Investigation of Photorefractive Waveguides Fabricated by Excimer Laser Ablation and Ion-Implantation.

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The fabrication of thin films optical waveguides of photorefractive materials is particularly desirable for applications in integrated optics. It is also of interest because the guided-wave intensity-length product can be considerably larger than in bulk media because of the optical confinement within the waveguide. The increased intensity-length product may therefore allow much faster response times than in the bulk (typically by a factor of $\approx 10^3$-10^4). Thin crystalline films can be fabricated by a variety of techniques such as RF sputtering, flash evaporation, molecular beam epitaxy and liquid phase epitaxy. However, the films grown are often of the incorrect (or variable) composition and phase and are rarely of good optical quality. We discuss here two methods that we have investigated for producing optical waveguides in several different photorefractive materials.

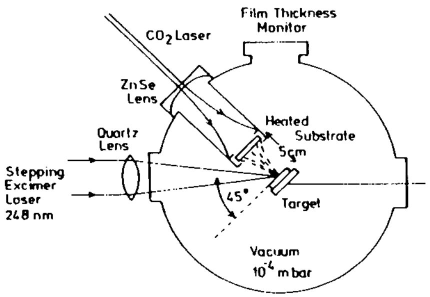

Figure 1. Experimental arrangement for excimer laser ablation.

Laser ablation provides a simple and convenient method for depositing films of a wide range of materials which allows the stoichiometry of a single target to be easily reproduced at the substrate. The experimental arrangement used to deposit such films is shown in figure 1. We report the growth of waveguides of the photorefractive material $Bi_{12}GeO_{20}$ by the technique of excimer laser ablation. Using x-ray diffraction these films have been shown to be epitaxial crystalline layers of [310] orientation and of the correct stoichiometry and phase. Two waveguide modes (one TE and one TM) have been observed using the arrangement in figure 2, corresponding to effective waveguide refractive indices of 2.40 and 2.37 respectively[1].

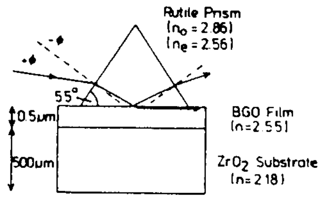

Figure 2. Arrangement for Prism Coupling Light into a Waveguide.

Secondly, work on waveguides formed by H^+ and He^+ ion-beam implantation of bulk crystals of $Sr_xBa_{1-x}Nb_2O_6$ is also presented. Ion-beam implantation is an established technique for fabricating waveguides of depth in the range 1μm to 20μm, via refractive index variations produced in the material due to interactions with the crystal lattice. Typically a barrier layer of lower refractive index occurs (see figure 3), which allows optical confinement within the waveguide layer[2]. Photorefractive two-beam coupling, degenerate four-wave mixing and limited experiments on self-pumping, have been undertaken in Ce-doped crystals of SBN:52 and SBN:65, in multimode waveguides of typical dimensions of between 4μm and 15μm. Results so far demonstate that although problems may exist concerning changes to the bulk electro-optic coefficient, and anisotropic absorption may be induced via the ion-beam implantation process, the technique can provide a useful means of achieving speed-up effects, via local intensity increase characteristic of the photorefractive nonlinearity.

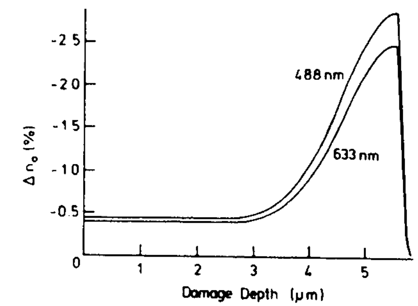

Figure 3. Refractive index profile for the ordinary ray in a He^+ implanted waveguide.

We present results on the above techniques, and discuss the applications of such waveguide materials in the context of real-time integrated optical configurations.

[1] Epitaxial growth of $Bi_{12}GeO_{20}$ Thin Film Optical Waveguides Using Excimer Laser Ablation. K.E. Youden, R.W. Eason, M.C. Gower. Submitted to Appl. Phys. Letts.
[2] Optical Effects of Ion Implantation. P.D. Townsend. Rep. Prog. Phys. **50** (1987) 501-558.