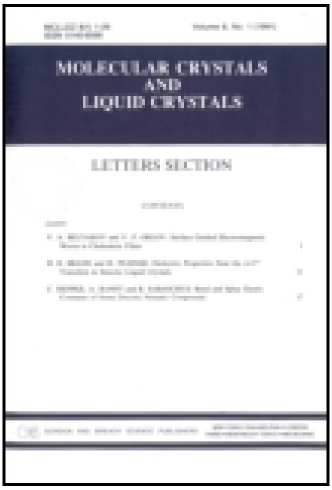


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# Diffraction on Anisotropic Substrates with Sinusoidal Surface Microrelief

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# Diffraction on Anisotropic Substrates with Sinusoidal Surface Microrelief

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*Light polarization management by diffractive optical elements (DOE) can enhance light efficiency in LCD backlight systems. The OAGSM software developed earlier provides calculation of diffraction efficiency for optically anisotropic gratings with periodical sinusoidal surface microrelief. In this paper the software has been checked for the cases of oblique incidence as well as of microrelief period and thickness.*

**Keywords** diffractive optical elements; sinusoidal surface microrelief; birefringence

## 1. Introduction

Development of methods of light utilization enhancement in LCD backlight systems is an urgent task. Some types of special films like BEF, DBEF et al. use polarization conversion and surface microrelief [1]. The software Optically Anisotropic Grating with Surface Microrelief (OAGSM) developed by us earlier [2, 3] provides calculation of diffraction efficiency for optically anisotropic gratings with periodical surface microrelief. In [2, 4, 5] this software has been used to calculate light diffraction on birefringent substrates with symmetric rectangular and sine microrelief for its period reduced to the light wavelength $\Lambda/\lambda = 3.3$. The birefringence value changed from 0 to 0.2 and microrelief height reduced to the light wavelength $h/\lambda$ varied from 0 to 3.0. For both reflected and transmitted TE- and TM-waves light intensities in the diffraction orders from 0 to $\pm 5$ have been calculated for the normal light incidence. Both theoretical and experimental data are compared in [6].

In [7, 8] the OAGSM software was checked for the cases of oblique incidence on birefringent substrates with rectangular microrelief and different number of the layers in the relief protrusion.

In [5] valuable difference between diffraction properties was demonstrated for both rectangular and sine microrelief.

In this paper the software has been checked for the cases of oblique incidence as well as of sinusoidal microrelief period. The results are to be used to develop backlights with enhanced properties.

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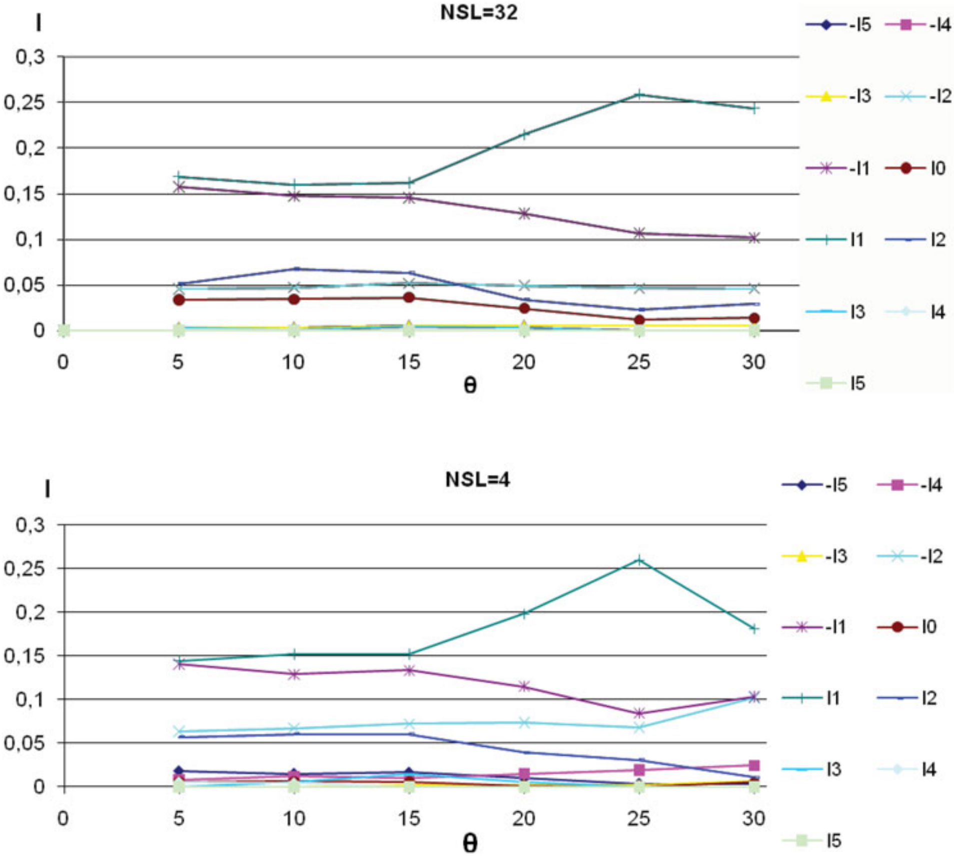



