Nonlinear optics

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Nonlinear Optics. Materials and Devices: Proceedings of the International School of Materials Science and Technology, Erice, Sicily, July 1–14, 1985/Eds. C. Flytzanis and T. L. Oudar. Springer-Verlag, Berlin; Heidelberg; New York; Tokyo, 1986. pp. 246 (Springer Proceedings in Physics V.7).

During the last quarter century nonlinear optics had so many new optical phenomena added to it that it now represents a broad direction of physical and molecular optics penetrating different fields of physics, technology and materials science.

The present 7th volume of the Springer Proceedings in Physics contains lectures presented at the summer school in Erice in Sicily devoted to nonlinear-optical devices and materials. The book is divided into four parts.

Part I. Nonlinear optics in wave guide structures. The theory of propagation of light in waveguides, the theory of coupled modes and the construction of devices for switching and modulation of different types of interferometers and for transformation of phase into amplitude modulation and a number of other questions are discussed.

The lecture on nonlinear waveguides examines nonlinear generation of waves and, in particular, second harmonic generation, parametric amplification and generation of light, degenerate four-wave interaction, CARS, and also the appearance of nonlinear phase gratings and some of their properties.

The section concludes with a lecture on nonlinear interactions and exciton effects in semiconductors.

Part II. Ultrafast dynamics of charge carriers in semiconductors. The development of the technique of generating short intense light pulses of subpicosecond and femtosecond duration have made it possible to develop methods of investigating the dynamics of nonequilibrium charge carriers in semiconductors. In particular, nonequilibrium relaxation processes of transitions of charge carriers between the conduction band and the valence band are examined.

Generators of light pulses of duration of 27 fs with a pulse repetition rate of 10^8 Hz, and even from 8 to 12 fs with a repetition rate of 10 kHz are being used or are expected to be used in the apparatus described for such investigations.

The lectures describe investigations of the relaxation time of hot carriers in semiconductors in the femtosecond and picosecond ranges of time intervals. A theoretical discussion is given of non-steady-state and nonlinear optical processes in semiconductors, the dynamics of nonlinearity, and also results are discussed of the study of the dynamics of saturation of absorption in a semiconductor in the picosecond and femtosecond time ranges.

Schematic diagrams of experiments are given and discussed as well as the experimental results of investigations of the dynamics of electron-hole luminescence in the picosecond time range.

Part III. Nonlinear optical materials. In four lectures contained in this section problems are discussed of utilizing in nonlinear optics organic materials such as aniline, nitrobenzene and polymers characterized by a high degree of nonlinearity. Values of second-order polarizability are quoted. The preparation of an optical waveguide with an organic crystal core is described as well as the propagation of light and three-wave mixing in such a fiber. Liquid-crystal materials are not discussed in this book. Of particular interest is the lecture devoted to photorefractive crystals in which, because of the high degree of optical nonlinearity, it is possible with relatively weak light to record in real time the amplitudes and phase of wave fronts. Such systems have very diverse applications and, in particular, are effective for reconstruction of wave fronts and recording of various types of information.

In the lecture on the nonlinear optics of surfaces of composite materials a discussion is given, in particular, of such a phenomenon as surface-enhanced Raman scattering by molecules situated on the surface, and a possible explanation of this phenomenon is given. A discussion is also given of the problems of the generation of second harmonic of light by a surface and monolayers, the reconstruction of a wave front, and some other problems of nonlinear optics of surfaces.

Part IV. Optical bistability and instability in nonlinear optical devices. A comprehensive lecture is devoted to a presentation of the phenomenological and microscopic theory of optical bistability characteristic of semiconductors in layers of the type of a Fabry-Perot interferometer.

A discussion is given of experimental results of recent investigations and the possibility of utilizing elements possessing optical bistability, in constructing large fast-acting computer systems.

In another lecture results are presented of an experimental observation of optical bistability due to biexcitons in copper chloride at low temperature placed within a Fabry-Perot interferometer. In both lectures it is pointed out that the use of bistable elements in computer systems promises very rapid action up to 10^{12} operations per second. Finally, the last lecture is devoted to a brief review of the problems of the appearance of instability and a transition to chaos. In the interaction of light beams and nonlinear optics it is well known that when the intensity of light of the nonlinearily interacting light beams is greater than a certain value, instability arises which then leads to chaos.

The lecture examines specific examples of such phenomena. The problem of transition to chaos in nonlinear optics belongs to a number of problems being intensively investigated in recent years.

The book examines pressing problems of contemporary nonlinear optics, and therefore it is of interest for all those who work in this field.

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There are also some lapses in the text of the book; for example, instead of the ratio of two quantities their product is given (p. 186). On some diagrams the notation is missing to which there are references in the text; there are also some other deficiencies.

However, it should be noted that the materials of the school which took place in July 1985 were already published in 1986 and have become accessible to the readers. And this is, perhaps, much better than a carefully published book whose publication is so long delayed that it already becomes obsolete.

Low-energy electron diffraction

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M. A. Van Hove, W. H. Weinberg, and C. M. Chan. *Low-Energy Electron Diffraction: Experiment, Theory, and Surface Determination*, Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo; 1986, pp. 603 (Springer Series in Surface Sciences, V. 6).

Low-energy electron diffraction (LEED) is the principal method used to determine the surface position of atoms. Crystallography of the surface plays a fundamental role in the study of physical and chemical properties of the surfaces of solids. The determination of the structure of the surface on an atomic scale is of great interest for microelectronics, catalysis, corrosion prevention etc.

The first chapter of the book under review emphasizes the importance of studying the crystallography of the surface (the electron and lattice properties of the surface, and also the structures of atoms and molecules adsorbed on the surface), and provides a historical review of the development of LEED.

In Ch. 2 a discussion is given of the apparatus required for studying LEED, and it also contains a review of the experimental methods for measuring different parameters, in particular the Debye temperature.

Chapter 3 is devoted to a general description of the structures of surfaces, to superlattices on the surface, and also to the interpretation of the results of LEED.

In Ch. 4 the kinematic theory of LEED is presented, scattering processes and the influence of temperature are examined, and limitations on the use of the kinematic theory of LEED are indicated.

Chapter 5 describes the dynamic theory of LEED (taking multiple scattering into account). In particular, the transition matrix is evaluated for a number of layers of a periodic lattice.

Chapter 6 is devoted to the application of the kinematic and dynamic theory of LEED to the crystallography of surfaces. A discussion is given on the accuracy of determining a structure with the aid of LEED.

In Ch. 7 results are collected of structural analysis carried out with the aid of LEED (clean restructured surfaces, restructured surfaces, adsorbed layers of atoms and molecules).

In Ch. 8 two-dimensional order–disorder transitions are examined, in particular the interaction of hydrogen with metal surfaces.

Chapter 9 is devoted to the study with the aid of LEED of chemical reactions (for example, between hydrogen and oxygen), occurring on metal surfaces.

In Ch. 10 the formation of islands on the surface is studied with the aid of LEED. The nature of the origin of islands and their ordering is investigated. As an example the formation of CO islands on the (001) surface of Ru is discussed.

Chapter 11 is devoted to the prospects of further development of LEED from the theoretical and experimental points of view, to possible new directions, and to progress in the determination of structures, and also of the connection of LEED with different methods of studying surfaces (scattering of ions, neutron diffraction, electron and scanning vacuum microscopy and other methods).

The book is written in a clear language, can be easily read, is richly illustrated, and contains a sufficiently complete bibliography. On the whole it provides a good idea of the present state of the problem under discussion. The book will be useful to a large number of specialists in solid state physics.