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Alignment of Liquid Crystal on Photoinduced Surface Relief Grating of Azo Polymer Film

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Introduction

The alignment of the liquid crystal on a substrate strongly influences on the characteristics of display device. So far rubbing technique has been used for the alignment of liquid crystal. However, there are some problems such as dust and static electricity. In order to solve these problems, a photoinduced alignment is actively studied. Since it has been reported that photoinduced surface relief grating (SRG) is fabricated by the irradiation of two interfering laser beams on the polymer containing photochromic azobenzene in its side chain [1-2], the possibility of various application has been examined. The application to the liquid crystal alignment has attracted attention in term of not only alignment technique but also the possibility of new functional applications.

In this study, we fabricate surface relief grating on thin film using poly[[4'-[[2-(acryloyloxy)ethyl]ethylamino]-4-nitroazobenzene] (pDR1A) containing azobenzene in its side chain, and investigate the alignment characteristics of liquid crystal on SRG.

Experiment

Molecular structure of pDR1A synthesized in this study is shown in Fig.1. The method to synthesize [3] is shown below. The monomer was synthesized by reacting Disperse Red 1 (DR1) and acryloyl chloride with triethylamine as HCl acceptor in THF as stirring at 0°C for 1 hour followed at room temperature for 6hour. The resulting salt was filtered, and the resulting solution was evaporated and then precipitated into water. The resulting salt was filtered, dried and

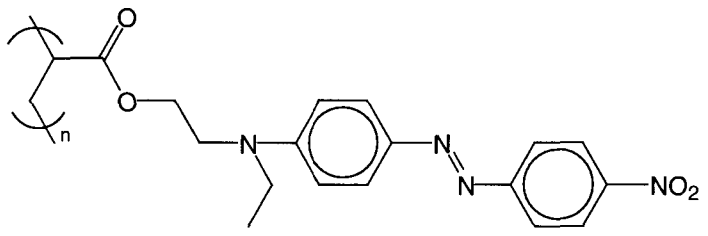

Fig.1: Molecular structure of pDR1A.

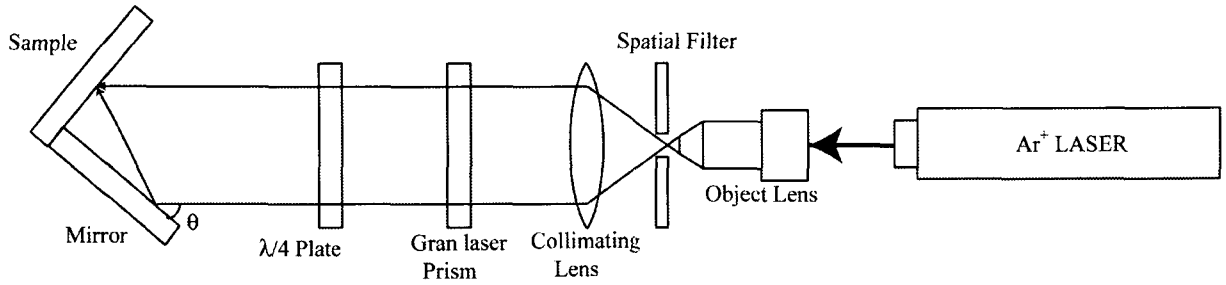

Fig.2: Experimental setup for the fabrication of surface relief grating.

recrystallized from ethanol. Polymerization was performed in dry toluene with 10% AIBN of monomer as stirring at 60°C for 4 days. Polymerization reaction was stopped by precipitating in methanol. Resulting precipitation was dissolved in THF or THF/methanol, and reprecipitated in methanol and dried in vacuum. The glass transition temperature of pDR1A is around 90°C.

Thin film of pDR1A was prepared by spin-coating the chloroform solution of pDR1A on glass substrate. Thin film was heated up to 100°C for over 12 hour in order to remove any residual solvent. Figure 2 shows an experimental setup for the fabrication of SRG. The light source is an Ar^+ laser with a wavelength of 488nm. Two interference laser beams were circularly polarized using gran laser prism and λ/4 plate. The total power density of laser was 20mW/cm^2. In order to monitor the grating formation, the intensity of diffracted beam of a He-Ne laser light at 633nm was measured by a powermeter. The surface profile of SRG was investigated using an atomic force microscope (AFM), JSTM-4200A (JOEL).

Nematic liquid crystal, ZLI1132 (Merck), was inserted into a thin sandwich cell consisting of SRG glass substrates with various grating periodicity, and then alignment of liquid crystal was investigated using a polarizing microscope.

