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BOOK REVIEW

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# Peter Y. Yu, Manuel Cardona, Fundamentals of semiconductors; physics and materials properties, 3rd rev. and enlarged edn. (Advanced texts in physics).

**Springer, Berlin Heidelberg New York, 2001, Hardcover, 654 pp (ISBN 3-540-41323-5), €54.65**

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Most of us consider semiconductors as a very technical subject, thinking of computer chips and all the electronic equipment in the lab and at home. Chemists may have in mind some elaborate etching and deposition processes, but "Fundamentals" demonstrates the strong mutual interaction of semiconductor sciences and applied solid state physics, reading somewhat like an advanced and specialized edition of the "Introduction to solid state physics" by C. Kittel, the famous bible of solid state physics.

Yu's and Cardona's book features nine chapters, including an introduction about materials and their deposition, and an appendix with nine pioneers of semiconductor physics reviewing their greatest works. After a short materials sciences introduction, things really start with electronic band structures in chapter 2. Semiconductors are among the most perfect crystals available, and thus the treatment begins with group theory and quantum mechanics (LCAO) in translationally invariant systems. The experimental backup to these calculations is photoelectron spectroscopy, which is discussed on a higher level than in most textbooks in chapter 8. Translational symmetry is not only substantial for the electronic but also for the vibrational properties of crystalline semiconductors. Chapter 3 explains phonon dispersion and the underlying physics. In this context the electron–phonon interaction is of special importance: electronic states are influenced by phonon-induced lattice deformations, which is a very obvious and important example for the limits of the Born–Oppenheimer approximation. The most common technique for visualizing phonons in solids, Raman spectroscopy, is extensively discussed in the second part of chapter 7.

Semiconductors are not only examples of perfect crystals. Essential for the technical application is doping by defect atoms with different numbers of electrons, which means breaking of translational symmetry. The electronic properties of such defects and their implications to the spectroscopy of the system are treated explicitly. Chapters 4 and 9 focus on the perturbations of the overall wave functions by defects and on their electronic levels, starting from the particle in the box and ending with the quantum Hall effect, respectively.

Light emission or detection by semiconductors is of vast importance in daily life (think of CD players, LEDs or CCD devices). Chapters 6 and 7 discuss the physics of absorption and emission, respectively, on the basis of the band structures and electronic transitions between the bands. These two chapters do not only present a lot of elementary physics of the interaction of electromagnetic radiation with matter, including Einstein coefficients and Planck's law, but also give details of several standard experimental techniques such as ellipsometry, the vacuum UV lamp, the photomultiplier, and the Fabry–Perot interferometer. Last but not least, electron transport is treated in chapter 5. Technological applications of semiconductors are nearly always making use of their specific properties with respect to electrical current. Astonishingly enough, the physics of all this can be exposed in one short chapter. Reference is made only to a few rather special applications such as the Gunn diode and the Hall probe, but this is not a shortcoming of the book, since there is extensive literature around on the technology.

The authors claim that they fill the gap between solid state textbook and research articles. One might also say that they have written a crystal physics textbook with some focus on semiconductors. Even though a search at Amazon returns some 1600 entries for the keyword "semiconductor", the book by Yu and Cardona is probably unique for deriving the specific properties of these materials so consequently from the fundamentals of physics.

On the other hand, materials science aspects are poorly treated, and the subtitle "Physics *and materials*

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*properties*'' is simply misleading. The remarks in the introduction will at best give some keywords to look for in solid state chemistry books. Important disordered materials, such as amorphous silicon, are nearly completely neglected, probably since they do not fit into the crystal physics approach of the book. The long historical appendix on the early days of semiconductors is rather punctual. As a student, I had preferred a more contiguous presentation of the development of semiconductors and of the substantial contributions of these nine scientists and others to it.

''Fundamentals'' will be of greatest interest for graduate students who need a theoretical background for their work or even want to specialize in semiconductors. The treatment usually revises the basics before coming to the specialties of silicon, etc., but nevertheless the reader should have a good understanding of physics. The wealth of exercises at the end of each chapter will be helpful for lectures. The consequent use of ''old fashioned'' c.g.s. units in parallel with SI in the respective formulas may be very helpful, especially when reading the theoretical literature.