Fast Writing of Surface Relief Gratings Based on Azo Dye-Poly(Methyl Methacrylate) Mixtures

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Abstract: We report the observation of surface relief gratings (SRGs) based on azo dye-poly(methyl methacylate) by fast writing of Nd: YAG 532 nm laser (s-polarized) of holographic grating method.The dependence of intensity of writing beams on the diffraction efficiency is studied. The first order diffraction of SRGs depends on the polarization of probe beam (s-polarized and p-polarized) were measured. The depths of SRGs were measured by atomic force microscopy (AFM), and the depths of SRGs can be obtained a relative high value for the high intensity of writing beams.[Ying-Chuan Wang. **Fast Writing of Surface Relief Gratings Based on Azo Dye-Poly(Methyl Methacrylate) Mixtures**. *Life Sci J*. 2012;9(2): 1196-1198] (ISSN:1097-8135). http://www.lifesciencesite.com.

Keywords: surface relief gratings, azo dye-poly(methyl methacylate), holographic grating method, the diffraction efficiency, atomic force microscopy

1. Introduction

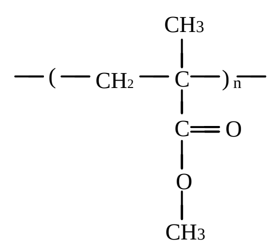
Thin films of polymers containing azo dye have been shown to offer interesting prospects for a variety of applications, such as optical data storage, optical switching devices, diffractive optical elements integrated optical devices, polarization splitters and electro-optical devices [1-6]. Many of these applications are due to photoisomerization and photoinduced anisotropy of the azo dye. The surface relief gractings can be inscribed by irradiation of interference fringes with two coherent laser beams [7, 8]. The irradiation of films with interference fringes can induce not only the alignment of the azo dye chromophores throughout the volume of polymer but also the controlled of surface modulations. SRGs, which are formed by the mass transport induced by the excitation and trans to cis isomerization of azo dye, and thermal diffusion enables rotation of dye molecules within the matrix.Thus, the reorientation of azo dye induces the large-scale molecular motion and the free volume requirements, and results in the expansion of irradiated azo dye doped polymer film [9-11].

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

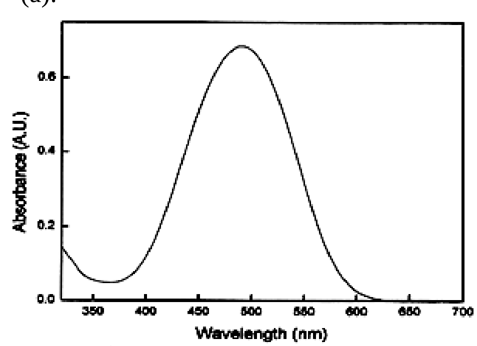
2. Experimental

Sample Fabrication

The azo dye and polymer are Disperse Red 1 (DR1) and poly(methyl-methacrylate) (PMMA) in the experiment, respectively. The weight concentration of DR1 and PMMA are 7wt% and 93wt%, respectively. The chemical structure of PMMA 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. Samples were spin-coated films of the azo-dye (DR1) in poly(methyl-methacrylate).The films were dried in a vacuum and the temperature was about 80℃ under the glass temperature (Tg) of PMMA for more than 24 h . The thickness of the films were 3 μm.



(a).



(b)

Figure 1 (a) the chemical stucture of PMMA (b) the absorption spectrum of DR1

Setup

Figure 2 shows the experimental setup for the fast recording of surface relief grating in DR1 doped poly(methyl-methacrylate) (PMMA) thin film. A Q-switched Nd:YAG laser was employed for the single shot excitation beam at 532 nm. Two s-polarized writing beams were crossed in the sample. The He-Ne laser with s- or p- polarization was used as a probe beam and incident normally into the sample. The SRGs was inscribed by a single shot of a pair of s-polarized wrinting beams. The diffraction signals were probed by a He–Ne laser at 632.8 nm and detected by a photodiode and recorded with a oscilloscope.