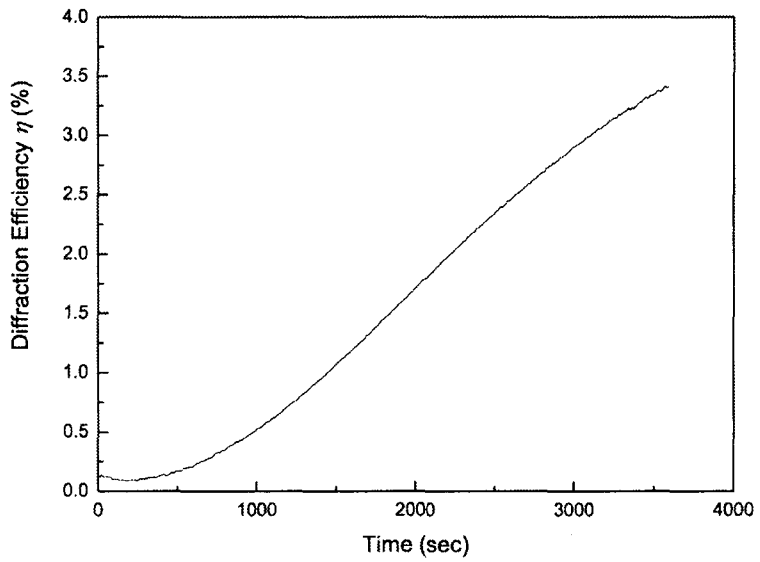

Fig.3: Time dependence of diffraction efficiency of surface relief grating.

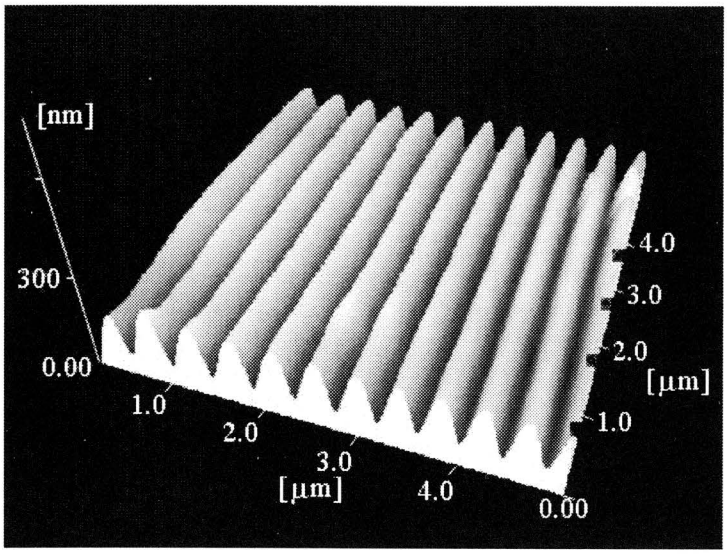

Fig.4: AFM image of surface relief grating.

Results and Discussion

Figure 3 shows the time dependence of the diffraction efficiency of SRG on thin film of pDR1A. As starting the irradiation of Ar^+ laser beam, grating structure was fabricated, and the diffraction efficiency gradually increased. From this result, it was cleared that the depth of SRG can be controlled by the irradiation time.

SRG was fabricated at various incidence angle θ of the recording light (Fig.2). Figure 4 shows AFM image of SRG fabricated at $\theta = 40°$. It is confirmed that the periodicity of SRG depends on θ.

Figure 5 shows polarizing microphotographs of nematic liquid crystal on SRG. It is found that the director of nematic liquid crystal is parallel to the grating direction, and alignment characteristics depends on the periodicity of SRG.

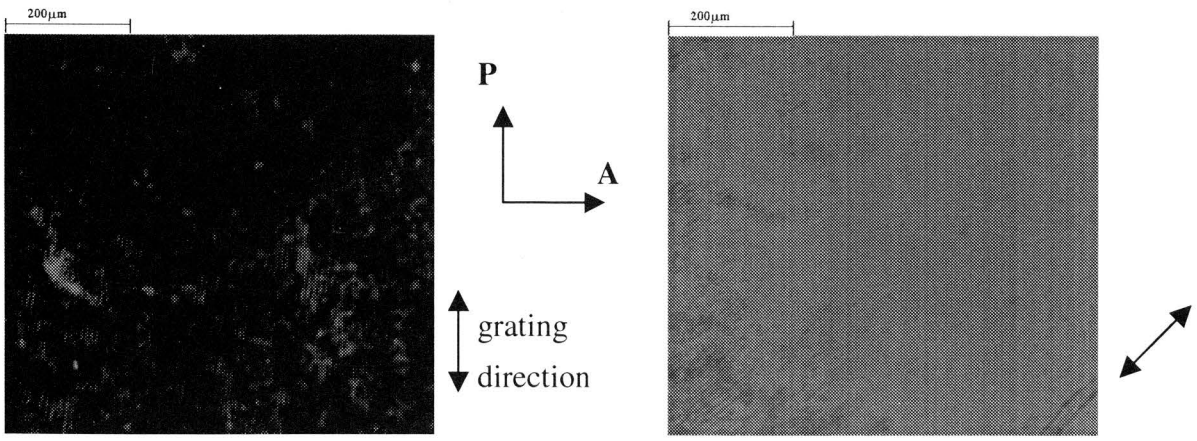

Fig.5: Polarizing microphotograph of nematic liquid crystal on surface relief grating.

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