**Figure 1.** Diffraction efficiency of the transmitted TE-wave *vs.* incidence angle $\theta$ for the case of the sine microrelief for the diffraction orders from $-5$ to $+5$. $\Lambda/\lambda = 5$, $h/\lambda = 1$. *top*) number of layers 32, *bottom*) number of layers 4.

## 2. Methods

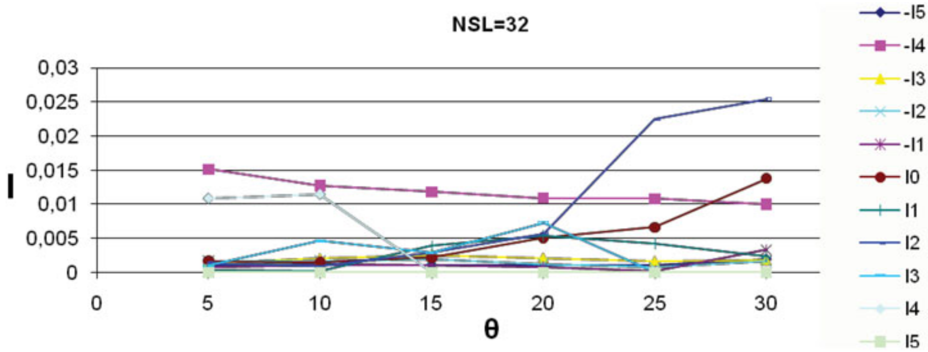
The method of calculation was described in detail in [6, 7].

In the case of investigation of oblique incidence influence on the diffraction orders' intensity the incidence angle was varied in range from 5° to 30° and then the intensities in every positive and negative order were compared. In the OAGSM method every system is divided by a definite numbers of intermediate layers [2, 3]. The calculation accuracy depends on the layers number.

Then a dependence of the diffraction on the reduced period $\Lambda/\lambda$ has been checked in the range from 0 to 10 and compared with known formulas for the diffraction on a split.

## 3. Results

A dependence of the diffraction efficiency of the transmitted TE-wave on the layers number NSL is illustrated in Fig. 1. If compare the cases of NSL = 32 and 4, respectively, the



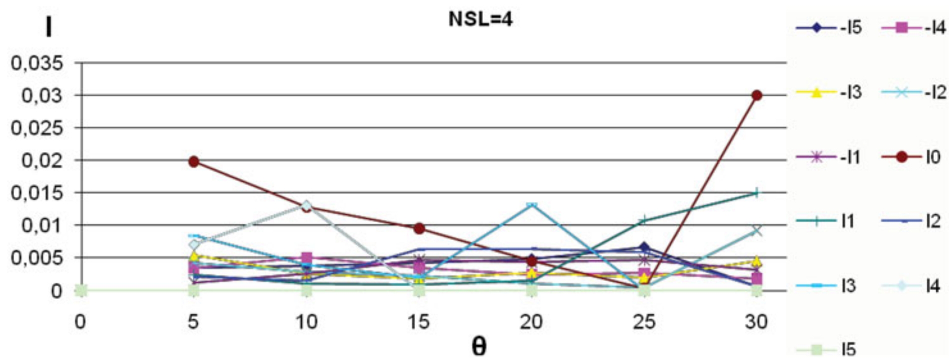




**Figure 2.** Diffraction efficiency of the reflected TE-wave *vs.* incidence angle $\theta$ for the case of the sine microrelief for the diffraction orders from $-5$ to $+5$. $\Lambda/\lambda = 5$, $h/\lambda = 1$. *top*) number of layers 32, *bottom*) number of layers 4.

