Scanning the Issue

Special Issue on Photorefractive Materials, Devices, and Applications, Part I: Optical Effects and Memories

Photorefractive optics has been known as one of the interesting optical phenomenon in some electrooptic materials for which the local refractive index can be recorded by the interference of light beams. Since the discovery of the photorefractive effect in the 1960's, it has become a widely used nonlinear-optic material for photonic applications. Nevertheless, photorefractive effect is derived from the optically generated charge carriers. In turn, a space-charge field is then created by drifting and diffusing of these carriers which induce a refractive index change in the material. The space-charge field that induces the refractive index changes in the crystal is known as the Packels effect or electrooptic effect.

Photorefractive materials are, in fact, the most efficient materials for encoding volume holograms that offer significant application to high-density optical memories. Aside from this potential application, the unique property of nonreciprocal energy transfer of photorefractive optics can also offer many other applications such as photorefractive resonators, self-pumped phase conjugators, optical interconnects, conjugate interferometry, laser beam cleanup, and others. It is not possible, however, to cover all the possible applications of photorefractive optics in one special issue. The contents of this special issue were contributed by the world authorities of this field.

In this Special Issue (Part I of II), the first paper, by Kukhtarev *et al.*, provides a unified treatment of photorefractive optics. They have analyzed the dynamic and static behaviors using the coupled wave theory and nonlinear Kukhtarev equations, such that the self-diffraction and phase conjugation phenomena can be obtained. This paper is in fact a leading article which provides the basic and fundamental theory of photorefractive optics.

The second paper, by Banerjee and Jarem, uses the coupled wave theory to analyze the induced transmission and reflection grating within a photorefractive crystal. Starting from a simplified model, they used the famous Kukhtarev equations to investigate the time evolution of the recorded gratings that is resulting from diffraction.

The third paper, by Khoo *et al.*, provides the basic mechanisms of photo-induced space charge field formation within a dye-doped nematic liquid crystal. In particular, within an aligned methyl-red-doped nematic liquid crystal film, they have observed a nonlinear index change coefficient, which can be as high as 10 cm^2/W.

Holography is one of the most important discoveries in the twentieth century, and it is one of the significant pillars for the application to optical memory. The fourth paper, by Yi *et al.*, has investigated the crosstalk phenomenon in a volume holographic memory. They have presented a thorough analysis on the crosstalk noise limitation in a multiplexed volume holographic memory. They have shown that crosstalk noise also occurs due to the expansion and shrinkage of the material. Several interesting holographic configurations, as proposed by the authors, can minimize the crosstalk.

One of the interesting applications of photorefractive memory may be the random access capability as proposed by Chuang *et al.* in their paper. They have shown that a photorefractive random access memory system can be developed. Although the realization of such a system is difficult, it is possible to construct in a few years.

Application of phase code to a three-dimensional (3-D) memory is advocated by Yang and Jutamulia in their paper. This article reviews the recent development of the 3-D holographic memory using phase-code approach. They have proposed a generalized Hadamard phase code for the 3-D memory to ensure the full use of the pixel elements in a spatial light modulator.

The possibilities of realizing super-resolution holographic memory is advocated by Mikaelian *et al.* They have shown that it is possible to record a Fourier microhologram of limited spatial spectrum in relation with the first-zero crossing. Their configuration has shown that the recording density over 109 bits/cm^2 in the two-dimensional (2-D) layers can be achieved in practice.

Another form of photorefractive optics is the photorefractive fiber, as demonstrated by Yin. He has shown that single crystal photorefractive fibers can be grown by a laser heated pedestal growth system. By using a counter propagating encoding technique, he has shown that wavelength multiplexed holographic data can be recorded in a photorefractive fiber. He has further shown that the photorefractive fibers can be applied to fast turnable filters,

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picosecond true time delay line, and high-gain microchannel plates spatial light modulators.

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Dr. Yu is a recipient of the 1983 Faculty Scholar Medal for Outstanding Achievement in Physical Sciences and Engineering, a recipient of the 1984 Outstanding Researcher in the College of Engineering Award, was named Evan Pugh Professor of Electrical Engineering in 1985 at Penn State, a recipient of the 1993 Premier Research Award from Penn State Engineering Society, was named Honorary Professor in Nankai University in 1995, and is the co-recipient of the 1998 IEEE Donald G. Fink Prize Paper Award. He is a Fellow of the Optical Society of America and SPIE.