CONTROL OF POLARIZATION OF LIGHT TRANSMITTED AND REFELECTED BY ANISOTROPIC SUBSTRATES WITH MICRORELIEF

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Abstract

Light diffraction on optically anisotropic substrates with the surface microrelief has been calculated by using the OAGSM method. Varying of the microrelief depth and material birefringence allows to realize different polarization state of the light beam transmitted or reflected by the substrate. The approach can be used to optimize the LCD backlight.

1. Introduction

Many recent LCD, LED and OLED have components with the surface microrelief to enhance light efficiency of the device [1-6]. The microrelief has various periodicity and different shape (sine, triangle, rectangular, cylinder etc.). As a rule optically isotropic materials are used for these components. A case of influence of optical anisotropy on light propagation with different polarization states had not been considered yet. The goal of the paper is to give advanced results of calculation of polarized light diffraction in birefringent media with the surface microrelief on the base of Optical Anisotropic Gratings with Surface Microrelief (OAGSM) approach developed in [7-9].

2. Calculation parameters

A case of the normal light incidence onto gratings with Δn varying from 0 to 0.2 and microrelief depth from 0 to 3λ was investigated.

The calculations were made for the microrelief with both rectangular and sinusoidal form. The majority of computations were made for the rectangular microrelief because of smaller computing time (Fig.1). A substrate was presented in calculations as a set of rectangular ones with different width of the birefringent medium. The following dimensions and angles were chosen as variable parameters: the substrate's thickness H/λ and the microrelief period Λ/λ (both normalized to the light beam wavelength λ), the angle φ between the incidence plane and the grooves direction, the direction of polarization in relation to the incidence plane (parallel and perpendicular), the incidence angle θ. The cases of both optically isotropic and anisotropic substrates were considered. The refraction index value for the ordinary ray was accepted equal to 1.50, for the extraordinary ray 1.50, 1.505, 1.60 and 1.70 respectively.

3. Calculation results

In Fig.2 dependencies of diffraction efficiency in the zero, 1st, 2nd and 3rd diffraction orders of transmitted TE-wave *vs* microrelief depth reduced to wavelength at of the substrate birefringence at Δn=0.1 are drawn. In Figs.3 and 4 dependencies of diffraction efficiency in the 1st diffraction order of transmitted TE-wave *vs* microrelief depth reduced to wavelength at different values of the substrate birefringence are shown. For all the diffraction orders the intensity of TM-waves does not depend on optical anisotropy of the material. In turn, for the TE-waves the position of the extrema of diffraction efficiency shifts to lower values at higher values of birefringence. This is owing to longer optical path for extraordinary waves.

If compare the anisotropic gratings with the isotropic ones the birefringence the diffraction efficiency in the 1st order which carries the information on the image displayed or processed. Polarization state in the 1st order is orthogonal to the polarization state in the zero order.

For the isotropic grating the I_0 value of the TE-wave has minimums at h/λ=1.0 and 2.8. The I_1 value of the TE-wave has maximums at these conditions. The diffraction efficiency of the reflected TE- and TM-waves is <3% for all diffraction orders at the normal incidence. For both isotropic and anisotropic gratings the I_0 value of the TM-wave has minimums at h/λ=1.1 and 2.7, and the I_1 value of the TM-wave has maximums at these conditions. The $I_2(h/\lambda)$ dependence has only one maximum at I_1 minimum in the range of calculation.

4. Conclusion

It is obvious that varying the microrelief parameters (depth and period) as well as refractive indices of the anisotropic medium with the surface microrelief it is to realize almost any combination of TE- and TM-waves, i.e. almost any polarization state of the light beam transmitted or reflected by the substrate. Additionally, varying the microrelief shape it is to achieve better homogeneity of LCD backlight [1,2].