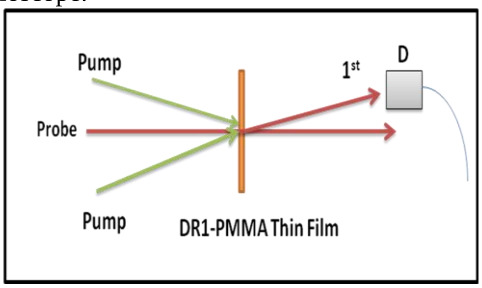


Figure 2 Experimental setup. Pump: Nd:YAG laser , Probe: He-Ne laser, D: Photodetector

3. Results and Discussions

Figure 3 plots the dependence of intensities of the pump beams on the diffricaton efficiency. The intensities of single pulse are 0.5, 1.0, 2.0 2.5 and 3.0 mJ/cm^2, respectively. The magnitude of diffraction efficiency and the relaxation mechanism depend on the intensity of the pump beams. Initially, the singal rises for all curves of single shot of pump laser. Subsequently, the signal relaxes down to almost zero and nonzero for 0.5, 1.0 and 2.0 mJ/cm^2, respectively. The signals maintain a constant value without relaxation for the pump energy is larger than 2.5 mJ/cm^2. The relaxation of diffraction efficiency is due to the thermal effect of cis to trans isomerization of azo dye.

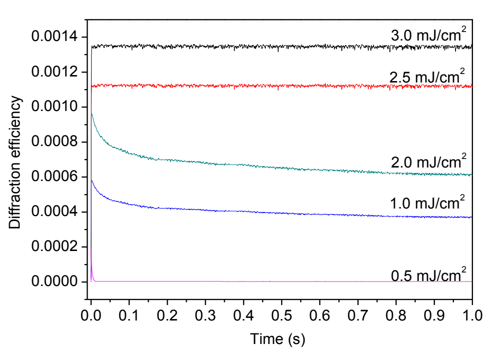


Figure 3 The dependence of intensities of pump beam on the diffraction efficiency

Figure 4 plots the first order diffraction of SRGs depends on the polarization of probe beam. The results show that the diffraction efficiency is independent of the ploarization of the probe beam. As SRGs is inscribed by a single shot of wrinting beams, the photoisomerization process of azo dye is completed. The independence of the diffraction efficiency on the polarization of probe beam implied that the diffraction efficiency was mainly attributed to the SRGs on the thin film. The diffraction efficiency is increasing with the increasing of pump energy.

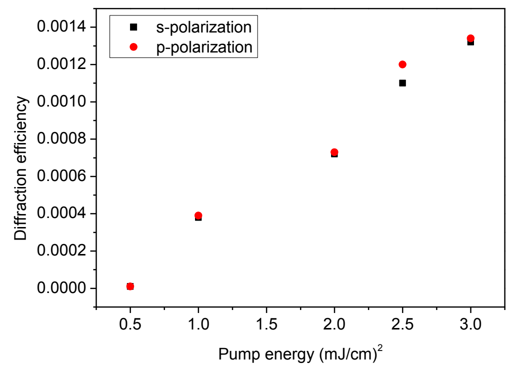
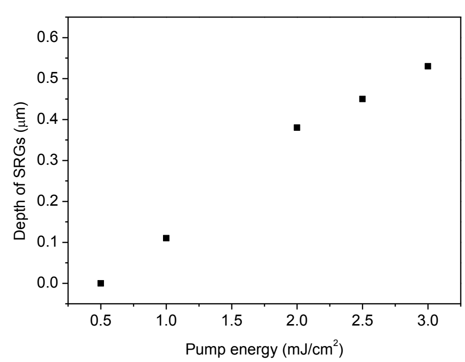


Figure 4 The dependence of the polarization of probe beam on the diffraction efficiency

Figure 5 plots the surface modulation of SRGs. The depths of SRGs are increasing with the increasing energy. The depth of SRGs can not be obtained in low energy of pump beam (0.5 mJ/cm^2). As the energy larger than 1.0 mJ/cm^2, the depth of SRGs can be measured, and the maximun value is 0.53μm in this experiment. The results also reflect the diffraction efficiency as shown in Figure 4.



4. Conclusion

In this study, we report the observation of surface relief gratings (SRGs) based on azo dye-poly(methyl methacylate) by fast writing of Nd:

YAG 532 nm laser (s-polarized) of holographic grating method. The diffraction efficiency is increasing with the increasing of pump energy. The diffraction efficiency is independent of the polarization of probe beam. The depth of SRGs is 0.53μm with pump energy of 3.0 mJ/cm^2 in this experiment.

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