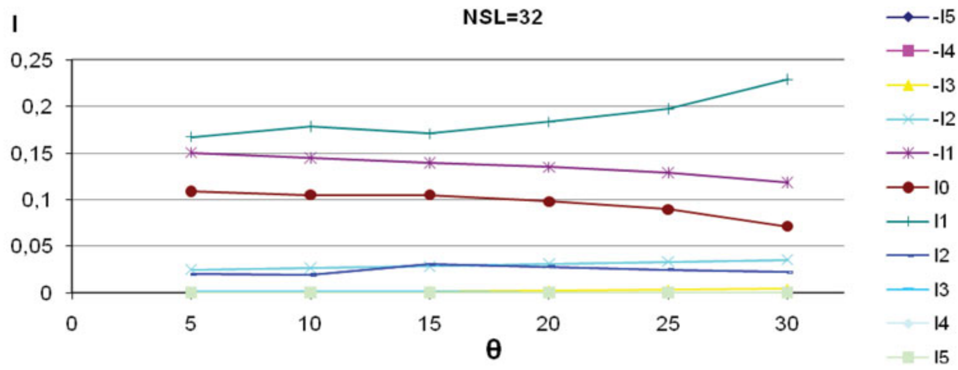
dependences of all diffraction orders intensities coincide up to incidence angle 25° and diverge at 30°.

However there is a big difference of the diffraction intensity in different orders in the case of reflected TE- and TM-waves (Fig. 2). Reduced numbers of the intermediate layers results in significant change of the diffraction order intensity and its relative fraction in comparison with total reflected light.

If the intermediate layers number is small then main component of the reflected TE-wave is $I_0$. It reduces up to angle 25° and then sharply increases. For the microrelief with 32 layers the $I_0$ intensity increases smooth. The relative weight of orders $I_{-4}$ and $I_{-5}$ is changed dramatically for the cases of different number of intermediate layers.

In Fig. 3 there the same data for the transmitted TE-wave and case of the rectangular microrelief [7]. For both types of the microrelief the angular dependence are similar only for both positive and negative first orders and the third order. The difference of intensities in the zero and other orders is reviewed in detail in [5].

In Fig. 5 one can see a dependence of the zero order intensity on the period reduced to the wavelength for the different values of reduced microrelief height for two types of the microrelief. Small shift of the $I_0$ intensity extrema *vs* the microrelief thickness is observed. For another microrelief depth the view of $I_0(\Lambda/\lambda)$ changes strongly.



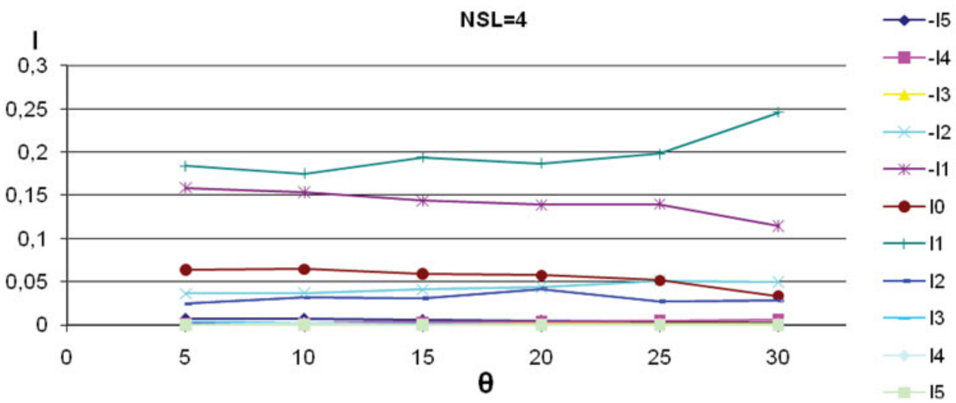




**Figure 3.** Diffraction efficiency of the transmitted TE-wave *vs.* incidence angle $\theta$ for the case of the rectangular microrelief for the diffraction orders from $-5$ to $+5$. $\Lambda/\lambda = 5$, $h/\lambda = 1$. *top*) number of layers 32, *bottom*) number of layers 4.

