Polarization Dependence of Polymer Surface Relief Gratings

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Abstract: We report the polarization dependence of surface relief grating (SRGs) based on azo dye-poly(methyl methacylate). The S-polarized and P-polarized writing beams were introduced into the sample and fabricated the surface relief gratings (SRGs). The He-Ne laser with S-polarization or P-polarization was served as a probe beam and measured the first order diffraction of SRGs. The results showed that the diffraction efficiency was highly correlated with the polarization of writng beams. The atomic force microscopy was employed to observe the morphology of SRGs, and the depths of SRGs can be obtained a relative high value for the P-polarization of writing beams.[Ying-Chuan Wang. **Polarization Dependence of Polymer Surface Relief Gratings**. *Life Sci J*. 2012;9(3):1255 -1257] (ISSN:1097-8135). http://www.lifesciencesite. com.

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1. Introduction

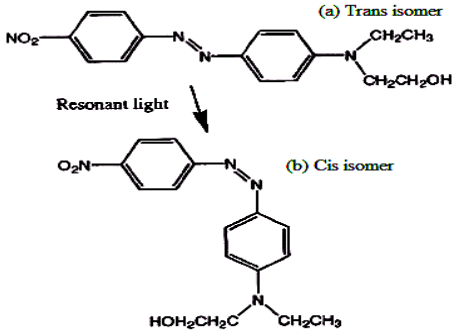
In the past several years, azo polymers have shown to offer many interesting applications, such as optical data storage, optical switching devices, diffractive optical elements, integrated optical devices, polarization splitters and electro-optical devices [1-6]. It is well-established that following excitation of azo dye and trans-cis isomerization, thermal diffusion enables rotation of azo dye in the bulk. Photoinduced surface relief gratings (SRGs) is an important result of molecular translation control using optical fields. With the irradiation of an interference pattern on azo dye molecules, the alignment of the chromophores can be induced and the modification of the surface can be controlled[8-13]. SRGs has the following properties: (1) It can be fabricated upon azobenzene functionalized polymers such as side-chain azo polymers. (2) The diffraction efficiency and the depth of SRGs depend on the energy of writing beams and the polarization of the writing beams. (3) SRGs is highly stable below the glass transition temperature T_g.

In this study, the polarization dependence of SRGs is discussed. The surface relief gratings based on azo dye doped polymer film with a single pulse writing is fabricated. The first order diffraction efficiency dependes on the polariztion of writing beams and probe beam is studied. The depths of inscribed surface relief gratings (SRGs) depends on the polarization of writing beam is also discussed.

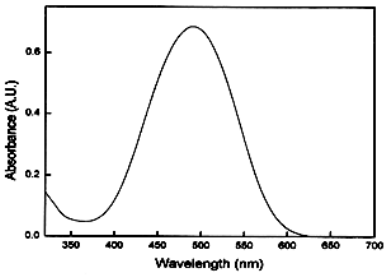
2. Experimental

Sample Fabrication

Samples were spin-coated films of the azo-dye molecule Disperse Red 1 (DR1) in poly(methyl-methacrylate)(PMMA). The weight concentration of DR1 and PMMA are 7wt% and 93wt%, respectively. The excitation and isomerization from trans to cis form and the absorption spectrum of DR1 are shown in Figure 1(a) and 1(b). The absorption peak is around 500 nm. First, we dissolved DR1 and PMMA in toluene, and the azo dye in polymer solutions were filtered by filter with 0.2 μm. The solutions were spin-coated on the glass substrate. The thickness of the films were about 3μm.



(a)



(b)

Figure 1 (a) The isomerization from trans to cis form of DR1 (b) The absorption spectrum of DR1

Setup

Figure 2 shows the experimental setup for the fabrication of surface relief gratings in azo dye DR1 doped poly(methyl-methacrylate) (PMMA) thin film. Two simultaneously incident pump pulses derived from a Nd:YAG laser were operated at a wavelength of 532 nm. The pump beams were S-polarization or P-polarization and crossed in the sample with an irradiance of 3.0 mJ/cm^2 for each pulse. As the writing pulses acted on the sample with a single shot, the surface relief gratings were formed. Then S-polarized or P-polarized He-Ne probe laser was incident normally on to the sample and the first order of diffraction efficiency was measured with a photodiode and recorded with a oscilloscope.

