EE 506 - Semiconductor Physics

Semiconductor devices in the form of Si integrated circuits have revolutionized our life by facilitating communications, computation and control of most aspects our daily living. The emergence of new semiconductor materials and devices are now enabling another revolution in computing, energy, visual display, lighting, personal wireless communications and a myriad of other technologies. This course provides a unified understanding of the physical origins of semiconducting materials properties and device characteristics that enable these new applications. This is done by exploring the relationship between atomic properties and bonding in semiconductors, the crystalline structure and the energy band structure of materials more diverse than Si and the thermal, electronic transport and magnetic properties that are characteristic of these materials. Such fundamentals of Semiconductor Physics will also be applied in this course to solve real world device problems via some application examples, such as non-volatile memories for Machine Learning, Neuromorphic Computing and Artificial Intelligence. The course is intended to be self-contained and designed in a way to better prepare senior and master students for jobs in emerging electronic devices and Ph. D students for interdisplinary research topics.

Instructor: J. Joshua Yang; email: jjoshuay@usc.edu

Lectures: Monday and Wednesday 12:00 – 1:50 PM, Grace Ford Salvatori Hall (GFS) 223

Office Hours: Monday and Wednesday 2:30 PM – 4:30 PM by appointment

Recommended Text Book:

Robert F. Pierret, "Semiconductor Devices Fundamentals", 2nd edition, Addison-Wesley (1996). ISBN: 978-0201543933.

Rolf E. Hummel, "Electronic Properties of Materials" Springer. ISBN-13: 978-1441981639;ISBN-10: 1441981632

Suggested reading:

Jasprit Singh, "Electronic and Optoelectronic Properties of Semiconductor Structures, 1st Edition" ISBN-13: 978-0521035743; ISBN-10: 0521035740

Charles Kittel, "Introduction to Solid State Physics", Wiley. ISBN-13: 978-0471415268; ISBN-10: 047141526X

S.M. Sze & Kwok K. Ng, "Physics of Semiconductor Devices" 3rd edition, Wiley (2006). ISBN: 978-0471143239.

Donald Neamen, "Semiconductor Physics and Devices: Basic Principles", 4th edition, McGraw Hill (2011). ISBN: 978-0073529585.

Prerequisites: Introductory Quantum Mechanics or equivalent
Introductory Solid-State Physics or equivalent

Grading:

Homework	30%
Midterm Exam	35%
Final Exam	35%

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1	Logistics and courses overview	Lecture Notes	
Week 2	Semiconductor models	*Lecture Notes*	Homework
Week 3	Carrier concentration	Lecture Notes	Homework
Week 4	Carrier transport and Equation of states	Lecture Notes	Homework
Week 5	Heterojunctions	Lecture Notes	Homework
Week 6	metal-semiconductor contact	Lecture Notes	Homework
Week 7	Midterm exam	Review Lecture Notes and Homeworks	exam
Week 8	MOSFET fundamentals	Lecture Notes	Homework
Week 9	Magnetic properties	Lecture Notes	Homework
Week 10	Thermal and Optical properties	Lecture Notes	Homework
Week 11	Emerging memory devices beyond CMOS	Lecture Notes	Homework
Week 12	Emerging logic devices beyond CMOS	Lecture Notes	Homework
Week 13	Experiments on emerging memory devices	Hands on experiments	Experimental report
Week 14	Applications for Machine learning and Artificial Intelligence	Lecture Notes	Homework
Week 15	Experiments on Machine Learning accelerators	Hands on experiments	Experimental report
FINAL	Final exam	Reviewing Lecture Notes and Homeworks	exam

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus,* the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: http://www.usc.edu/dept/publications/SCAMPUS/gov/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.