# 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 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 optical properties that are characteristic of these materials. Finally, we will discuss interfaces between materials and the properties of heterojunctions made from them. Heterojunctions will lead us to discuss artificially structured materials and quantum structures. This journey will take us from atoms to crystals and back to artificial atoms. During this time we will constantly expand our understanding of the influence of the atoms that make up a semiconductor on the resulting crystals and develop a methodology for designing new device concepts.

**Prereqisite:** **Solid State Physics; Quantum Mechanics**

**Instructor:** P. Daniel Dapkus; VHE 310; Ph:1-213-740-4414; email: dapkus@usc.edu

**Office Hours:** Tuesday and Thursday 3:00 PM – 4:30 PM by appointment

**Recommended Text Book:** *"Electronic and Optoelectronic Properties of Semiconductor Structures, 1st Edition"*

by Jasprit Singh ; ISBN-13: 978-0521035743; ISBN-10: 0521035740

**Prerequisites:** Quantum Mechanics – EE 471 or equivalent

Solid State Physics - EE 338 as a minimum, preferably EE / MASC 501

**Grading:**

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| Homework | 30% |
| Midterm Exam | 35% |
| Final Exam | 35% |

Outline:

| Week | Dates | Topic | |
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| 1 | Aug 21 - 23 | Atomic Structure, Bonding and Crystalline structure | Singh Chap 1 and Handouts<br>HW 1 Assign |
| 2 | Aug 28 – Aug 30 | Crystalline Structures and Symmetry | Singh Chap 1 and Handouts<br>HW #1 Due Aug 30 |
| 3 | Sept 4 - Sept 6 | Covalent Bonding and Energy Bands | Singh Chap 2 and Appendix C<br>HW 2 Assign |
| 4 | Sept 11 - Sept 13 | Energy Bands in Semiconductors | Singh Chap 2 and Handouts<br>HW 2 Due Sept 13 |
| 5 | Sept 18 - Sept 20 | Tight Binding Approximation | Singh Chap 2 and Handouts<br>HW 3 Assign |
| 6 | Sept 25 – Sept 27 | k•P Formalism for band structure calculations | Singh Chap 2 and Handouts<br>HW 3 Due Sept 27 |
| 7 | Oct 2- Oct 4 | Band structure of alloys and the effect of strain and polarization | Singh Chap 3 and Handouts<br>HW 4 Assign |
| 8 | Oct 9 - Oct 11 | Intrinsic and extrinsic carrier densities; Midterm | Handout Notes<br>Homework 4 Due Oct 11 |
| 9 | Oct 16 - Oct 18 | Boltzmann transport equation; Impurity scattering | Singh Chaps 4 & 5 and Handouts;<br>HW 5 Assign |
| 10 | Oct 23 – Oct 25 | Phonon dispersion and phonon scattering | Singh Chap 6 and Handouts<br>HW 5 Due Oct 25 |
| 11 | Oct 30 - Nov 1 | High field transport | Singh Chap 7 and Handouts<br>HW 6 Assign |
| 12 | Nov 6 – Nov 8 | Optical Properties- interband transitions in 2- and 3-D materials | Singh Chap 9 and Handouts<br>HW 6 Due Nov 8 |
| 13 | Nov 13 – Nov 15 | Excitonic states and optical properties | Singh Chap 10 and Handouts<br>HW 7 Assign |
| 14 | Nov 20 – Nov 22 | Heterojunctions; Thanksgiving | Notes |
| 15 | Nov 27 – Nov 29 | Quantum Wells | Notes; HW 7 Due Nov 29 |
| | Dec 11, 2018 | Final 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/.