Engineering of photorefractive polymers
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Published in:
Conference on Lasers and Electro-Optics Europe, 1994


**CThK3 (Invited) 1600**

**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 large data. The well known generation of nematic liquid crystal devices is now being complemented by the faster ferroelectric devices. (See the talks by W. Crossland in this topic area and by J. L. de Bougrenet (SEED) family, at present the only commercial application of optical computing devices is legitimation receiving significant attention.) Another recent example that is presently being developed is the photorefractive B.C. T. in which the required functionalities are implemented in FET-SEED technology. This approach is particularly interesting because it can be used for photoreactivity, 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 and optimization for a specific application can be done via chemical synthesis.

We have investigated both host-guest (e.g., photoconducting polymers like PVK-TNF doped with electrooptic molecular or electrooptic polyurethanes doped with charge transporting molecules like DEH and sensitizers like TNF and C60) 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 exploited and optimized for specific application. All the photorefractive polymers have been reported to show net gain and subsecond response at various laser lines in the visible part of the spectrum. With the proper selection of the functional components, we have made host-guest polymers optimized to show net gain and subsecond response at various laser lines in the visible part of the spectrum. This is especially important, as in order to be advantageous for...
applications, a photorefractive material should have a large range of wavelengths where it can be used. Especially where information storage density is concerned, response in the visible is preferable.

In order to maintain the photorefractive effect in a polymer, a noncentrosymmetric arrangement of the electrooptic molecules should be achieved. For this reason, the intrinsic response of an external electric field is necessary, as these molecules relax in a centroymmetric 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. We have prepared a noncentrosymmetric arrangement of the electrooptic molecules 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 elastooptic 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 $d_{31}$ and $d_{33}$, the absolute values of the electrooptic coefficients, and all the electroo-optic measurements. Both low frequency electrooptic measurements in a stress-free sample and the measurements in a strain-stressed 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 achieved using a numerical fitting procedure. The signs of the electrooptic coefficients could also be determined with great confidence. We propose that the new calculated values are used as a reference for the material parameters of the BaTiO3 crystal, in particular for describing its photorefractive properties, that is, to calculate its effective electroopto and dielectric properties.

In order to demonstrate the benefits of the newly determined complete set we calculate effective electrooptic 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 electrooptic 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 photorefractive behaviour was unknown at the time, recent attempts to identify the dominant photorefractive centre has suggested that rhodium (in the variscite structure $Rh^3+/Rh^4+$) may be responsible.

The single level band transport model most commonly used to describe photorefractive behaviour has, despite its simple nature, met with considerable success in explaining many of the photorefractive 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 wavelengths 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 $7.27 \times 3.01 \times 5.64$ mm$^3$ 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.