscopic properties of

semiconductors.

- Students can characterize the crystalline structures and bonding configurations of semiconductors.
- Students can illustrate graphically a schematic and explain the difference between delocalized and localized electrons in semiconductors.
- Students can explain energy band diagrams of semiconductors.
- Students can calculate the carrier density based on Fermi-Dirac distribution and density of states.
- Students can explain drift current and mobility and diffusion current and different transport mechanism in inorganic and organic semiconductors.
- Students can elucidate the doping mechanism in semiconductors, and explain the energy bands of both p-type and n-type semiconductors.
- Students can describe differences between electron/hole trapping states and electron/hole scattering states.
- Students can explain energy band diagram, band bending, and built-in potential of p-n junction.
- Students can describe the working principle of diodes, and current modulation of p-n diodes.
- Students can name practical applications of p-n diodes.
- Students can explain the energy band diagram of thermionic emission and field emission processes, and can explain different carrier injection mechanism in inorganic and organic semiconductors.
- Students can characterize metal-semiconductor contacts.
- Students can measure the contact resistance of metal-semiconductor contacts.
- Students can explain the energy band diagram of metal-oxide-semiconductor structures, and understand the origin of carrier depletion, accumulation and inversion.
- Students can describe working principles and device behaviors of different transistors such as MOSFETs, MESFETs, and TFTs.
- Students can describe working principles and device behaviors of different memories such as flash memory and memristive systems.

(3) Assessments for the Course

- **Course Score = Class Discussion (CD, 45%) + Midterm Presentation (MP, 5%) + Final Exam (FE, 50%)**
- **Achievement of Course Goal = (CD Mean Score*CD Weight*0.45 + MP Mean Score*MP Weight*0.05 + FE Mean Score*FE Weight*0.5) / (100*CD Weight*0.45 + 100*MP Weight*0.05 + 100*FE Weight*0.5)**

Course Goal	Class Discussion CD Weight	Midterm Presentation MP Weight	Final Exam FE Weight
(I) Use knowledge in semiconductor physics and semiconductor devices to analyze and quantify complex problems in the field of nanotechnology. (Support	0.3	0	0.7

Graduation Requirements Indicator 1-2)			
(II) Conduct effective analysis and literature review to address complex problems related to semiconductor physics and semiconductor devices. (Support Graduation Requirements Indicator 2-2)	0.7	1	0.3

Rubrics for the Course:

Course Goal	90-100 (Excellent)	75-89 (Good)	60-74 (Pass)	0-59 (Fail)
(I) Use knowledge in semiconductor physics and semiconductor devices to analyze and quantify complex problems in the field of nanotechnology. (Support Graduation Requirements Indicator 1-2)	Students understand comprehensive knowledge in semiconductor physics and semiconductor devices, and are able to find innovative ways to analyze and calculate related complex problems.	Students understand comprehensive knowledge in semiconductor physics and semiconductor devices, and are able to use the knowledge to efficiently analyze and calculate related complex problems.	Students understand key knowledge in semiconductor physics and semiconductor devices, and are able to use the knowledge to correctly analyze and calculate related complex problems.	Students are lack of key knowledge in semiconductor physics and semiconductor devices, and/or are not able to use the knowledge to analyze and calculate related complex problems.
(II) Conduct effective analysis and literature review to address complex problems related to semiconductor physics and semiconductor devices. (Support Graduation Requirements Indicator 2-2)	Students are able to conduct analysis in innovative ways and offer their viewpoints in literature review to address complex problems related to semiconductor physics and semiconductor devices.	Students are able to conduct comprehensive analysis and thorough literature review to address complex problems related to semiconductor physics and semiconductor devices.	Students are able to conduct correct analysis and appropriate literature review to address complex problems related to semiconductor physics and semiconductor devices.	Students are not able to conduct analysis and literature review to address complex problems related to semiconductor physics and semiconductor devices.