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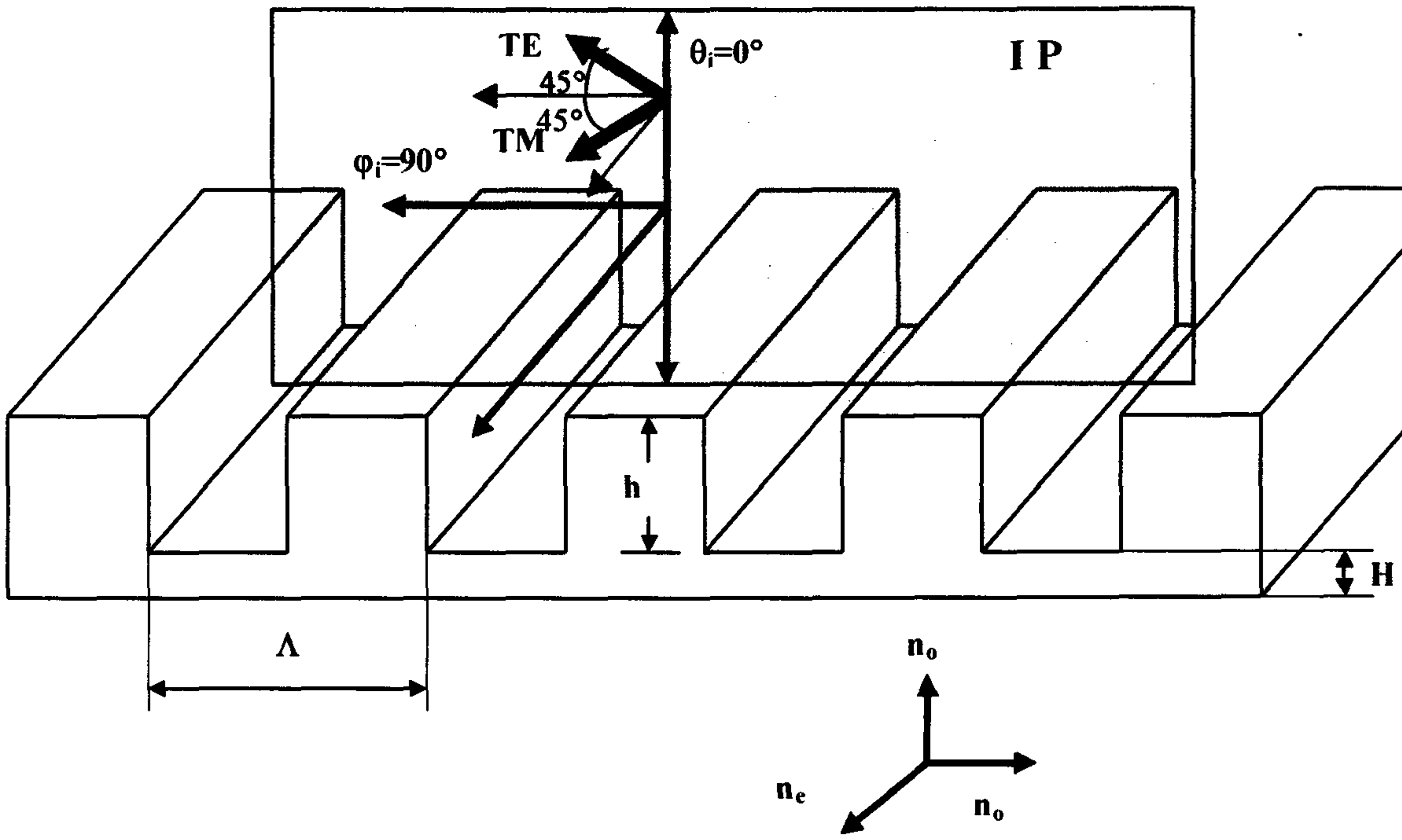

Fig. 1. Scheme of polarized light incidence onto an optically anisotropic rectangular substrate with periodic microrelief used for calculations. *H* is the height of the substrate, *h* is the depth of the microrelief, *Λ* is the period of the microrelief, n_e and n_o are refractive indices of the substrate along and perpendicular to the microgrooves direction respectively, *IP* is the light incidence plane, θ and φ are polar and azimuthal angles of the light incidence respectively. Two directions of the *TE*-polarization parallel and perpendicular to the microgrooves direction are shown. The case of *TM*-polarization is not shown.

