Roland H. Tarkhanyan
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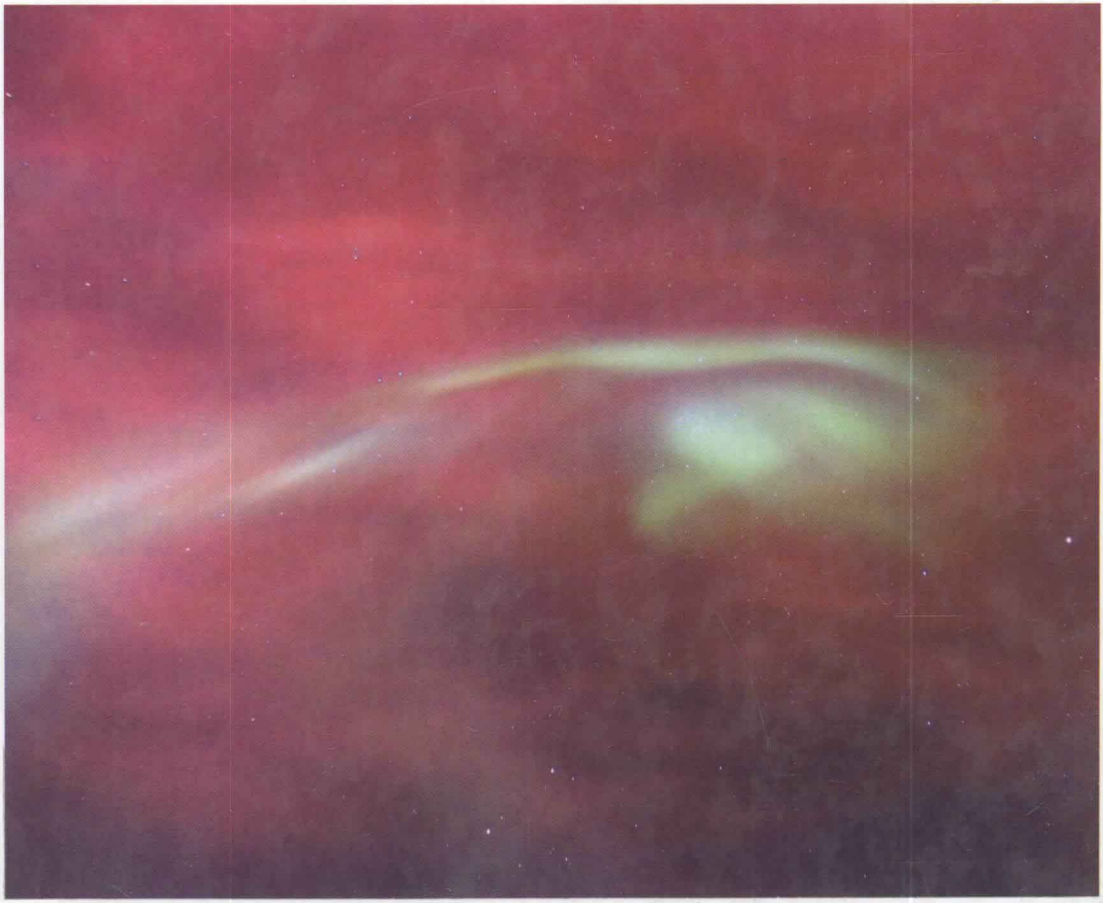
Radiowaves and Polaritons in Anisotropic Media

Uniaxial Semiconductors



Divided into four main sections, this monograph presents the theory of propagation and excitation of volume and surface electromagnetic waves in anisotropic polar and nonpolar conducting crystals, together with the effects of external magnetic and strong electric fields. It also investigates the spectrum of bulk as well as surface phonon-plasmon polaritons in uniaxial semiconductors, as well as electromagnetic instabilities leading to the generation and amplification of radiowaves. Additional topics include total transmission, magnon-plasmon polaritons, and the influence of hot 2D carriers.

This unparalleled systematic treatment includes novel research on special topics in the field, such as the peculiarities of the polaritons in anisotropic semiconductors in the presence of mobile charge carriers.

