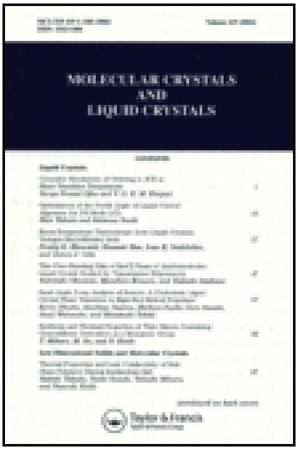

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Optical and Electro-Optical Control of Grating Efficiency in a Nematic Liquid Crystal Cell with Azo Polymer Boundary

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Optical and Electro-Optical Control of Grating Efficiency in a Nematic Liquid Crystal Cell with Azo Polymer Boundary

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A novel control of the grating efficiency in a nematic liquid crystal cell with an azobenzene polymer surface is proposed. In an optical control regime, the grating effect can be controlled by alternate polarization switchings of one pump beam due to strong polarization sensitivity of azobenzene chromophores. Moreover, the grating efficiency can be easily tuned by an external ac electric field.

Keywords: liquid crystal grating; polarization grating; azobenzene polymer

INTRODUCTION

Recently, liquid crystal (LC) gratings have been actively investigated because of their high birefringence and low voltage control scheme. These gratings are operated by a photorefractive-like mechanism in a dye-doped LC cell[1] or by optical reorientation related to the surface adsorption in a dye-doped LC cell[2]. In this paper, we show that the LC grating formed in a LC cell with an azobenzene polymer surface (APS) can be optically or electro-optically controlled. This configuration provides several unique features such as the increase or decrease of the grating effect only by the illumination of a single pump beam.

EXPERIMENTAL

The azobenzene copolymer used by our previous research[3] was spin-coated onto an indium-tin-oxide (ITO) glass substrate. In this copolymer, azobenzene chromophore chains and liquid crystalline chains are attached as side groups. The homogeneous polyimide was spin-coated onto the other ITO glass substrate followed by rubbing. Glass spacers maintain the cell gap as 5μm. The cell was filled with a nematic LC which has a positive dielectric anisotropy. We used a 488nm Ar ion laser as pump beams and a 633nm He-Ne laser as a probe. The pump beam illumination was performed after the LC cell fabrication. Two pump beams were incident into the APS side of the cell with an angle about 6°~7°. The polarizations of two pump beams were the *S* and the *P* states to the plane of incidence. The first-order diffraction efficiency (DE) of the linearly polarized probe beam was observed with illuminating one or two pump beams and with applying an external voltage of a few volts across the LC cell after the formation of the grating.

RESULTS AND DISCUSSION

It is known that a bulk LC director in the LC cell with the APS can be aligned along the molecular axes of azobenzene chromophores at the light-controlled surface. When the cell was initially assembled, there occurred some degree of unidirectional alignment of LC directors together with the existence of a preferred direction of azobenzene molecular axes even though without any pre-treatments on the APS. The longitudinal absorption axis of azobenzene molecules was parallel to the direction of LC alignment.

The polarization grating means a spatially periodic modulation of light polarization[4]. Two orthogonal linear polarizations (OLPs) co-incident on the APS can construct the periodic polarization modulation. In our configuration, the generated polarization pattern by the *S* and *P* polarization pair modulates the molecular axes of azobenzene chromophores on the APS followed by the LC director modulation.

Before two-beam illumination, we first chose a certain spot, to produce the grating, where the azobenzene molecular axis (the longitudinal absorption axis) on the APS is parallel to the *S* polarization direction. If a linearly polarized single pump beam is incident onto the spot, the *S*-polarized pump beam would exert a large optical torque on azobenzene molecules while the *P*-polarized pump beam would produce a negligible torque.

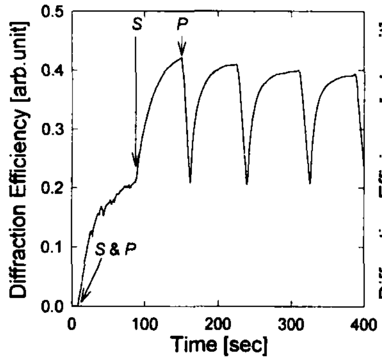

FIGURE 1. Optical control

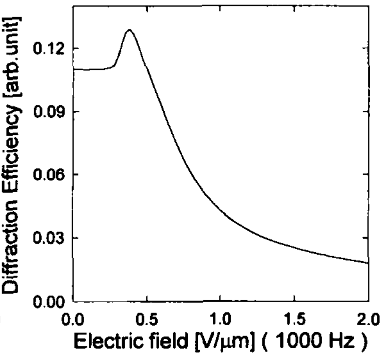

FIGURE 2. Electro-optical control

We inscribed the LC grating to some extent by the co-incidence of the *S* and *P* polarization pair. Figure 1 shows the first-order DE of the probe beam. After about 90 seconds, only the *S*-polarized pump beam was illuminated without the *P*-polarized pump beam. More enhanced LC grating is clearly seen from Figure 1. This is because the single incidence of the *S*-polarized pump beam exerts a larger optical torque onto azobenzene chromophores than the co-incidence of the *S* and *P* polarization pair. This means that the single incidence induces larger LC director modulation. At about 150 seconds, we changed the polarization state of the *S*-polarized pump beam to the *P* polarization just by rotating the input polarizer (still with blocking the other *P*-polarized pump beam). The grating effect was then rapidly decreased since the incidence of the *P* polarization tends to recover the initial undistorted state parallel to the *S* polarization direction from the modulated azobenzene molecular axes. The linear polarization state of a single pump beam was alternatively switched between the *P(S)* and the *S(P)* polarization. The grating effect was controlled by such alternate switching processes of the polarization state of one pump beam.

Figure 2 shows the first order DE of the probe beam as a function of the ac applied electric field. After the formation of the grating, the pump beams were blocked and the electric field was subsequently applied across the cell. As the electric field increases, the DE decays significantly because LC director reorientation along the surface normal reduces the refractive index modulation through the whole cell. In conclusion, the precise tuning of the DE could be achieved using the applied electric field.

Acknowledgment

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