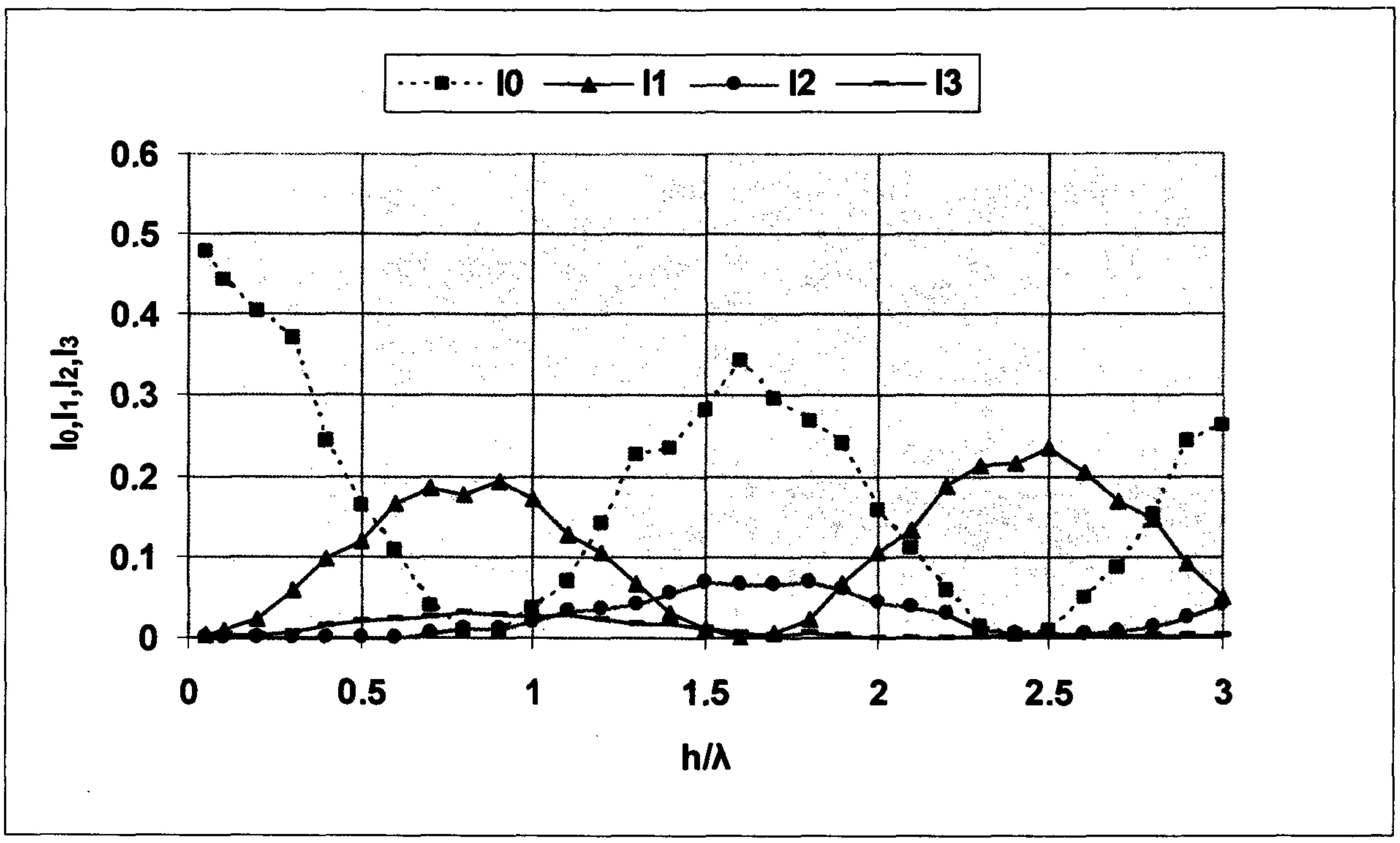

Fig. 2. Dependence of diffraction efficiency in the zero, 1st, 2nd and 3rd diffraction orders of transmitted TE-wave *vs* microrelief depth reduced to wavelength at of the substrate birefringence. $\Delta n=0.1$.

