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Photonic Crystals, Theory, Applications and Fabrication Electromagnetic Theory and Applications for Photonic Crystals Theory and Applications of Liquid Crystals Photonic Crystals Site Symmetry in Crystals Symmetry Relationships between Crystal Structures Photonic Crystals 2D Photonic Crystals Photonic Crystals Photonic Crystals *PHOTONIC CRYSTALS* Photonic Crystals Etching of Crystals *Photonic Crystals* Flexoelectricity in Liquid Crystals Mineralogical Applications of Crystal Field Theory Piezoelectricity: Volume One Photonic Crystals Photonic Crystals Variational Theories for Liquid Crystals *Piezoelectricity* The Static and Dynamic Continuum Theory of Liquid Crystals Liquid Crystals Theoretical Foundations and Application of Photonic Crystals Site Symmetry in Crystals Piezoelectricity: Volume Two *Biaxial Nematic Liquid Crystals* Parametric X-Ray Radiation in Crystals *Excitations in Molecular Crystals Flexoelectricity in Liquid Crystals* Site Symmetry in Crystals Electronic States in Crystals of Finite Size Photonic Crystals: Physics and Technology *Applications of Liquid Crystals* Nonlinear Photonic Crystals Itching of Crystals Theory, Experiment & Application Group Theory in Solid State Physics and Photonics Symmetry, Group Theory, and the Physical Properties of Crystals Excitons in Molecular Crystals; Theory and Applications [by] D. F. Craig [and] S. H. Walmsley *Variational Theories for Liquid Crystals*

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While group theory and its application to solid state physics is well established, this textbook raises two completely new aspects. First, it provides a better understanding by focusing on problem solving and making extensive use of Mathematica tools to visualize the

concepts. Second, it offers a new tool for the photonics community by transferring the concepts of group theory and its application to photonic crystals. Clearly divided into three parts, the first provides the basics of group theory. Even at this stage, the authors go beyond the widely used standard examples to show the broad field of applications. Part II is devoted to applications in condensed matter physics, i.e. the electronic structure of materials. Combining the application of the computer algebra system Mathematica with pen and paper derivations leads to a better and faster understanding. The exhaustive discussion shows that the basics of group theory can also be applied to a totally different field, as seen in Part III. Here, photonic applications are discussed in parallel to the electronic case, with the focus on photonic crystals in two and three dimensions, as well as being partially expanded to other problems in the field of photonics. The authors have developed Mathematica package GTPack which is available for download from the book's homepage. Analytic considerations, numerical calculations and visualization are carried out using the same software. While the use of the Mathematica tools are demonstrated on elementary examples, they can equally be applied to more complicated tasks resulting from the reader's own research. Volume I of this complete, systematic survey by an expert in the field examines the fundamental properties of crystals and various formulations of piezoelectric theory, including production and measurement. 1946 edition. The aim of the work is give an overview of the activity in the field of Photonic Crystal developed in the frame of COST P11 action . The main objective of the COST P11 action was to unify and coordinate national efforts aimed at studying linear and nonlinear optical interactions with Photonic Crystals (PCs), without neglecting an important aspect related to the material research as idea and methods of realizations of 3D PC, together with the development and implementation of measurement techniques for the

experimental evaluation of their potential applications in different area, as for example telecommunication with novel optical fibers, lasers, nonlinear multi-functionality, display devices, opto-electronics, sensors. The book contains contributions from authors who gave their lecture at the Cost P11 Training School. Photonic crystals are a very hot topic in photonics. The basics, fabrication, application and new theoretical developments in the field of photonic crystals are presented in a comprehensive way, together with a survey of the advanced state-of-the-art report. Site Symmetry in Crystals is the first comprehensive account of the group-theoretical aspects of the site (local) symmetry approach to the study of crystalline solids. The efficiency of this approach, which is based on the concepts of simple induced and band representations of space groups, is demonstrated by considering newly developed applications to electron surface states, point defects, symmetry analysis in lattice dynamics, the theory of second-order phase transitions, and magnetically ordered and non-rigid crystals. Tables of simple induced respresentations are given for the 24 most common space groups, allowing the rapid analysis of electron and phonon states in complex crystals with many atoms in the unit cell. The book intends to give a state-of-the-art overview of flexoelectricity, a linear physical coupling between mechanical (orientational) deformations and electric polarization, which is specific to systems with orientational order, such as liquid crystals. Chapters written by experts in the field shed light on theoretical as well as experimental aspects of research carried out since the discovery of flexoelectricity. Besides a common macroscopic (continuum) description the microscopic theory of flexoelectricity is also addressed. Electro-optic effects due to or modified by flexoelectricity as well as various (direct and indirect) measurement methods are discussed. Special emphasis is given to the role of flexoelectricity in pattern-forming instabilities. While the

