Introduction

This volume proposes both course work and problems with detailed solutions. It is the result of many years' experience in teaching at MSc level in applied, materials and electronic physics. It is written with device physics and electronics students in mind. The book describes the fundamental physics of materials used in electronics. This thorough comprehension of the physical properties of materials enables an understanding of the technological processes used in the fabrication of electronic and photonic devices.

The first six chapters are essentially a basic course in the rudiments of solid-state physics and the description of electronic states and energy levels in the simplest of cases. The last four chapters give more advanced theories that have been developed to account for electronic and optical behaviors of ordered and disordered materials.

The book starts with a physical description of weak and strong electronic bonds in a lattice. The appearance of energy bands is then simplified by studying energy levels in rectangular potential wells that move closer to one another. Chapter 2 introduces the theory for free electrons where particular attention is paid to the relation between the nature of the physical solutions to the number of dimensions chosen for the system. Here, the important state density functions are also introduced. Chapter 3, covering semi-free electrons, is essentially given to the description of band theory for weak bonds based on the physical origin of permitted and forbidden bands. In Chapter 4, band theory is applied with respect to the electrical and electronic behaviors of the material in hand, be it insulator, semiconductor or metal. From this, superlattice structures and their application in optoelectronics is described. Chapter 5 focuses on ordered solid-state physics where direct lattices, reciprocal lattices, Brillouin zones and Fermi surfaces are good representations of electronic states and levels in a perfect solid. Chapter 6 applies these representations to metals and semiconductors using the archetypal examples of copper and silicon respectively. An excursion into the preparation of alloys is also proposed.

The last four chapters touch on theories which are rather more complex. Chapter 7 is dedicated to the description of the strong bond in 1D media. Floquet's theorem, which is a sort of physical analog for the Hückel's theorem that is so widely used in physical chemistry, is established. These results are extended to 3D media in Chapter 8, along with a simplified presentation of silicon band theory. The huge gap between the discovery of the working transistor (1947) and the rigorous establishment of silicon band theory around 20 years later is highlighted. Chapter 9 is given over to the description of energy levels in real solids where defaults can generate localized levels. Amorphous materials are well covered, for example, amorphous silicon is used in non-negligible applications such as photovoltaics. Finally, Chapter 10 contains a description of the principal *quasi*-particles in solid state, electronic and optical physics. Phonons are thus covered in detail. Phonons are widely used in thermics; however, the coupling of this with electronic charges is at the origin of phonons in covalent materials. These polarons, which often determine the electronic transport properties of a material, are described in all their possible configurations. Excitons are also described with respect to their degree of extension and their presence in different materials. Finally, the coupling of an electromagnetic wave with electrons or with (vibrating) ions in a diatomic lattice is studied to give a classical description of *quasi*-particles such as plasmons and polaritons.