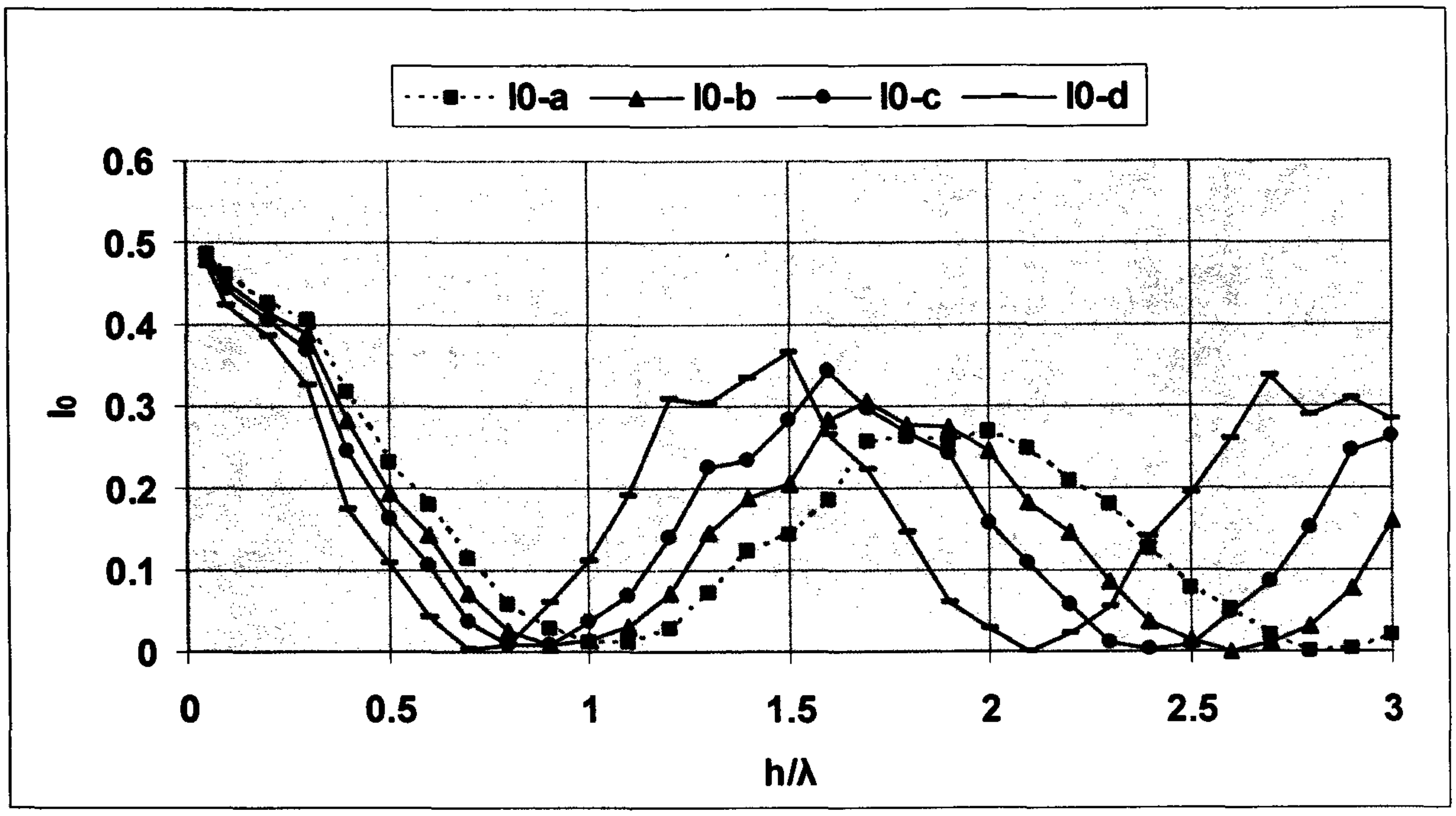

Fig. 3. Dependence of diffraction efficiency in the zero diffraction order of transmitted TE-wave *vs* microrelief depth reduced to wavelength at different values of the substrate birefringence. a – Δn=0; b – Δn=0.05; c – Δn=0.1; d – Δn=0.2. $n_1 = n_3 = 1,5$.