main focus of the book lies in flexoelectricity in nematic liquid crystals, peculiarities of other mesophases (bent-core systems, cholesterics, and smectics) are also reviewed. Flexoelectricity has relevance to biological (living) systems and can also offer possibilities for technical applications. The basics of these two interdisciplinary fields are also summarized. Contents:Introduction to Flexoelectricity: Its Discovery and Basic Concepts (R B Meyer)Molecular Theory of Flexoelectricity in Nematic Liquid Crystals (M A Osipov)Flexoelectro-optics and Measurements of Flexocoefficients (N V Madhusudana)Flexoelectricity of Bent-core Molecules (A Jákli, J Harden and N Éber)The Role of Flexoelectricity in Pattern Formation (Á Buka, T Tóth-Katona, N Éber, A Krekhov and W Pesch)Flexoelectricity in Chiral Polar Smectics (M Čepič)Flexoelectricity in Lyotropics and in Living Liquid Crystals (A G Petrov)Applications of Flexoelectricity (P Rudquist and S T Lagerwall)Appendix A. Measured Flexoelectric Coefficients of Nematic Liquid Crystals (N Éber)Appendix B. Abbreviations Readership: Graduate students and researchers in physics, biology and their applications. Keywords:Liquid Crystals;Flexoelectricity;Polarization;Nematic;Cholesteric;Smectic;LyotropicKey Features:A gap-filling first comprehensive review of the fieldChapters written by prominent expertsThe book features an interdisciplinary character - physical, biological and application aspectsReviews:"The present book brings together the expertise of a range of authors to provide an understandable, timely and up-to-date account of the topic. One can thus recommend this volume to anyone who is interested in polar effects of liquid crystals, and beyond."Liquid Crystals Today The book intends to give a state-of-the-art overview of flexoelectricity, a linear physical coupling between mechanical (orientational) deformations and electric polarization, which is specific to systems with orientational order, such as liquid crystals. Chapters written by experts in the field shed light on

theoretical as well as experimental aspects of research carried out since the discovery of flexoelectricity. Besides a common macroscopic (continuum) description the microscopic theory of flexoelectricity is also addressed. Electro-optic effects due to or modified by flexoelectricity as well as various (direct and indirect) measurement methods are discussed. Special emphasis is given to the role of flexoelectricity in pattern-forming instabilities. While the main focus of the book lies in flexoelectricity in nematic liquid crystals, peculiarities of other mesophases (bent-core systems, cholesterics, and smectics) are also reviewed. Flexoelectricity has relevance to biological (living) systems and can also offer possibilities for technical applications. The basics of these two interdisciplinary fields are also summarized. The first volume of the book concerns the introduction of photonic crystals and applications including design and modeling aspects. Photonic crystals are attractive optical materials for controlling and manipulating the flow of light. In particular, photonic crystals are of great interest for both fundamental and applied research, and the two dimensional ones are beginning to find commercial applications such as optical logic devices, micro electro-mechanical systems (MEMS), sensors. The first commercial products involving two-dimensionally periodic photonic crystals are already available in the form of photonic-crystal fibers, which use a microscale structure to confine light with radically different characteristics compared to conventional optical fiber for applications in nonlinear devices and guiding wavelengths. The goal of the first volume is to provide an overview about the listed issues. This book is devoted to the description of research and design of photonic crystals. Topics included in the book cover a wide range of research in the field of theoretical analysis and experimental investigation: the electromagnetic field in the photonic crystal, propagation of waves in the gyrotropic magnetophotonic crystals, low

