

Preface

The main goal of solid-state physics is investigation of the properties of the matter including the mechanical, electrical, optical, magnetic, and so on with the aim of developing new materials with defined characteristics. Nowadays, it consists of the synthesis of superconductors with high critical temperature or fabrication of new heterostructures on the base of semiconductors, in creation of layered, amorphous, organic, or nanofabricated structures and many others. To do all of these, the various methods of investigation are developed during the past. Because it is impossible to find an universal method to investigate a variety of materials, which are either conducting or insulating, crystalline or amorphous, thin-layered or bulk, magnetic or segnetoelectric, and so on, various kind of spectroscopies, like optical, neutron, electron, tunnel and so on, are widely used in solid-state physics. Recently, a new type of spectroscopy, namely, the Point-Contact Spectroscopy (PCS), was designed for study of the conduction–electron interaction mechanism with a whole class of elementary excitations in the solids. In PCS, a small constriction, about a few nanometers large, between two conductors plays a role of a spectrometer. Namely, because of inelastic scattering of accelerated electrons, the $I - V$ characteristic of such a tiny metallic contact is nonlinear versus an applied voltage and its second derivative surprisingly turns out to be proportional to the electron–quasiparticle–interaction spectrum. This property of point contact carries spectroscopic investigations of different excitations in solids, first of all the phonons, as well as magnons, magnetic, and some nonmagnetic impurities with internal degrees of freedom, crystal-field-induced electron levels, and many other processes influenced by the electrical transport. To provide an analogy, the PCS can be compared with the optical absorption spectroscopy, where frequency-dependent absorption of light gives characteristic energy of excitations in insulating materials. Hence, the great power of absorption spectroscopy is peculiar to PCS, which measures the imaginary part of conduction electron self-energy. This can be compared with its “antipode”, the Tunneling Spectroscopy, where net conductivity is proportional to the electron density of quasiparticle states and, consequently, measures the real part of the conduction electron self-energy in solids. PCS can be considered in a much wider sense. Suppose we have a constriction between any “massive” banks that size is much smaller than the inelastic mean free path of any carriers (charge, magnetic moments, energy, mass, etc.). The flow of these carriers versus the generalized forces applied to the banks contains the spectral information similar to PCS. As an example of such generalized PCS, one can consider the flow of ballistic phonons between the small con-

striction connecting the banks with the applied difference in temperatures. Such a theory and experiment are successfully elaborating in a recent time for dielectrics. Another well-known example is the Knudsen regime of mass flow through the small orifice to the vacuum versus the gas pressure in the source. If there are some seldom impurities with the internal degree of freedom present in vacuum, then such a process can be considered as a PCS of these excitations.

The goal of the book is to introduce the readers to PCS, the method that has already been widely used since the beginning of 1970s. Created at the Institute for Low Temperature Physic and Engineering, National Academy of Sciences of Ukraine, and placed in Kharkiv, PCS was soon recognized in the physical laboratories of Europe, Japan, and North America. Among them there are Grenoble High Magnetic Field Laboratory (France), Leiden and Nijmegen Universities (The Netherlands), the Physical Institutes of Cologne, Darmstadt and Karlsruhe (Germany), Institute of Experimental Physics in Kosice (Slovakia), Universities in Cornell, Maine (USA), and Madrid (Spain). In the book we put more attention on the experimental aspects of PCS and present above 200 figures. The theoretical part is restricted essentially in presenting the main relations without sometimes superfluous details. This is because to provide the theory of PCS in full measure, a separate book is necessary. We are sure that the method of PCS because of its simplicity and direct information should gain more places where the properties of new materials are studied, especially in the mainstream of mesoscopic or nanoscale physics.

The authors are grateful to all who assisted in preparing the book. We acknowledge all authors whose results we used for preparing the figures and whose names are written in the figure captures. Special thanks are addressed to A. G. M. Jansen and P. Wyder for the discussion of the book contents and practical comments. We wish to acknowledge very enlightening discussions and long-time collaboration with I. O. Kulik, A. N. Omelyanchouk, R. I. Shekhter, A. A. Lysykh, O. I. Shklyarevskii, and Yu. A. Kolesnichenko. We are thankful to K. Gloos, G. Goll, J. M. van Ruitenbeek, E. Scheer for giving us the figures in the final form, and to O. E. Kvitnitskaya for the help in digitizing of numerous curves and preparing of many pictures. Y. N. thanks P. Wyder for the opportunity to stay in Grenoble HMFL, where the draft of the book was written. I. Y. thanks the Solid State Division of Kamerlingh Onnes Laboratory guided by L. J. de Jongh for long-term mutual collaboration with J. M. van Ruitenbeek and his group. The authors are indebted to H. von Löhneysen, Alexander von Humboldt Stiftung, DFG and MPI für Festkörperforschung (all from Germany) for support of the PCS method during the last few decades.

Kharkiv,
December 2003

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Point-Contact Spectroscopy

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2005, XI, 297 p. 35 illus., Hardcover

ISBN: 978-0-387-21235-7