Engineering of photorefractive polymers
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Active subjects in optical computing
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The situation of optical computing has changed dramatically over the last few years because of the development and availability of at least three complementary technologies that now open the way to applications to the parallel processing of information.

The well known generation of nematic liquid crystal devices is now being complemented by the fast ferroelectric devices. (See the talks by W. Crossland in this topical meeting and by L. de Buigne in topic area 11.) Both optically addressed and electrically addressed light valves are commercially available, with switching times of the order of 10 μs. Considering the large parallelism that they offer, their computing throughput is significant.

The development of compound semiconductor device technology is getting close to the level of integration, sophistication, and energy efficiency required for applications. One leading figure in the field is the self electro-optic device (SEED) which is now a commercially available component that offers optical nonlinearity on an array of sites; recent developments include the combination of electronic functions with SEED devices into “smart pixel arrays.” (See the talk by F. C. McCormick in this topic area.) Another recent example that is legitimately receiving significant attention at this meeting is the ppn photothyristor array. (See the contributions by P. Heremans, G. Borghs, and co-workers in this topic area.)

The photorefractive effects in sili-}

CThL1 (Invited) 1500
Engineering of photorefractive polymers
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Photorefractive polymers offer advantages such as their considerable flexibility in synthesis, doping, processing, and low cost. Furthermore, compared to their crystalline counterparts, they offer the possibility of improved value in the photorefractive index change figure-of-merit n′/ε′, owing to the small dielectric constant ε′ and reasonable linear electro optic coefficient r and refractive index n.

The required functionalities responsible for photorefractivity, namely charge generation, transport, trapping, and linear electrooptic effect are given in the polymer with the addition of specific molecules or monomer. In this way, engineering of the properties of a photorefractive polymer is possible. For a specific application can be done via chemical synthesis.

We have investigated both host-guest (e.g. photocconducting polymers like PVK-TNF doped with electrophoic molecules or electrooptic polyurethanes doped with charge transporting molecules like DEH and sensitizers like TNF and CD8) and single component (where all the necessary functional components are covalently bonded on the same polyurethane backbone) polymer materials. Various trade-offs that exist in photorefractive polymers have been characterized. In other words, the future of optical computing may lie in parallel vision machines and the potential markets for such a machine are obviously significant.

Assuming progress on active devices and on system definition, the practical integration of these systems remains a major challenge. Modern solutions include the etching of arbitrary interconnect functions using diffractive optics and total internal reflection imaging and the standardization of micro lens array and beam splitter array fabrication techniques.

CThL 1500
Room B
Photorefractive Materials
V. Shkunov, Institute for Problems in Mechanics, Russia, President
based materials that can sustain a permanent effect in a polymer, a noncentrosymmetric arrangement of the electrooptic molecules should be achieved. For this reason, the noncentrosymmetric response in the visible is preferable. These molecules relax in a centrosymmetric arrangement when this field is switched off. We have prepared a novel class of single component polyurethane-based materials that can sustain permanent orientation of the electrooptic molecules and studied its photorefractive properties.


CThL2 1530

Electro-optic, dielectric, and elastic-optic properties of photorefractive BaTiO3 crystal

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Measurements on high quality samples of top-seeded-solution-grown crystal BaTiO3 have been performed in order to complete the set of data, which is necessary to describe the electrooptic response of this material to electric fields and elastic deformation. Improvements in the accuracy of some previously published results could be obtained because of better optical quality and larger size of the crystal samples that are available nowadays. The most important results are the values and the signs of the piezoelectric coefficients d33 and d31, the absolute values of the elastic-optic coefficients, and all the electro-optic measurements. Both low frequency electro-optic measurements in a stress-free sample and the measurements in an ionised sample using a step-like electric field were used to correct the previous results. The complete set of material parameters of the BaTiO3 crystals at room temperature has been afforded by a numerical fitting procedure. The signs of the electro-optic coefficients could also be determined with great confidence. We propose that the new calculated values are used as a starting point for future measurements of the BaTiO3 material, in particular for describing its photorefractive properties, that is, to calculate its effective electro-optic and elastic properties.

In order to demonstrate the benefits of the newly determined complete set we calculate effective electro-optic coefficients and dielectric constants of BaTiO3 in photorefractive experiments, where the elastic deformations associated with a periodic space-charge field have to be considered. We show that a complete knowledge of the material parameters of a photorefractive crystal is necessary. The newly determined values for the effective electro-optic and effective dielectric constants of barium titanate for the most common photorefractive geometries are considerably different from the values that have been used until now.


CThL3 1545

Shallow trap modelling of infrared sensitive BaTiO3

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Recent interest in photorefractive BaTiO3 has turned toward near infrared wavelengths compatible with solid-state laser diodes. The demonstration of applications, such as diode injection locking and brightness enhancement in this region of the spectrum using modest laser powers has renewed interest in the ferroelectric material.

Infrared sensitive BaTiO3 has been reported recently using crystals, blue in colour, which possess enhanced absorption in the red and near infrared regions of the spectrum. Although the impurity responsible for the blue colour and enhanced photo-refractive behaviour was unknown at the time, recent attempts to identify the dominant photorefractive centre has suggested rhodium (in the valence states RhVII/RhVI) may be responsible.

The single level band transport model most commonly used to describe photo-refractive behaviour has, despite its simple nature, met with considerable success in explaining many of the photo-refractive effects observed. However, in order to account for more complex photorefractive phenomena, such as sublinear two beam coupling response time and intensity dependent absorption, model refinements have been suggested including the introduction of additional levels closer to the conduction (or valence) band edge. The addition of these shallow traps is of concern for longer wavelength infrared compatible photorefractive crystals where the lower energy photons are capable of photoexcitation. The model (illustrated in Fig. 1) assumes that the photoexcitation coefficient for both deep and shallow traps is wavelength dependent. Numerical modelling of the shallow trap rate equations has allowed various parameters to be derived from the experimental points measured at infrared, red, and blue wavelengths.

Photoinduced absorption was assessed by measuring the transmission of an o-polarised HeNe (633 nm) beam through the blue crystal (dimensions 7.27 × 3.01 × 5.64 mm3 with the crystal c-axis parallel to the 5.64 mm edge). The observed changes in the apparent absorption through the 3.01 mm thickness were characterised by an initial rapid decrease followed by a slow recovery (a few seconds) consistent with previous observations. The timescale of the process was intensity dependent: occurring faster for higher intensities. Figure 2 shows a plot of the maximum change in the absorption with the logarithm of the incident HeNe intensity. The graph indicates an apparent intensity dependence of the absorption. The solid line shown in Fig. 2 is the best fit curve using the numerical simulation of the shallow trap model.

In addition to intensity induced transparency, light induced absorption has also been observed. The crystal was first exposed to a 1-mm-diameter, 6.7-mW o-polarised HeNe laser beam—the intensity of which remained constant throughout the experiment near the saturation limit according to Fig. 2. The transmission of the HeNe beam was then monitored.