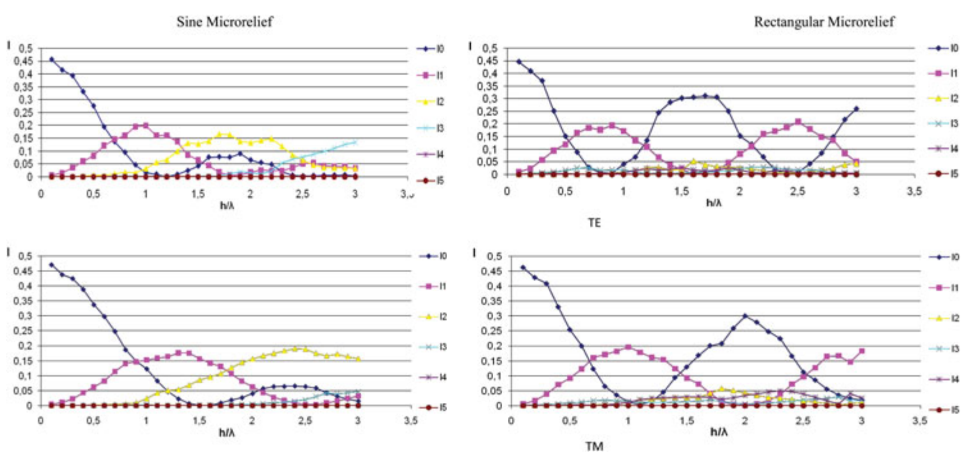



**Figure 4.** Diffraction efficiency of the transmitted TE- and TM-waves *vs* parameter $h/\lambda$. $\Lambda/\lambda = 3.3$ (left) and 5 (right), $\theta = 0^{\circ}$. Left – sine relief, right – rectangular relief.

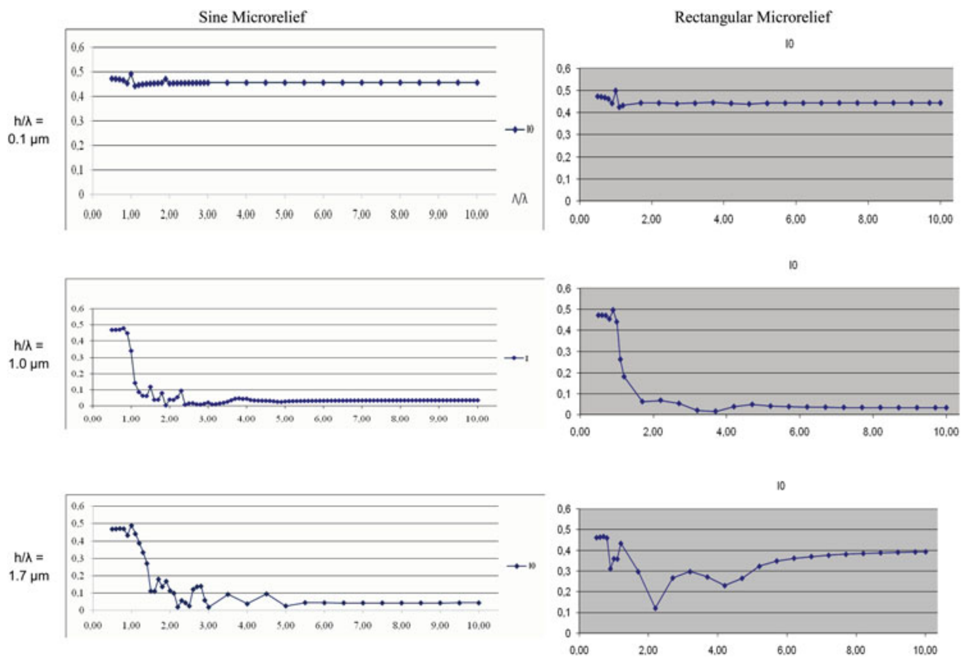



**Figure 5.** Diffraction efficiency of the transmitted TE-wave in the zero order *vs.* period Λ/λ at different values of h/λ, $\theta = 0°$. *left*) sine microrelief, *right*) rectangular microrelief.

## 4. Conclusion

The results obtained can be used for designing new efficient backlights. Combination of different polarization status in different diffraction orders can provide bidimensional distribution of polarized light beams onto different LCD pixels, rows or columns. E.g., it can be used in designing 3D displays.

## Acknowledgments

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