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Photo-induced in-plane Alignments of Liquid Crystal Molecules on Alternate Self-assembled Ultrathin Films Containing Azo-dye and Evaluation by the Attenuated Total Reflection Measurement

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Photo-induced in-plane Alignments of Liquid Crystal Molecules on Alternate Self-assembled Ultrathin Films Containing Azo-dye and Evaluation by the Attenuated Total Reflection Measurement

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A liquid crystal (LC) cell with alternate self-assembled films containing azobenzene dye as aligning layers was fabricated and photo-induced in-plane alignments of nematic LC molecules, 5CB, have been investigated in the cell using the attenuated total reflection (ATR) method. The ATR properties due to excitations of surface plasmon polaritons (SPP) were observed in the LC cell and sensitively changed with irradiation of linearly polarized visible light to the LC cell. The experimental results corresponded well with the calculated shifts at different alignment states. It was evaluated that the LC molecules within the penetration length of the SPP (about 130 nm) were aligned perpendicular to the polarized direction of the irradiation light, and that the tilt angle was almost 0 degree.

Keywords: self-assembled film; azo dye; LC molecule; attenuated total reflection; photo-induced alignment

INTRODUCTION

Attenuated total reflection (ATR) measurement [1] is one of the most

useful methods for evaluation of LC molecules in LC cells [2,3]. Tilt angles of LC molecules close to the aligning layers and bulk LC molecules in cells can be estimated using the surface plasmon polariton (SPP) [1] and the guided wave excitation modes (GWEM) [4]. Recently, photo-induced alignments of LC molecules using photoisomerization of azo dye have been reported [5]. However, evaluation of in-plane alignments of LC molecules utilizing the ATR method has been rarely reported until now [6].

In this report, the photo-induced in-plane alignments of nematic LC molecules, 5CB, have been investigated in hybrid LC cells prepared with alternate Direct Red 80 (DR80 : azo dye) and poly (diallyldimethyl-ammonium chloride) (PDADMAC) self-assembled films [7] on gold electrodes using the ATR measurement method. From the ATR curves, in-plane switching properties and orientation of the LC molecules were evaluated during and after irradiation with lincarly polarized light.

EXPERIMENTAL DETAIL

Figure 1 shows the Kretschmann configuration for the ATR measurement. Half-cylindrical prisms (HOYA FDS90, n = 1.85) and nematic LC molecule, i.e. 4-cyano-4'-n-pentylbiphenyl (5CB:Merck Japan Co.) were used for the measurement. Gold films of approximately 40nm thick were vacuum evaporated onto the flat side of the prism. Self-assembled films of the PDADMAC and the DR80 were deposited 10 bilayers on the gold-coated prism and a slide glass as aligning layers of the LC cell. Dipping directions of the film deposition on both the prism and the slide glass were set in the Y direction in the LC cell. DR80 contains azo groups and has been used for photo-induced alignment of LC molecules [7]. PDADMAC is used to prepare well-defined self-assembled films. In-plane alignments of the LC molecules due to photoisomerization of DR80 have been investigated during and after irradiation of polarized light of the halogen lamp at 300W.

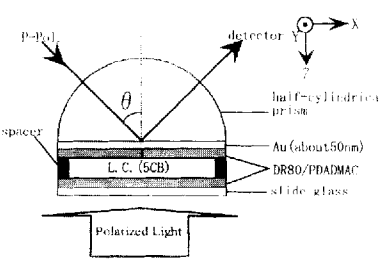

Figure 1 The Kretschmann configuration for the ATR measurement.

RESULTS AND DISCUSSION

Figure 2 shows the experimental ATR properties in the region of the resonant angles of the SPP for the LC cell. Dotted line was measured before irradiation of the linearly polarized visible light. Open circles 1 to 4 were each measured sequentially after one-hour irradiation of the visible light, where the angles between the x-axis of the cell and the polarized direction of the irradiated light (θ_D) were set to be 0°, 30°, 60° and 90°, respectively. The results showed that the ATR measurements were very sensitive to the irradiation of the polarized light, which induced orientations of the LC molecules in the cell. The changes of ATR curve due to the irradiation were repeatedly observed. The resonant angles of the SPP increased with polarization angle θ_D from 0° to 90°. Solid curves in Fig.2 show the calculated ATR properties corresponding to the experimental ones. It was evaluated that the in-plane alignments of the LC molecules within the penetration length of the SPP (130 nm) were aligned perpendicular to the polarized direction of the irradiation light, and that the tilt angle was almost 0 degree.

Figure 3 shows the reflectivity change at 70.9° of the fixed angle in the ATR measurement as a function of the irradiation time of the linearly polarized light. The LC cell was heated locally to about 40 ℃

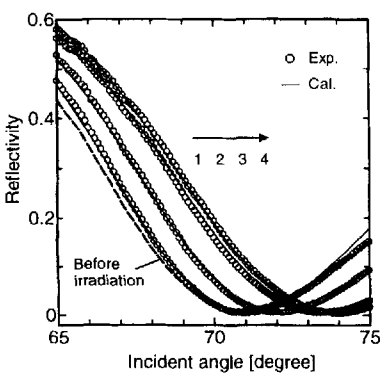

Figure 2 ATR curves for the LC cell during and after irradiation of the polarized light at θ_D = 0, 30, 60 and 90°.

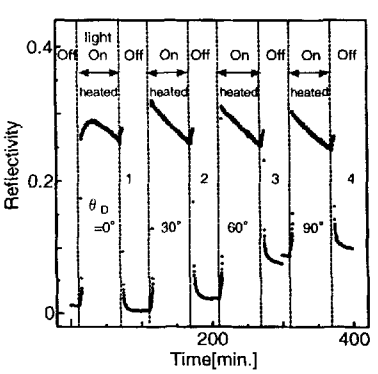

Figure 3 Reflectivity change caused by irradiation of the polarized light at fixed angle 70.9° in the ATR property.

during the irradiation making the LC layer isotropic. This also enabled the irradiated light to pass through the LC layer all the way to the self-assembled film on the prism side. The proof of these lies on the fact that the reflectivity increased (shift in ATR curve to higher angles) whenever the irradiated light was on, and decreased when it was turned off. It was considered that the photoisomerization of DR80 molecules induced the reflectivity changes during the light irradiation. Thus we ascertained that the reflectivity changes with polarized angles θ_D and that the photo-induced alignments on the LC cell were mainly due to reorganization on the self-assembled films.

CONCLUSION

Photo-Induced alignments of LC molecules on alternate self-assembled films containing azobenzene dye were evaluated using the ATR measurement. The ATR properties sensitively changed with re-orientations of the LC molecules by means of irradiation with linearly polarized visible light. In-plane alignments of the LC molecules could be controlled by the polarized direction of the irradiated light used for photoisomerization of the azobenzene dye in the self-assembled films.

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