one-photon absorption, ultratransparent photonic crystals, colloidal assembly, photonic crystal application for development of all-optical computational system, design strategies for PC devices, self-organization of liquid crystalline nanostructures, and optical diodes. This book will be useful for engineers, technologists, researchers, and postgraduate students interested in the research, design, fabrication processes, and applications of photonic crystals. The majority of the contributions in this topically edited book stems from the priority program SPP 1113 "Photonische Kristalle" run by the Deutsche Forschungsgemeinschaft (DFG), resulting in a survey of the current state of photonic crystal research in Germany. The first part of the book describes methods for the theoretical analysis of their optical properties as well as the results. The main part is dedicated to the fabrication, characterization and modeling of two- and three-dimensional photonic crystals, while the final section presents a wide spectrum of applications: gas sensors, micro-lasers, and photonic crystal fibers. Illustrated in full color, this book is not only of interest to advanced students and researchers in physics, electrical engineering, and material science, but also to company R&D departments involved in photonic crystal-related technological developments. Nonlinear optical studies of periodic dielectric structures have blossomed in the past two decades. New fabrication techniques are producing fiber grating and multidimensional photonic crystals in materials where the refractive index can be varied by light pulses and beams. Gap solitons that can propagate at any velocity from zero to the speed of light and spatial solitons that prevent the diffractive spread of light in waveguide arrays are two examples of the new phenomena described in this book. Many new materials and structures are being developed that will impact new optical devices with applications in optical communications and optical data processing. All the above topics are addressed in detail in

this book. The history of applications of space group theory to solid state physics goes back more than five decades. The periodicity of the lattice and the definition of a k-space were the corner-stones of this application. Prof. Volker Heine in Vol. 35 of Solid State Physics (1980) noted that, even in perfect crystals, where k-space methods are appropriate, the local properties (such as the charge densi ty, bond order, etc.) are defined by the local environment of one atom. Natural ly, "k-space methods" are not appropriate for crystals with point defects, sur faces and interfaces, or for amorphous materials. In such cases the real-space approach favored by chemists to describe molecules has turned out to be very useful. To span the gulf between the k-space and real space methods it is helpful to recall that atoms in crystalline solids possess a site symmetry defined by the symmetry of the local environment of the atom occupying the site. The site symmetry concept is familiar to crystallographers and commonly used by them in the description of crystalline structures. However, in the application of group theory to solid state physics problems, the site symmetry approach has been used only for the last ten to fifteen years. In our book Methods oj Group Theory in the Quantum Chemistry oj Solids published in Russian in 1987 by Leningrad University Press we gave the first results of this application to the theory of electronic structure of crystals. Defects in Solids, Volume 15: Etching of Crystals: Theory, Experiment, and Application focuses on the processes, reactions, and methodologies involved in the etching of crystals, including thermodynamics and diffusion. The publication first underscores the defects in crystals, detection of defects, and growth and dissolution of crystals. Discussions focus on thermodynamic theories, nature of pit sites, surface roughening during diffusion-controlled dissolution, growth controlled by simultaneous mass transfer and surface reactions, and chemical and thermal etching. The text then examines the theories of dissolution and etch-pit formation

and the chemical aspects of the dissolution process, including catalytic reactions, dissolution of semiconductors, topochemical adsorption theories, and diffusion theories. The book tackles the solubility of crystals and complexes in solution and the kinetics and mechanism of dissolution. Topics include metallic crystals, semiconductors, stability of complexes, relationship between solubility, surface energy, and hardness of crystals, and solvents for crystals and estimation of crystal solubility in solvents other than water. The publication is a dependable source of data for readers interested in the etching of crystals. This book presents an analytical theory of the electronic states in ideal low dimensional systems and finite crystals based on a differential equation theory approach. It provides precise and fundamental understandings on the electronic states in ideal low-dimensional systems and finite crystals, and offers new insights into some of the basic problems in low-dimensional systems, such as the surface states and quantum confinement effects, etc., some of which are quite different from what is traditionally believed in the solid state physics community. Many previous predictions have been confirmed in subsequent investigations by other authors on various relevant problems. In this new edition, the theory is further extended to one-dimensional photonic crystals and phononic crystals, and a general theoretical formalism for investigating the existence and properties of surface states/modes in semi-infinite one-dimensional crystals is developed. In addition, there are various revisions and improvements, including using the Kronig-Penney model to illustrate the analytical theory and make it easier to understand. This book is a valuable resource for solid-state physicists and material scientists. Since it was first published in 1995, Photonic Crystals has remained the definitive text for both undergraduates and researchers on photonic band-gap materials and their use in controlling the propagation of light. This newly expanded and revised