From the contents:

- Volume Electromagnetic Waves in Anisotropic Crystals with Electronic Plasma
- Surface and Interface Electromagnetic Waves in Semiconductor Structures
- Electromagnetic Instabilities in Uniaxial Semiconductors with Hot Carriers
- Radiation of a Dipole and Propagation of the Guided Electromagnetic Waves in Gyromagnetic Dielectric Medium

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Abstract

A theory of propagation and excitation of volume and surface electromagnetic waves in anisotropic polar and nonpolar conducting crystals is presented. Effects of external magnetic and strong electric fields are considered. The spectra of bulk as well as surface phonon-plasmon polaritons in uniaxial semiconductors are investigated. Effects caused by the interface magnon-plasmon polaritons in layered structures semiconductor/magnetic insulator and superlattices are presented. Electromagnetic instabilities leading to the generation and amplification of UHF radio waves and guided waves in semiconductor heterostructures with hot two-dimensional charge carriers are studied.

A number of original and interesting phenomena are considered which have not been presented in the monographical literature formerly. In particular, the influence of the anisotropy of parameters describing the crystal lattice and free charge carriers on the high-frequency electromagnetic instabilities in semiconductors with positive differential conductivity is investigated. Radiation of a dipole source in the presence of a grounded gyromagnetic slab is studied.

This book is written for specialists in solid-state and semiconductor physics, as well as for electrical and materials engineers, who want to gain a fundamental understanding of the optical properties of anisotropic materials. In addition, it can be useful for students learning applied electrodynamics, crystallooptics and microelectronics.

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Preface

The present book on propagation and excitation of electromagnetic waves in anisotropic conducting media is, in many aspects, different from other books on solid-state physics. First of all, our major interest lies in showing how the anisotropy of parameters describing the crystal lattice as well as the free charge carriers (electrons or holes in semiconductors) cause new physical phenomena which are absent in isotropic media. Second, we give a more detailed description of the interaction of electromagnetic waves (radio waves, millimeter and submillimeter waves, far-infrared radiation) with different vibrational subsystems in anisotropic materials: electronic plasma longitudinal vibrations (in semiconductors), optical phonons (in polar crystals), optical magnons (in antiferromagnetic insulators) and spin waves (in ferrites), as well as the possible combinations of these vibrations (that is, bulk phonon-plasmon and interface magnon-plasmon polaritons). Third, this monograph is not an encyclopedia. The selection of topics is restricted to material which is considered to be essential and which is partly due to our personal inclinations. Fourth, this book is distinctly divided into four self-contained parts which may be read independently. Parts 1-3 are written by R.H. Tarkhanyan and Part 4 by N.K. Uzunoglu.

Part 1 includes more details of volume electromagnetic waves in uniaxial polar crystals with electronic plasma, as well as the influence of an external magnetic field on the propagation and reflection of the waves. Part 2 introduces the reader to the fundamentals of the surface and interface electromagnetic wave theory, in different semiconductor structures. In particular, propagation of the surface waves in a ferrite/semiconductor superlattice at quantum Hall effect conditions is considered. Basic concepts of the electromagnetic instabilities in uniaxial semiconductors with hot carriers are introduced in Part 3. It contains some original results on generation and amplification of the waves and a number of interesting phenomena which have not been presented in monographs yet. For example, instability of the waves in the absence of a falling region in the current-voltage characteristic is considered. In Part 4, radiation of a dipole source in a grounded gyromagnetic slab is considered, using the Green function method.

Finally, this book is written for specialists and postgraduate students in solid-state and semiconductor physics, as well as for engineers, particularly electrical and materials engineers, who want to gain a fundamental understanding of the

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optical properties of anisotropic semiconductor materials and devices. Thus, we tried to bridge the gap between physics and engineering. That is why our book stresses concepts rather than mathematical formalism, which should make the presentation relatively easy to understand. Nevertheless, it is assumed that the reader has taken courses in solid-state and semiconductor physics, classical electromagnetics and crystallooptics. In addition, the reader should be familiar with the necessary mathematics in vector and tensor calculations.

Roland H. Tarkhanyan
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N.K. Uzunoglu received his M.Sc. and Ph.D. degrees in 1974 and 1976 from the University of Essex, UK. Since 1987 he has been Professor at the National Technical University of Athens, Department of Electrical Engineering, where he was elected Chairman twice. His research interests include electromagnetic scattering radiation phenomena, fiber optics telecommunications and high-speed circuits. In 1981 he obtained the International G. Marconi award in telecommunications.

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He has over 200 publications in journals and he has published three books in Greek on microwaves, fiber optics telecommunications and radar systems.

Contents

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Part 1
Volume Electromagnetic Waves in Anisotropic Crystals with Electronic Plasma

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