Competition Between the Absorption and Refractive index gratings on the Beam Coupling in Bi_{12} TiO_{20} employing a Vector approach.

González-Trujillo M.A.[1], I. Casar[2], J. G. Murillo[3], Farías J. Rurik[3]

[1]ESCOM-IPN, UPALM, Zacatenco, México D.F. 07738, México; [2]Instituto de Física, Universidad. Nacional Autónoma de México, Apartado Postal 20-364, México Distrito Federal, Código Postal 0100 México; [3]Centro de Investigación en Materiales Avanzados S.C., Miguel de Cervantes 120, Complejo Industrial Chihuahua, México; e-mail: jose.murillo@cimav.edu.mx.

Abstract: Employing a tensor approach, numerical simulations of beam coupling in the photorefractive recording in $Bi_{12}TiO_{20}$ were made. The competition between the refractive index and the absorption gratings at high modulation depth was studied.

OCIS codes: 050.2770; 050.5080.

1. Introduction

We studied the characteristics of the simultaneous recording of an absorption grating α and a refractive-index grating Δn in a $Bi_{12}TiO_{20}$ (BTO) crystal under a non-linear regime (high modulation; m_o=0.9 and an applied electric field 10 kV/cm). A two wave mixing self-consistent tensor approach was employed considering complex amplitudes, and coupling functions as well as the spatial non-uniformity of the recorded refractive index grating along beam propagation. Optical activity as well as birefringence was taken into account for the Kg // [001] configuration.

2. Coupled Wave Equations

We simulated the non-uniformity of the grating along beam propagation by solving numerically, until steady state was reached, the set of non-linear material rate equations [1]. With this we obtained the complete space charge field without approximations for several values of light modulation. Then using a tensor approach we described the variation of the four complex amplitudes (R_E, R_M,S_E,S_M) of the optical waves (I_R,I_S) along sample thickness (z) by solving the two wave mixing (TWM) equations [2].

Optical activity, birefringence, and two different complex coupling factors k_1 and k_2 that include the amplitude and phase of the refractive index ($\Gamma_{\Delta n}$, $\Phi_{\Delta n}$) and the absorption gratings (α, Φ_α) were taken into account:

$$k_1(z) = i(\Gamma_{\Delta n}(z)e^{i\Phi_{\Delta n}(z)} - i\alpha e^{i\Phi_\alpha(z)}) \qquad \text{and} \qquad k_2(z) = i(\Gamma_{\Delta n}(z)e^{-i\Phi_{\Delta n}(z)} - i\alpha e^{-i\Phi_\alpha(z)})$$

$$\Gamma_{\Delta n}(z) = \frac{\pi\Delta n(z)}{\lambda\cos(\theta)} = \frac{\pi n_0^3 r}{2\lambda\cos(\theta)} * \frac{|E_1(z)|}{|m(z)|} e^{i\Phi_g} m(z) \qquad m(z) = \frac{R_E(z)S_E(z)^* + R_M(z)^* S_M(z)}{I_0}$$

Where k_1 and k_2 are defined in terms of the change of the refractive index Δn, the wave-length of writing light beams λ, the incidence angle θ, the average refractive index n_o and the effective electrooptic coefficient r. E_1 is the Fourier first component of the space charge field and $m(z)$ is the modulation depth, which is a function of thickness sample z.

Numerical solutions for the TWM equations were obtained in a self-consistent manner to account for the spatial non-uniformity of the grating along sample thickness. The evolution of the phase and amplitude of the refractive index and absorption gratings were calculated along z for different phase shifts of the grating ϕ_g, applied fields and absorption coefficients.

3. Results

We found that the non-uniformity of the grating considered in this work induces remarkable changes on the variation of the relative phase between the absorption grating Φ_α and the index-refractive grating $\Phi_{\Delta n}$ along the sample thickness, which determines a strong competence in the photorefractive recording between the two gratings. Also this relative phase between both gratings can be optimized by combining the phase shift of the refractive index grating regarding to the illumination pattern ϕ_g, the initial polarization angles of the incident beams and the magnitude of the light modulation.

4. References

[1]. - N. V. Kukhtarev, V. Markov, S. G. Odulov, M. S. Soskin and V. L. Vinetskii. "*Holographic storage in electrooptic crystals. I.Steady state*". Ferroelectrics 22, 949, (1979).

[2] A. Marrakchi, R.V. Johnson, A.R. Tanguay, *"Polarization properties of photorefractive diffraction in electrooptic and optically active sillenite crystals"* J. Opt. Soc. Am. B 3,2 321-335 (1986).

[3] Isabel Casar, José Murillo, Luis Fernando Magaña, "*Diffraction efficiency of non-uniform gratings in $aB_{12}SiO_{20}$ crystal for a non-linear regime under and external d.c. field*". Phys. Lett. A 352, p. 416-420, 2006.