OB8

LIGHT DIFFRACTION ON ACOUSTOPHOTOREFRACTIVE DYNAMIC GRATINGS

G. V. Kulak, *A. G. Matveeva*
I.P. Shamyakin Mozyr State Pedagogical University, Mozyr, 247760, Belarus
Corresponding author e-mail: g.kulak@mail.ru

The volume [1] and surface [2] photorefractive (PR) holographic gratings are widely used for creating the systems of optical information recording and reading. Acoustooptic memory in photorefractive crystals is attracting great interest of researchers in connection with the problem of recording acousto-optical signals by optical methods [3]. Raman-Nath diffraction of light on the acousto-photorefractive dynamic gratings writings in cubic photorefractive crystals in the mechanism of synchronous detection is investigated in [4].

In the present work, we study the recording of photorefractive holographic gratings (HGs) in photorefractive cubic crystals upon interference of light beams formed as a result of Bragg diffraction by ultrasound in an alternating electric field according to the synchronous detection mechanism. Reading of the recorded acoustophotorefractive holographic gratings was studied in the intermediate diffraction regime close to the Bragg diffraction.

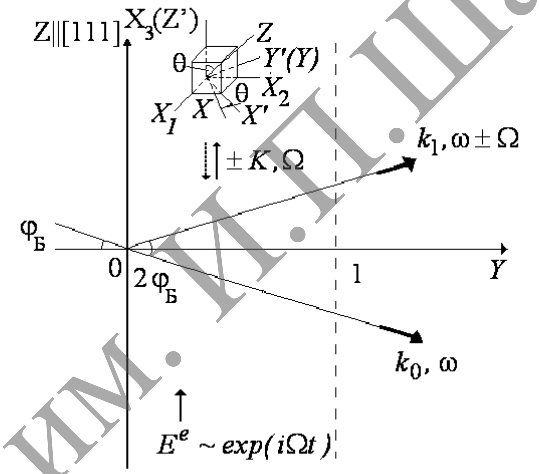

Fig. 1. Scheme of acousto-optic recording of holographic gratings upon Bragg diffraction of light by ultrasound in an alternating electric field

We considered the intermediate diffraction regime close to the Bragg diffraction [5, 6]. It was assumed that only four diffraction orders – $A_{\pm1}(B_{\pm1})$, $A_{+2}(B_{+2})$, and $A_0(B_0)$ – differ from zero. It was taken into account that wave the parameter $Q = \lambda_0 f^2 l / n\upsilon$, where υ is the ultrasound phase velocity, l is the length of light interaction with the PR grating, f is USW frequency. It was assumed that the temperature is T = 300 K, the USW frequency is f = 100 MHz, the writing wavelength is $\lambda_w = 0{,}45\,\mu m$, and the reading wavelength is $\lambda_0 = 0{,}63\mu m$. This crystal was chosen due to its unique PR properties in combination with a strong photoelastic effect [7]. We studied the dependences of relative diffracted light intensity η_{+1} on recording ultrasound intensity I_a at different amplitudes of external alternating electric field strength E_0^e. All the possible cases of polarizations of the recording and reading light are considered.

The maximum diffraction efficiency for the bismuth silicate crystal with and without gyrotropy is approximately the same for all possible polarizations of light recording and reading the holographic grating. The highest diffraction efficiency in nongyrotropic crystals was achieved for p-polarized writing and reading light and at the considerable external electric field strength. This case of diffraction (in the absence of gyrotropy) can be realized, for example, in gallium arsenide crystals (GaAs) and corresponds to the largest modulation depth of a photoelastic grating upon holographic grating recording and to the largest modulation depth of an electrooptic PR grating upon its reading. In this case, we should assume that the photoelastic constants for the GaAs crystal of class 43m satisfy the relation $p_{12} = p_{21}$ [7]. At AO interaction length l = 2 cm and the optimal polarization conditions for recording and reading of a holographic grating, the maximum diffraction efficiency is 0,17 in the presence of gyrotropy and $\eta_{+1\max}$ = 0,35 in the absence of gyrotropy ($\rho = 0$). The low diffraction efficiency in the presence of gyrotropy is caused by inhomogeneity of the holographic grating recorded in a gyrotropic crystal over its depth and by light scattering into other diffraction orders. Numerical calculations show that the Bragg diffraction regime is achieved at wave parameter Q ~ 1,4.

We studied the dependence of diffraction efficiency η_{+1} on recording ultrasound intensity I_a at different lifetimes of charge carriers τ in the conduction band and at AO interaction lengths l upon recording and reading of a PR grating. It is shown that the diffraction efficiency decreases with increasing τ due to a decrease in PR grating field strength E_{sc} determined by drift field strength E_μ. For recording of holographic gratings under the conditions of high-frequency ultrasound and significant external electric fields strengths E_0^e, it is necessary to take into account the relations $E_0 > E_\mu + E_D, E_0 > E_q$ because of which $E_{sc} \approx -m_0 E_\mu E_q / E_0$ [8]. With a fourfold decrease in the AO interaction length (l ~ 0,5 cm), the maximum diffraction efficiency in the presence and absence of gyrotropy decreases by an order of magnitude.

Thus, it is shown that, using gyrotropic and nongyrotropic RP crystals, it is possible to record and read ultrasound signals by a holographic method in an external alternating electric field by the synchronous detection mechanism with moderate acoustic powers and reasonable strengths of external high-frequency electric fields in the pulsed regime. Taking into account that the sillenite crystals, in contrast to other materials, have a high sensitivity to the recording light and simultaneously are reversible, we can conclude that they are preferable for holographic recording of ultrasound signals. The theoretical results obtained qualitatively agree with the experimental data given in [3].

REFERENCES

[1] E.Yu. Ageev, S.M. Shandarov, S.Yu. Veretennikov, A.G. Mart'yanov, V.A. Kartashov, A.A. Kamshilin, V.V. Prokofev, and V.V. Shepelevich, Kvantovaya Elektron., **31** (4), 343 (2001).

[2] N.I. Burimov and S.M. Shandarov, Fiz. Tverd. Tela, **48**, 491 (2006).

[3] A.A. Berezhnoi and T.N. Sherstneva, Opt. Spektrosk., **67** (6), 1313 (1989).

[4] V.G. Gudelev, G.V. Kulak, A.G. Matveeva, JAS, **80** (1), 65 (2014).

[5] V.I. Balakshii and T.G. Kulish, Opt. Spektrosk., **8** (2), 294 (1996).

[6] G.V. Kulak, Opt. Spektrosk., **81** (1), 486 (1996).

[7] Acoustic Handbook, Ed. by M.P. Shaskol'skaya (Nauka, Moscow, i982) [in Russian].

[8] P.N. Ilinykh, O.P. Nestiorkin, and B.Ya. Zel'dovich, J. Opt. Soc. Am., **8** (5), 1042 (1991).