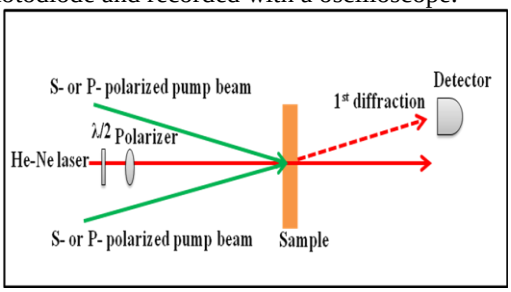


Figure 2 Experimental setup for the fabrication of surface relief gratings.

3. Results and Discussions

Figure 3 plots the polarization dependence of the pump beams on the diffraction efficiency with the S-polarized probe beam. The influence of the S- or P-polarized pump beams on the grating diffraction efficiency, P-polarized pump lasers interferences producing surface gratings with diffraction efficiency 3.0 times larger than S-polarized ones. This result indicates that the intensity modulation by the two incident pump beams play an important role for the fabrication of SRGs. The SRGs were stable, and the diffrcation efficiency retained the same value even after six months.

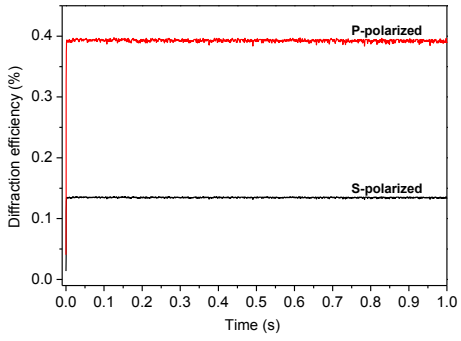


Figure 3 The polarization dependence of pump beams on the diffraction efficiency

The diffraction efficiency depended on the polarization of pump/probe beams were shown in Table. 1. The higher diffraction efficiencies were obtained when P/S or P/P polarized pump/probe beams were used. The diffraction efficiency for P/S or P/P beams are around 3 times larger than that of S/S or S/P polarizations. The diffraction efficiency dpended on the polarization of pump beams, but less affected by the polarization of probe beams.

Table. 1 The polarization dependence of pump/probe beams on the diffraction efficiency

Polarization of Pump/ Probe beams	Diffrcation efficiency (%)
S/S	0.13
S/P	0.12
P/S	0.39
P/P	0.37

The morphologies of inscribed surface relief gratings for P- or S- polarized pump beams were shown in Figure 4. The surface relief gratings were recorded with a spatial period of ~12 μm and the surface modulations were 1.51 and 0.53μm for the P- and S- polarized pump beams, respectively. The ratio of surface modulation was also consistent with the ratio of the first-order diffraction efficiency.

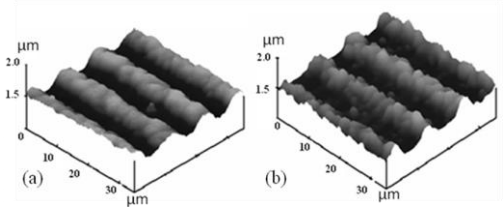


Figure 4. The morphologies of inscribed surface relief gratings for (a) P- or (b) S- polarized pump beams

4. Conclusion

In this study, we report the polarization dependence of surface relief gratings (SRGs) based on azo dye-poly(methyl methacylate). The diffraction efficiency for P-polarized pump beams was about 3.0 times larger than that of S-polarized pump beams. The diffraction efficiency was independent of the polarization of probe beam. The ratio of surface modulation was also consistent with the ratio of the first-order diffraction efficiency.

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