Preface

This is the first volume of a set of three within the Springer Series in Optical Sciences, and is devoted to photorefractive effects, photorefractive materials, and their applications. Since the publication of our first two Springer books on Photorefractive Materials and Their Applications (Topics in Applied Physics, Vols. 61 and 62) almost 20 years ago, a lot of research has been done in this area. New and often expected effects have been discovered, theoretical models developed, known effects finally explained, and novel applications proposed. We believe that the field has now reached a high level of maturity, even if research continues in all areas mentioned above and with new discoveries arriving quite regularly.

We therefore have decided to invite some of the top experts in the field to put together the state of the art in their respective fields. This after we had been encouraged to do so for more than ten years by the publisher, due to the fact that the former volumes were long out of print.

This first volume is devoted to the description of the basic effects leading to photoinduced refractive index changes in electro-optical materials. As is commonly known, this photorefractive effect was originally discovered as undesirable optical damage in nonlinear and electro-optical crystals. Light- induced changes of the refractive index limited the usefulness of crystals such as $LiNbO_3$ with large electro-optic and nonlinear optical coefficients, because the index changes give rise to decollimation and scattering of laser beams in devices such as modulators and frequency doublers. Subsequently, materials exhibiting such an optical damage effect—later called the photorefractive effect—were proposed as holographic materials and when faster recording materials became available as dynamic holographic materials used for beam amplification, real-time interferometry, optical phase conjugation, and image processing applications. This class of photoinduced mechanisms has contributed to establish the link between the fields of nonlinear optics and coherent Fourier optics.

The optically induced refractive index changes are generally explained in the following way: When light of a suitable wavelength is incident on a crystal, photoelectron holes or ions are generated, which then migrate in the lattice and are subsequently trapped at new sites. The resulting space charges give rise to an electric field strength distribution in the material that changes the refractive index via the electro-optic effect.

This first volume gives a comprehensive treatment of several aspects of photorefractive effects. Besides the detailed description of the photoinduced refractive index changes observed in anisotropic media, newer effects such as the effects of photoinduced space charge waves, feedback controlled grating recording, the description of spatiotemporal instabilities, and self-organized optical pattern formation by self-induced refraction index gratings are covered. Special recording methods by band-to-band photorefraction or two-step recording are topics of two other chapters. The observation and theoretical description of dark and bright solitons induced by the photorefractive effect is another exciting, novel phenomena described in this volume. The status of research in thermally or electrically fixing photoinduced gratings by ionic charge transport and thermal treatment, or by domain reversal, is described in two chapters of this book.

The volume reviews the present understanding of the fundamental origins of the effect in a variety of materials from ferroelectrics, compound semiconductors to polar organic crystals and polymers. The parameters that enter into the design of optimized materials are described and these parameters will be further discussed in Volume 2, which will deal with 'materials.'

The different beam interactions, self-induced optical effects, grating fixing mechanisms, and so on that form the basis of the applications described in detail in Volume 3 are also treated.

The three volumes on photorefractive effects, materials, and applications have been prepared mainly for researchers in the field, but also for physics, engineering, and materials science students. Several chapters contain sufficient introductory material for those not so familiar with the topic to obtain a thorough understanding of the photorefractive effect. We hope that for researchers active in the field, these books should provide a useful reference source for their work.

We would like to thank all authors of chapters for their great efforts in presenting attractive overviews of the topics they present in this book. We are very much indebted to Mrs. Lotti Nötzli for her great administrative support. We also acknowledge the efforts of Dr. Hans Koelsch of Springer and his team who made a great effort in efficiently producing this first volume.

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