edition covers the latest developments in the field, providing the most up-to-date, concise, and comprehensive book available on these novel materials and their applications. Starting from Maxwell's equations and Fourier analysis, the authors develop the theoretical tools of photonics using principles of linear algebra and symmetry, emphasizing analogies with traditional solid-state physics and quantum theory. They then investigate the unique phenomena that take place within photonic crystals at defect sites and surfaces, from one to three dimensions. This new edition includes entirely new chapters describing important hybrid structures that use band gaps or periodicity only in some directions: periodic waveguides, photonic-crystal slabs, and photonic-crystal fibers. The authors demonstrate how the capabilities of photonic crystals to localize light can be put to work in devices such as filters and splitters. A new appendix provides an overview of computational methods for electromagnetism. Existing chapters have been considerably updated and expanded to include many new three-dimensional photonic crystals, an extensive tutorial on device design using temporal coupled-mode theory, discussions of diffraction and refraction at crystal interfaces, and more. Richly illustrated and accessibly written, Photonic Crystals is an indispensable resource for students and researchers. Extensively revised and expanded Features improved graphics throughout Includes new chapters on photonic-crystal fibers and combined index-and band-gap-guiding Provides an introduction to coupled-mode theory as a powerful tool for device design Covers many new topics, including omnidirectional reflection, anomalous refraction and diffraction, computational photonics, and much more. In the nematic liquid crystal phase, rod-shaped molecules move randomly but remain essentially parallel to one another. Biaxial nematics, which were first predicted in 1970 by Marvin Freiser, have their molecules differentially oriented along

two axes. They have the potential to create displays with fast switching times and may have applications in thin-film displays and other liquid crystal technologies. This book is the first to be concerned solely with biaxial nematic liquid crystals, both lyotropic and thermotropic, formed by low molar mass as well as polymeric systems. It opens with a general introduction to the biaxial nematic phase and covers: • Order parameters and distribution functions • Molecular field theory • Theories for hard biaxial particles • Computer simulation of biaxial nematics • Alignment of the phase • Display applications • Characterisation and identification • Lyotropic, thermotropic and colloidal systems together with material design With a consistent, coherent and pedagogical approach, this book brings together theory, simulations and experimental studies; it includes contributions from some of the leading figures in the field. It is relevant to students and researchers as well as to industry professionals working in soft matter, liquid crystals, liquid crystal devices and their applications throughout materials science, chemistry, physics, mathematics and display engineering. This IMA Volume in Mathematics and its Applications AMORPHOUS POLYMERS AND NON-NEWTONIAN FLUIDS is in part the proceedings of a workshop which was an integral part of the 1984-85 IMA program on CONTINUUM PHYSICS AND PARTIAL DIFFERENTIAL EQUATIONS We are grateful to the Scientific Committee: Haim Brezis Constantine Dafermos Jerry Eri cksen David Kinderlehrer for planning and implementing an exciting and stimulating year-long program. We espe cially thank the Program Organizers, Jerry Ericksen, David Kinderlehrer, Stephen Prager and Matthew Tirrell for organizing a workshop which brought together scientists and mathematicians in a variety of areas for a fruitful exchange of ideas. George R. Sell Hans Weinberger Preface The diversity of experimental phenomena and the range of applications of liquid crystals present timely and challenging questions for

