Photorefractive Nonlinear Optics

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Special issues on photorefractive materials, effects, and devices have routinely appeared throughout the last three years in the *Journal of the Optical Society of America B*. A multitude of papers on photorefractives are also presented at various conferences, namely those organized by SPIE, CLEO, OSA, as well as the Nonlinear Optics Meeting in Hawaii, and most recently, the Photorefractive Materials, Effects, and Devices Conference in Colorado. As more novel photorefractive materials are developed and their applications in various areas of applied optics become more common, it is imperative that readers of *Optical Engineering* get a chance to grasp some of the fundamental concepts, as well as acquaint themselves with existing and proposed applications.

The special section on photorefractive nonlinear optics in this issue is a sample of ongoing work in the field, and is by no means exhaustive. The 11 papers in this special section have contributions from some of the most prominent researchers in the area. Four of the papers, by Hong et al., Volodin et al., Yeh et al., and Yu and Yin, are invited contributions,[1] while the rest are contributed papers.

Many photorefractive materials are well suited for dynamic storage of volume holograms. The first paper, by Hong et al., provides a comprehensive review of volume holographic memory systems, and examines the role of photorefractive media and their impact on system design, including the recent developments at Rockwell. Yeh et al. describe a procedure for the restoration and enhancement of decaying holograms stored in photorefractive materials. One reason for the decay of a stored hologram is optical erasure during subsequent recordings or during readout. The discovery of highly efficient new materials is likely to revolutionize dynamic holography. Contrary to photorefractive crystals that are conventionally used for hologram storage, Volodin et al. describe a photorefractive polymer composite based on photoconductor poly-(N-vinylcarbazole) with a suitable doping to make the material photosensitive to visible light, in which a high light-induced refractive index (of the order 10^{-2}) can be achieved.

Other applications of photorefractive materials are in the area of image processing, namely, convolvers and correlators. While thick crystals are promising in large storage capacity memory applications, they impair the shift-invariant properties of photorefractive-based correlators. Yu and Yin show that of the various correlator geometries, the reflection type correlator performs the best in terms of shift tolerance. Also, in photorefractive-based optical correlation schemes, matched filters often need to be stored in the photorefractive material. The storage is subject to some of the same dynamic range limitations common to photographic emulsions. The paper by McMillen et al. explore a simple method for distributing the spectra more evenly through the photorefractive crystal by using a phase diffusing screen.

Evaluation of photorefractive materials in an important area required to assess their feasibility in applications, such as those mentioned previously. McMillen et al. study the anomalies of photovoltaic current (responsible for the photorefractive effect) in Ce:Fe-doped lithium niobate at different temperatures through a two-wave mixing experiment. Zhao et al. extend the evaluation of the material through a study of nondegenerate four-wave mixing and show enhanced performance at elevated temperatures of about 120°C. Malowicki et al. propose a scheme of characterizing the optical nonlinearity of a Ce-doped KNSBN crystal using the z-scan method, which is commonly used to measure the nonlinear refractive index and nonlinear absorption coefficients.

Hand in hand with experimental work in photorefractives, there is a lot of activity in modeling photorefractive materials and experimental observations in the open literature. This special section contains a paper by Banerjee and Jarem, who use a rigorous coupled wave theory to analyze two- and multiple-wave mixing photorefractive barium titanate, modeled through the Kukhtarev equations.

Even though the photorefractive effect is about 25 years new, novel effects and applications are still being discovered. Kukhtarev et al. discuss the novel phenomenon of linear and nonlinear hexagonal pattern generation using photorefractive potassium niobate, and investigate its storage and recall properties. Also, Kamra and Singh find a novel use for beam fanning in photorefractive barium titanate as a logarithmic optical processor, which is expected to find applications in joint transform correlation and logarithmic filtering.

I hope this special section will stimulate further interest among readers of *Optical Engineering* in novel photorefractive materials, their modeling, and applications. I look forward to many more papers in this area in *Optical Engineering* in the years to come. I would like to thank Dr. Brian Thompson for *inviting* me to put forth this special section,[1] all the staff at *Optical Engineering*, and all the contributors. Finally, I would like to acknowledge the help of all the reviewers, without whom this special section could not be published in time.

References

1. B. J. Thompson, "The anatomy of an invitation," *Opt. Eng.* **34**(4), 957 (1995).

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