Book Reviews

NLO, SiN, GaAs, CVD, Acronyms, and Abbreviations

Photorefractive Materials and Their Applications I: Fundamental Phenomena. By *P. Guenter* and *J.-P. Huignard.* Springer-Verlag, Berlin 1988. xvi, 295 pp., hard cover, DM 119. –ISBN 3-540-18332-9

The field of nonlinear optics has received quite a dramatic increase in interest lately from research groups both in industry and in academia. This development was initiated in the mid-seventies when it was recognized that reversible laser induced material changes, as observed in nonlinear optics, can actually be utilized to modify and process one light beam with another. Applications in optical signal processing, optical computing and realtime holography became feasible, and widespread technical use of the effects in image processing and fiber-optic switching can be envisaged in the not too distant future.

Photorefractive materials have played a key role in these developments and many important demonstrations of principles have been made with photorefractive crystals, e.g. in phase conjugation, pattern recognition and neural optical processing. The photorefractive effect is generally observed in doped inorganic single crystals, mainly $LiNbO_3$, $BaTiO_3$, $Bi_{12}SiO_{20}$, $KNbO_3$, InP or GaAs. Its main virtue is that relatively low light powers can induce large material changes, sources being for example helium–neon, diode or small argon lasers, at the expense, however, of relatively slow response times (milliseconds to hours). Being a rather complicated multistep process, the photorefractive effect was subject to a substantial body of material-centered research which is reviewed in this volume.

Generally the following sequential steps are involved: excitation of charge carriers from impurity centers upon light absorption, migration of these carriers to other impurities outside the illuminated area, and trapping there. The resulting space-charge field changes the refractive index via the electro-optic effect and hence modifies the optical properties of the material. Several theoretical models for this effect have been developed, with the band transport model of *N. V. Kukhtarev* being currently the most versatile and widely used.

The editors, both leading European researchers and pioneers in the field, have brought together a well balanced mixture of articles (four from the USA, two from the USSR and three from Europe) covering virtually all aspects of the above described process. After a very brief introduction, they summarize effects and materials mainly from an experimental point of view. A detailed treatment of the photorefractive effects in dielectric crystals by *G. Valley* and *J. Lam* follows, and all theoretical aspects of the band transport model are very clearly described by *N. V. Kukhtarev.* He also demonstrates the predictive power of his model. Spectroscopic investigations of photorefractive centers using optical techniques as well as ESR and Mössbauer spectroscopy are reviewed by *E. Kraetzig* and *O. F. Schirmer. R. A. Mullen* presents justification for the charge hopping model, which is the main theoretical model competing with the band transport model, and outlines boundaries between both descriptions as she summarizes the measurement of physical parameters of the material.

The following two articles describe two specific classes of photorefractive materials in more detail. *M. B. Klein* summarizes the properties of $BaTiO_3$, the material with the largest known photoinduced refractive index changes. The study of this material has been restricted to relatively few groups due to the difficulties in obtaining poled single crystals of good optical quality. A relatively recent development (since 1984) are photorefractive semiconductors which are reviewed by *A. M. Glass* and *J. Strait.* GaAs-Cr and InP-Fe are particularly interesting as they operate in the near infrared, close to the wavelengths of interest for fiber optic communications.

Finally, *S. I. Stepanov* and *M. P. Petrov* describe moving photoinduced gratings and their applications in coherent amplification and phase conjugation, leading naturally to the second volume of the series which is on applications of photorefractives. In reading the book, it becomes apparent that most of the research is actually prompted by the applications, and therefore the separation between materials and applications seems artificial in many places. The general level of understanding reached at the time of writing (late 1987) is such that the development of new improved photorefractive materials can be expected. New centers and host crystals should be predictable, and photorefractive organic polymeric composites seem also feasible in the view of the authors.

The reading of the book requires a fundamental knowledge of solid state physics, as well as some classical background in holography, image processing, phase conjugation or nonlinear optics. To this end the previous reading of selected chapters of the book "Laser-induced Dynamic Gratings" co-authored by *P. Guenter* (Springer Ser. Opt. Sci. Vol. 50) might be beneficial, especially to the inexperienced reader.

General conclusions: a very thorough overview from a materials point of view, quite complex in places, mainly for researchers entering or already active in nonlinear optics or related fields. The book is likely to become a standard reference for further research on photorefractive effects and materials.

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