experimentalists, mechanists, and mathematicians. The scope of this workshop was to bring together research workers and practitioners in these areas from laboratories, industry, and universities to explore common issues. The contents of this volume vary from descriptions of experimental phenomena, of which our understanding is insufficient, to questions of a mathematical nature and of efficient computation. Given the widespread interest in macroscopic phenomena in liquid crystals, stemming from their applications in displays and devices. The need has arisen for a rigorous yet accessible text suitable for graduate students, whatever their scientific background. This book satisfies that need. The approach taken in this text, is to introduce the basic continuum theory for nematic liquid crystals in equilibria, then it proceeds to simple application of this theory- in particular, there is a discussion of electrical and magnetic field effects which give rise to Freedericksz transitions, which are important in devices. This is followed by an account of dynamic theory and elementary viscometry of nemantics Discussions of backflow and flow-induced instabilities are also included. Smetic theory is also briefly introduced and summarised with some examples of equilibrium solutions as well as those with dynamic effects. A number of mathematical techniques, such as Cartesian tensors and some variational calculus, are presented in the appendices. Second in two-volume series covers properties and techniques of quartz, Rochelle salt, ferroelectric crystals, various applications of piezoelectricity, pyroelectricity, optical properties of crystals, and atomic theory of piezoelectricicty. 1946 edition. The second edition of this classic book provides an updated look at crystal field theory and its applications. Photonic crystals are a very hot topic in photonics. The basics, fabrication, application and new theoretical developments in the field of photonic crystals are presented in a comprehensive way, together with a survey of the advanced state-of-the-art report. The Only Source

You Need for Understanding the Design and Applications of Photonic Crystal-Based Devices This book presents in detail the fundamental theoretical background necessary to understand the unique optical phenomena arising from the crystalline nature of photonic-crystal structures and their application across a range of disciplines. Organized to take readers from basic concepts to more advanced topics, the book covers: Preliminary concepts of electromagnetic waves and periodic media Numerical methods for analyzing photonic-crystal structures Devices and applications based on photonic bandgaps Engineering photonic-crystal dispersion properties Fabrication of two- and three-dimensional photonic crystals The authors assume an elementary knowledge of electromagnetism, vector calculus, Fourier analysis, and complex number analysis. Therefore, the book is appropriate for advanced undergraduate students in physics, applied physics, optics, electronics, and chemical and electrical engineering, as well as graduate students and researchers in these fields. Covering numerous practical applications as yet not covered in any single source of information, this monograph discusses the importance of viscous and elastic properties for applications in both display and non-display technologies. The very well-known authors are major players in this field of research and pay special attention here to the use of liquid crystals in fiber optic devices as applied in telecommunication circuits. Complete with reference tables and sample problems, this volume serves as a textbook or reference for solid-state physics and chemistry, materials science, and engineering. Chapters illustrate symmetry, and its role in determining solid properties, as well as a demonstration of group theory. Photonic technology promises much faster computing, massive parallel processing, and an evolutionary step in the digital age. The search continues for devices that will enable this paradigm, and these devices will be based on photonic crystals. Modeling is a key process in developing

crystals with the desired characteristics and performance, and Electromagnetic Theory and Applications for Photonic Crystals provides the electromagnetic-theoretical models that can be effectively applied to modeling photonic crystals and related optical devices. The book supplies eight self-contained chapters that detail various analytical, numerical, and computational approaches to the modeling of scattering and guiding problems. For each model, the chapter begins with a brief introduction, detailed formulations of periodic structures and photonic crystals, and practical applications to photonic crystal devices. Expert contributors discuss the scattering matrix method, multipole theory of scattering and propagation, model of layered periodic arrays for photonic crystals, the multiple multipole program, the mode-matching method for periodic metallic structures, the method of lines, the finite-difference frequency-domain technique, and the finite-difference time-domain technique. Based on original research and application efforts, Electromagnetic Theory and Applications for Photonic Crystals supplies a broad array of practical tools for analyzing and designing devices that will form the basis for a new age in computing. Essentially there are two variational theories of liquid crystals explained in this book. The theory put forward by Zocher, Oseen and Frank is classical, while that proposed by Ericksen is newer in its mathematical formulation although it has been postulated in the physical literature for the past two decades. The newer theory provides a better explanation of defects in liquid crystals, especially of those concentrated on lines and surfaces, which escape the scope of the classical theory. The book opens the way to the wealth of applications that will follow. In crystal chemistry and crystal physics, the relations between the symmetry groups (space groups) of crystalline solids are of special importance. Part 1 of this book presents the necessary mathematical foundations and tools: the fundamentals of crystallography with special emphasis on