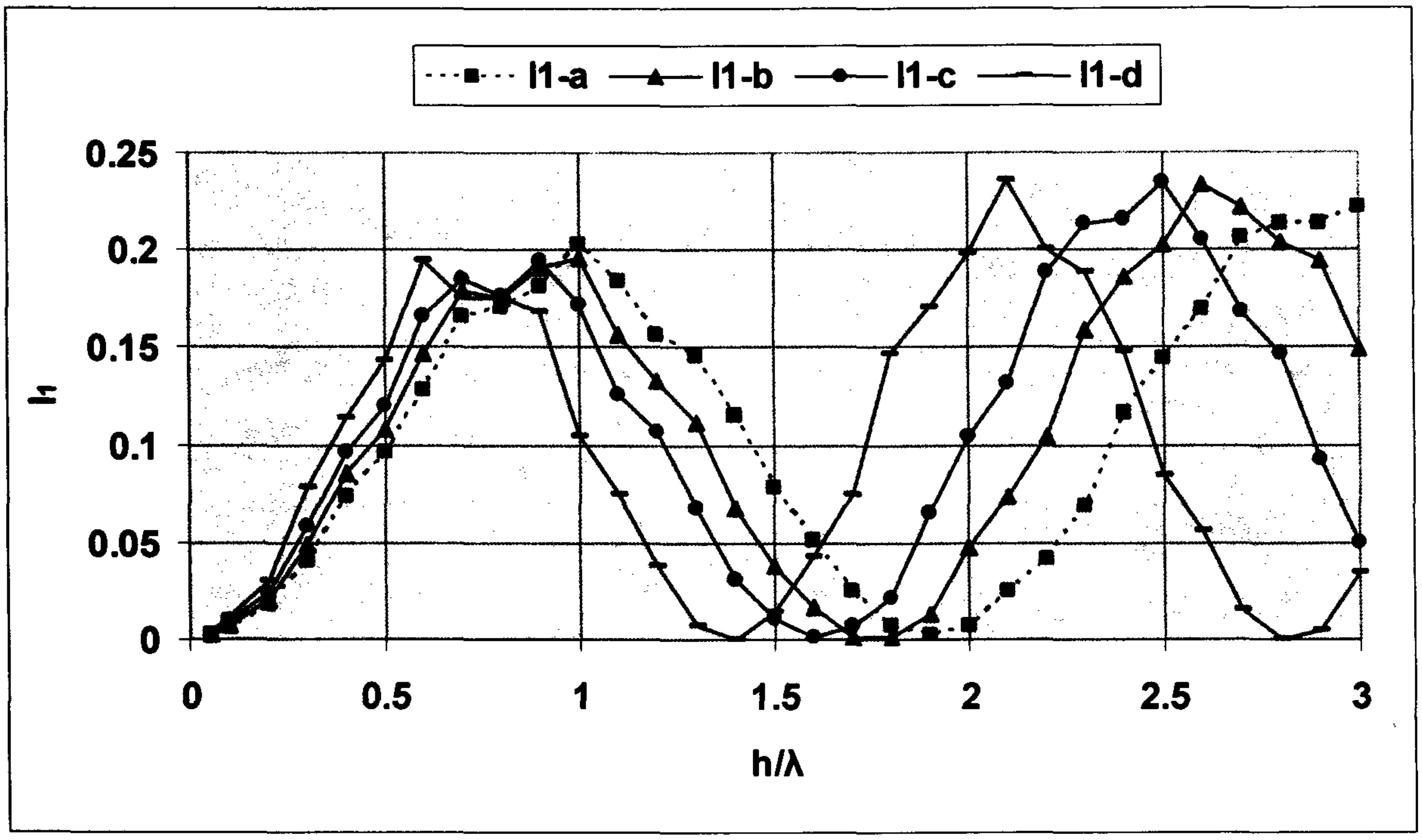

Fig. 4. Dependence of diffraction efficiency in the 1st diffraction order of transmitted TE-wave *vs* microrelief depth reduced to wavelength at different values of the substrate birefringence. a – Δn=0; b – Δn=0.05; c – Δn=0.1; d – Δn=0.2.