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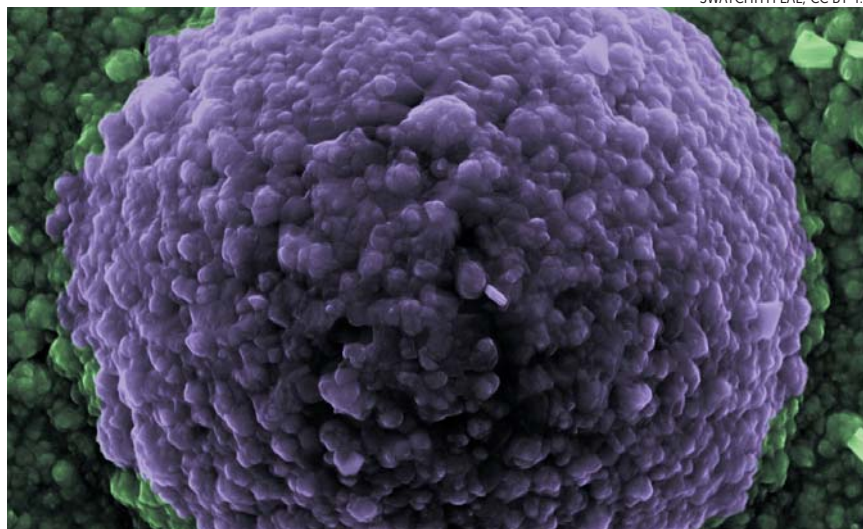
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BOOKS

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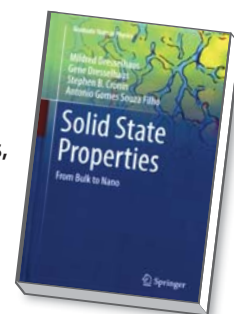
A new textbook explores the solid state

The first widely adopted solid-state textbook for undergraduates was *Introduction to Solid State Physics* by Charles Kittel (1953). The book went through multiple editions and served three generations of students. A popular competitor, *Solid State Physics* by Neil Ashcroft and N. David Mermin, appeared in 1976, but it has not been updated and so lacks the latest developments. Some more recent books, serving both graduates and undergraduates, are *Solid State Physics: Principles and Modern Applications* by John Quinn and Kyung-Soo Yi (2009), *Solid State Physics: Essential Concepts* by David Snoke (2009), *The Physics of Solids: Essentials and Beyond* by Eleftherios Economou (2010), *Condensed Matter in a Nutshell* by Gerald Mahan (2011), and *Fundamentals of Condensed Matter Physics* by Marvin Cohen and Steven Louie (2016). This reviewer has thrown his own hat in the ring with *The Physics of Solids* (2016).

Now a new book, *Solid State Properties: From Bulk to Nano*, enters the crowded field. The two senior authors are well known to the community. Mildred “Millie” Dresselhaus, who passed away early last year, was known for her work on carbon-based materials and thermoelectrics. Gene Dresselhaus performed fundamental work on cyclotron resonance and electronic states in semiconductors. Stephen Cronin is active in the fields of carbon nanostructures and plasmonics; Antonio

Solid State Properties From Bulk to Nano

Mildred Dresselhaus,
Gene Dresselhaus,
Stephen B. Cronin,
and Antonio Gomes
Souza Filho
Springer, 2018.
\$129.00



Gomes Souza Filho also studies carbon-based structures. According to the preface, both Cronin and Souza Filho attended Millie’s solid-state lectures at MIT.

The book is divided into three parts: “Electronic Structure,” “Transport Properties,” and “Optical Properties.” Each of the 22 chapters concludes with a rich collection of problems, a strong feature of the book. Part 1 starts with crystal lattices; atypically, *Solid State Properties* also introduces the reciprocal lattice and Brillouin zones in that chapter. In the second chapter, the student is confronted with the Hartree and Hartree–Fock methods and density functional theory, typically among the more advanced topics in a quantum mechanics course. It also introduces various basis sets, an unconventional derivation of the Bloch states, and the Slater–Koster fitting scheme. Those topics are the foundation for much theoretical activity in solid-state physics, and I thought they should have been presented more systematically.

I had a few criticisms of subsequent chapters in part 1 that detail such topics

as the nearly free electron and tight-binding approximations, effective mass theory, impurity states in semiconductors, and quantized one-dimensional oscillators. Although the tight-binding discussion is well done, the authors do not describe the Harrison nearly free electron construction, which was so important for clarifying the Fermi surfaces of polyvalent metals. Curiously, given that much of the book focuses on semiconductor properties, it does not discuss the orthogonalized-plane-wave method and its descendant pseudopotential method. Nor does it cover the augmented-plane-wave or the Green function methods, which are crucial to understanding the transition metals. Three-dimensional lattices receive little discussion, and the analysis of the electron-phonon interaction is likely too advanced for undergraduates.

Part 2 starts with the standard isotropic one-band Boltzmann treatment of electrical transport for metals, followed by a treatment of temperature-dependent carrier concentrations and transport in semiconductors. The next chapter deals with heat transport, both by electrons and phonons, and contains good descriptions of the related thermoelectric properties of metals and semiconductors. From there, part 2 provides a nice discussion of various scattering mechanisms involving electrons and phonons; covers electron dynamics, including magnetotransport; and offers up-to-date coverage of 1D and 2D systems. Of particular interest is its description of quantum-well phenomenology and the Landauer formula for 1D transport. *Solid State Properties* also includes a treatment of magnetic field-dependent quantum oscillations for ellipsoidal energy surfaces that is far more detailed than the usual fare.

In part 3, the authors go well beyond the usual coverage of optical properties. They start with a phenomenological approach based on the dielectric constant, followed by a treatment of the Drude model that includes plasma oscillations. The final part covers interband transitions. It treats the underlying matrix elements and the joint density of states and provides examples of spectra for 2D and 3D systems. Later chapters discuss Kramers-Kronig analysis, absorption associated with localized states that arise from various impurities and excitons, photoluminescence and photoconductivity, and the interaction of light with lattice vi-

brations. Also covered is Raman scattering, an area of expertise for all the authors.

Solid State Properties omits some important topics, including ferromagnetism and antiferromagnetism; superconductivity; piezo-, pyro-, and ferroelectricity; and second-order phase transitions. A greater emphasis on the quasiparticle concept would have been helpful, as would mention of the Cohen-Ehrenreich self-consistent field approach, which was included, for example, in *Principles of the Theory of Solids* by John Ziman (1964).

Solid State Properties has excellent discussions of many properties associated with semiconductors and low-dimensional systems, even if it avoids actual device structures. The book could be a useful text for a solid-state course in electrical engineering and materials science departments. I will recommend it to my students as supplementary reading and will also keep it nearby for reference.

John Ketterson

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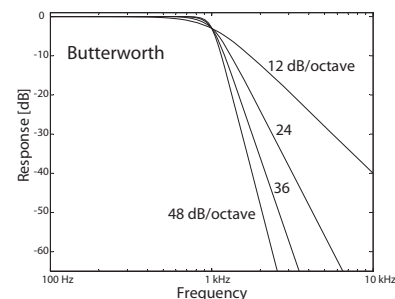
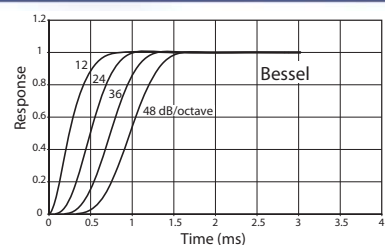


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