symmetry, the theory of the crystallographic groups, and the formalisms of the needed crystallographic computations. Part 2 gives an insight into applications to problems in crystal chemistry. With the aid of numerous examples, it is shown how crystallographic group theory can be used to make evident relationships between crystal structures, to set up a systematic order in the huge amount of known crystal structures, to predict crystal structures, to analyse phase transitions and topotactic reactions in the solid state, to understand the formation of domains and twins in crystals, and to avoid errors in crystal structure determinations. A broad range of end-of-chapter exercises offers the possibility to apply the learned material. Worked-out solutions to the exercises can be found at the end of the book. The great interest in photonic crystals and their applications in the last 15 years is being expressed in the publishing of a large number of monographs, collections, textbooks and tutorials, where existing knowledge concerning - eration principles of photonic crystal devices and microstructured ?bers, their mathematicaldescription, well-knownandnovelapplicationsofsuchtechno- gies in photonics and optical communications are presented. They challenges authors of new books to cover the gaps still existing in the literature and highlight and popularize of already known material in a new and original manner. Auth orsofthisbookbelievethatthenextsteptowardswideapplicatio nof photoniccrystalsisthesolutionofmanypracticalproblems ofdesignandc- putation of the speci?c photonic crystal-based devices aimed at the speci?c technicalapplication.Ino rdertomakethisstep,itisnecessarytoincreasethe number of practitioners who can solve such problems independently. The aim of this book is to extend the group of researchers, developers and students, who could practically use the knowledge on the physics of photonic crystals together with the knowledge and skills of independent calculation of basic characteristics of photonic crystals and modeling of various elements of - tegrated circuits and optical

communication systems created on the basis of photonic crystals. The book is intended for quali?ed readers, specialists in the ?eld of optics and photonics, students of higher courses, master degree students and PhD students. As an introduction to the snopest, the book contains the basics of wave optics and radiation propagation in simple guiding media such as planar waveguides and step-index ?bers. This systematic and comprehensive monograph is devoted to parametric X-ray radiation (PXR). This radiation is generated by the motion of electrons inside a crystal, whereby the emitted photons are diffracted by the crystal and the radiation intensity critically depends on the parameters of the crystal structure. Nowadays PXR is the subject of numerous theoretical and experimental studies throughout the world. The first part of the book is a theoretical treatment of PXR, which includes a new approach to describe the radiation process in crystals. The second part is a survey of PXR experimental results and the possible applications of PXR as a tool for crystal structure analysis and a source of tunable X-ray radiation. Essentially there are two variational theories of liquid crystals explained in this book. The theory put forward by Zocher, Oseen and Frank is classical, while that proposed by Ericksen is newer in its mathematical formulation although it has been postulated in the physical literature for the past two decades. The newer theory provides a better explanation of defects in liquid crystals, especially of those concentrated on lines and surfaces, which escape the scope of the classical theory. The book opens the way to the wealth of applications that will follow. Over the past ten years liquid crystals have attracted much interest and considerable progress has been made with respect to our knowledge in this field. The recent development was initiated mainly by the work of J. L. Fergason and G. H. Heilmeier, who pointed out the importance of liquid crystals for thermographic and electro optic applications. The first part of this book is a brief introduction to the

physics of liquid crystals. The structures and properties of the three basic types of liquid crystals are discussed. A special paragraph is devoted to electric-field effects, which are important in display applications. The chapter on Scientific Applications gives an insight into the potential applications of liquid crystals in fundamental research, with special emphasis on explaining the principles involved. Two groups of potential applications are discussed in detail: 1. the use of liquid crystals as anisotropic solvent for the determination of molecular properties by means of spectroscopy, and 2. their use in analytical chemistry, particularly in gas chromatography. The reverse process involves the use of the dissolved molecules as microscopic probes in the investigation of the dynamical molecular structure of anisotropic fluid systems (e.g. biological membranes). This extremely important technique is also described. Photonic Crystals: The Road from Theory to Practice explores the theoretical road leading to the practical application of photonic band gaps. These new optimal devices are based on symmetry and resonance and the benefits and limitations of hybrid "two dimensional" slab systems in three dimensions. The book also explains that they also signify a return to the ideal of an omnidirectional band gap in a structure inspired by and emulating the simplicity of two dimensions. Finally, the book takes a look at computational methods to solve the mathematical problems that underlie all undertakings in this field. Photonic Crystals: The Road from Theory to Practice should rapidly bring the optical professional and engineer up to speed on this intersection of electromagnetism and solid-state physics. It will also provide an excellent addition to any graduate course in optics.

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