Physics and technology of submicron structures

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In modern solid-state physics a prominent place is occupied by investigations of systems with lowered dimensionality. At the present time the increased interest in them has been brought about by the rapid development of submicron semiconductor technology. A real possibility has appeared of producing semiconductor devices on the basis of new specifically quantum effects characteristic of two-dimensional and one-dimensional electron systems. The rich functional possibilities of such "quantum" semiconductor devices will allow a significant expansion of the possibilities of the element basis of microelectronics.

The current 83-rd volume of the series "Solid-State Sciences" which is the proceedings of the international school on the physics and technology of submicron structures is devoted to such questions. The school was held in February 1988 near Salzburg and was already the fifth in a series of such schools devoted to new achievements in solid-state physics organized by the Austrian Physical Society. Among the more than 200 participants in it were representatives of European countries, USA, Japan and China. The volume includes only the invited papers. According to their topics they have been divided into five parts: fabrication of microstructures, vertical transport and tunneling phenomena; quantum interference effects in submicron structures and universal fluctuations of conductivity in mesoscopic systems; phenomena associated with the transition from two-dimensional to one-dimensional conductivity in semiconductors; and finally, the physical bases and the possible applications of submicron devices.

The first part (six papers) provides an idea of the modern level of the technology of fabricating structures on the basis of semiconductors of the $A^{III}B^{V}$ group with submicron dimensions. This covers electronic and ionic lithography, different methods of implantation and control of the surface. With the aid of these methods together with the unique possibilities of local epitaxy one can obtain practically any desired quantum structures, starting with wires of quantum dimensions up to surface superlattices. Physical restrictions on the dimensions of the structures obtained by some particular method are also discussed. The second part (three papers) is devoted to investigations of transport phenomena in multilayered structures with lateral dimensions comparable with the thickness of epitaxial layers. A discussion is given of special features of resonant and nonresonant tunnelling in such systems. The third part (five papers) provides data on the study of mesoscopic structures, i.e., disordered conductors with dimensions comparable to distances between electrons. Under such conditions quantum interference effects are manifested in the form of universal fluctuations of conductivity, independent of the time and reproducible for a given sample, that exhibit statistical scatter in going from one sample to another. The fourth part (six papers) examines different properties of a constricted two-dimensional gas. This includes transport phenomena, optical properties, nonlinear screening, etc. in structures with an isolated one-dimensional channel, and in devices with a gate in the form of a periodic microstructure. With the aid of the latter the density of a two-dimensional electron gas in an inversion layer can be modulated from an almost homogeneous to a quasi-one-dimensional situation when the electron system breaks up into a system of weakly coupled channels. The five papers of the last part describe different types of submicron devices, such as one-dimensional tunnelling transistors, transistors with a semiconductor-metal-semiconductor with a permeable base structure, and tunnelling transistors with hot electrons. Problems of degradation and noise in such structures are discussed, and also fields of application of such superfast future devices.

On the whole, the papers collected in this book are devoted to one of the most promising fields of the physics of semiconductors and semiconductor devices, and an acquaintance with them will be useful for a wide circle of specialists in this field.

Translated by G. M. Volkoff

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