Electronic transport in hydrogenated amorphous semiconductors

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Usp. Fiz. Nauk **160**, 202–203 (October 1990)

H. Oberhof and P. Thomas, *Electronic Transport in Hydrogenated Amorphous Semiconductors.* Springer-Verlag, Berlin; Heidelberg; New York, London; Paris; Tokyo, 1989. 174 p. (Springer Tracts in Modern Physics, Vol. 114).

Systematic research into amorphous semiconductors began over 30 years ago. The rapid expansion of experimental research was promoted by the availability of simple production methods for amorphous semiconductors, particularly a-Si:H, that could furnish the fundamental material for electronic devices based on thin semiconductor films.

Transport in amorphous semiconductors is usually described by phenomenological models that can be used to compute physical semiconductor parameters. Most specialists employ conduction activation energy measurements at constant current to determine the position of the Fermi level with respect to the mobility edges. The validity of this procedure is based on the existence of a theory that can compare experimental data with theoretical parameters.

The authors of the book under review proceed from a microscopic transport theory which takes into account statistical disorder and phonon interactions. Additional complications are introduced to address real systems. The theoretical techniques developed in the book are then employed to analyze experimental results and compare experimental data with microscopic parameters.

Chapter 1 (introduction) discusses the unique properties of amorphous semiconductors (lower susceptibility to impurities than in crystalline semiconductors which makes amorphous semiconductors essential for large-area devices, such as solar cells; wide spectrum of relaxation times, ranging from picoseconds to hours; unusual temperature behavior of conductivity, of Seebeck coefficient, etc.). A historical overview of amorphous semiconductor research is also provided.

Chapter 2 examines the atomic structure of tetrahedrally coordinated semiconductors, discusses the currently available models of the density of states, introduces the notions of Anderson localization and small polarons. The authors introduce the standard transport theory and discuss activated conduction.

Chapter 3 is devoted to experimental results. The authors cite data on dc and ac conductivities, Seebeck and Hall coefficients, and so forth. They demonstrate that the full range of experimental results cannot be described adequately by standard transport theory and requires more involved models.

Chapter 4 presents the basic physical foundations of a transport theory for a homogeneous model that incorporates statistical disorder and electron-phonon interaction. The theory is a generalization of hopping conduction. In the case of very weak electron-phonon interaction at zero temperature it reduces to the Anderson localization theory of Götze and co-workers. For electrons with energies far below the mobility edge the theory reduces to usual hopping conduction in the high-density and high-temperature limit.

Chapter 5 describes the theoretical apparatus employed in the derivation of the theory. At first reading this chapter may be skipped by experimentalists; theorists, on the other hand, will find it to be of particular interest.

Chapter 6 considers the effect of long-range potential. This potential acts over distances that are larger than the inelastic scattering length and hence this problem can be treated semiclassically.

Chapter 7 examines the temperature dependence of characteristic energies.

In Chapter 8 the theoretical techniques developed in earlier chapters are employed to describe the properties of a-Si:H and a-Ge:H.

In the concluding Chapter 9 the authors discuss some unsolved problems in transport theory.

The book under review provides a reasonably complete picture of research in amorphous semiconductor transport. Its contents should be of significant interest to a wide audience of theoretical and experimental solid state scientists. The book contains an ample bibliography.