Solid State Electronics (3)

General Outline

The aim of this course is to develop an understanding of solid state principles with emphasis on those of relevance to applied science and technology. The course begins with symmetry principles of crystal structures and the limitations imposed by symmetry on macroscopic physical properties such as mechanical, acoustical, electrical, magnetic and electromagnetic.

Symmetry imposed limitations on idealized (non-interacting) microscopic state structure are then considered beginning with the Block Theorem and ending with approximate methods for the description near high symmetry points. Phonons and electrons are of particular interest, however, the goal is to develop a general viewpoint. We consider the basic consequences of quantum structuring in one, two, and three dimensions.

We then wish to develop classical and quantum models to treat the coupling of microscopic states, mutual and otherwise, with the goal of understanding and designing macroscopic properties. Interactions to be considered include electrons with phonons and photons, spin, and holes.

The consequences of such interactions on transport properties of bulk and structured materials and devices are discussed.

As time permits electronic tunneling including quantum tunneling in single junctions, resonant tunnelling, and quantized conductivity due to transverse modes in junctions (Landauer Formula) are included.

Superconducting principles and applications are also considered as time permits.

Note that the book (Burns) suggests the alternative of beginning at Chapt. six with less emphasis on crystal structures. It is recommended that sec. 6.1 be read first to grasp the content of the first couple of weeks of the course.

<table>
<thead>
<tr>
<th>Topic and Main Reference</th>
<th>Additional References</th>
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| Symmetry and Crystal Structure  
(Chapt. 1,2,3; and 6-1 (summary of Chpts 1,2,3)) | Nye  
Cotton, Falicov |
| Constitutive relations and transport Parameters  
(Chpt. 5) | Nye |
| Review of quantum mechanics and statistics as necessary,  
(For Intro to q.m (Eisberg Fund. of Mod. Phys.(Wiley)) | Sakurai |
| Density of states, elementary quantum structures,  
(Ch 9 pgs 203-212 Ch 18 715-724 (artificial structures)) |  |
| Free-electron Metals and heavily doped semiconductors.  
(Ch 9 Note that this is an alternative start point in the book) |  |
| Diffraction in periodic structures, the reciprocal lattice,  
(Chapt. 4, 10-6, 10-7)  
Block and Floquets theorems.  
(Ch 10 Pages 252-253) |  |
<table>
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<tbody>
<tr>
<td>Bonding in solids (basic overview only); Repulsion (6-4), Van-der-Walls (6-5), Hydrogen (6-6), ionic (Ch. 7), and co-valent bonding and anti-bonding (Ch 8) Tetrahedral bonding in III-V and II-VI semiconductors based upon &quot;mode-coupling&quot; and symmetry approaches to treat the basic crystal lattices (8-4, 8-5, 8-6).</td>
<td>(Chuang Chapt 4) (Also see Datta)</td>
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<tr>
<td>Band structure, band-gaps, symmetry description of three dimensional band structure. A consideration of GaAs and Si and three-dimensional electro-magnetic filters. (Based upon 10.1 to 10.15 with emphasis on 10.13 to 10.15, additional material taken from Yu and Cardona) The k.p method for band calculations. (10-4d)</td>
<td>Chapt 13 of Chuang</td>
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<tr>
<td>(Read Secs. 10.16 to end as a review of p-n junctions and Schottky barriers)</td>
<td>Ludwig, Falter (235-244) Ferry, Chapt. 4, 7</td>
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<tr>
<td>Band structure modification- quantum wells, superlattices, modulation doped heterojunctions and applications. Electro-absorption and refraction (Based upon Secs. 18.1-18.5, 18.9-10)</td>
<td>Fox, Wooten</td>
</tr>
<tr>
<td>Coupled Oscillators and Lattice vibrations, Phonon scattering (Chapt. 12)</td>
<td>Prutton</td>
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<tr>
<td>Optical properties, direct and indirect transitions (Chapt. 13) gain and loss, scattering (Raman and the Stimulated Raman)</td>
<td>Tinkem-Chp 1</td>
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<td>Surface science (Chapt 17) (Ferry 5.10),</td>
<td>Ferry Chapt 8 (neglect 8.3)</td>
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<tr>
<td>Overview of phase transitions leading to ferroelectricity (Chapt 14) magnetic phenomena, and superconductivity (Chapts. 14, 15, 16) quantum Hall effect</td>
<td>Ferry 9.1,9.2 Ferry Chp 12 McKelvey</td>
</tr>
<tr>
<td>Calculation of transport parameters based upon Boltzmann’s equation. (Datta)</td>
<td>Recombination and photo-conductivity, Shockley-Read-Hall Ferry 9.4,9.5</td>
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<tr>
<td>Diffusion and excess carriers (Datta), electron-electron scattering (Datta)</td>
<td>High field transport, simulation techniques (Ferry Chapt. 10 &amp; Chapt. 11)</td>
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<td>Quantum transport, the Landauer equation (Ferry Secs. 14.3,14.4 and highlights of Chapts. 15 and 16)</td>
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Texts

**Basic General Text For The Course**


**Additional Material Taken From**


References


