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SHORT COMMUNICATIONS

Optical Writing Effect for Liquid Crystalline Polymer/ Photoisomerizable Molecule/Low Molecular Weight Liquid Crystal Ternary Composite System

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Recently, there has been a great deal of interest in composite systems consisting of liquid crystalline polymer and low molecular weight liquid crystal.[1–4] These composite systems comprise a side chain type liquid crystalline polymer (SCLCP) and a low molecular weight liquid crystal (LMWLC) which is miscible with SCLCP. Adding a photoisomerizable molecule to the composite system gives a rewritable optical storage effect.[5]

Our study has been conducted on the ground of these previous researches. This paper will focus on two experimental results; 1) to strengthen the aggregation of the ternary system by developing an induced smectic component system in order to realize a high contrast and improved memory characteristics, 2) to achieve fast optical write by using the third harmonic generation (THG) of YAG laser.

EXPERIMENTAL

Figure 1 shows the chemical structures of the side chain type liquid crystalline polymer (PS6EM),[6–8] photoisomerizable molecule (MPABB), and low molecular weight liquid crystal (5OCB).

A phase diagram for the composite system was determined from the measurements of differential scanning calorimetry (DSC), polarizing optical microscopy (POM), and X-ray diffraction.

The PS6EM/MPABB/5OCB ternary system was sandwiched between two indium tin oxide

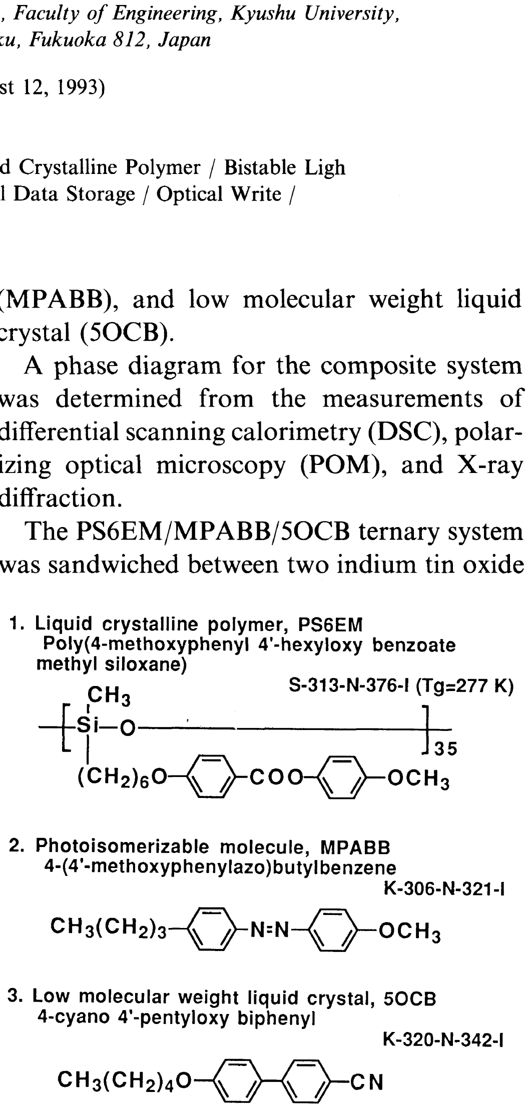

Figure 1. Chemical structure of components.

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(ITO) coated glass substrates. The gap between two electrodes was set at 20 μm by using a PET film spacer. After applying an ac electric field to the cell, the transmitted light intensity was measured by using a photodiode with a collection angle of 0.56 degree, the incident light source was a He–Ne laser. To photoisomerize the MPABB, an ultraviolet (UV) light (365 nm, 1.4 mW cm^{-2}) and visible light (VIS) (over 420 nm) from a 100 W high-pressure Hg lamp were irradiated to the cell for 30 minutes. Specific bright lines of the Hg lamp were selected through proper color filters (UV-D35 and L-42, Toshiba Co., Ltd.).

RESULTS AND DISCUSSION

Figure 2 shows the phase diagram of the ternary composite system. Equimolecular (monomer unit was regarded as a single molecular unit for SCLCP) composites composed of the SCLCP having mesogenic groups with weak polar end and LMWLC with strong one were prepared to stabilize an induced smectic phase. The composite system should be in the smectic phase to provide a stable memorized state. The ternary composite system with 40/10/50 mol% of PS6EM/MPABB/5OCB showed a smectic phase within a wide temperature range.

The light transmittance-frequency characteristics for the PS6EM/MPABB/5OCB (40/10/50 mol%) composite system is shown in Figure 3. The transmittance was measured with decreasing the frequency at 344 K. An electric field of 3.75 $MV_{rms}\,m^{-1}$ was applied to the cell for 1 minute at each frequency. The photoisomerizable molecules, MPABB used in this study isomerize from *cis* to *trans*-form upon irradiation of VIS light or thermal energy, and *trans* to *cis*-form upon UV light. Therefore, the configuration of MPABB is *trans*-form in the cell which is virgin or irradiated with the VIS light. They isomerize into *cis*-form when the cell is irradiated with UV light.

When an ac electric field is applied to the cell, two forces act on the liquid crystal molecules, one is an electric (ionic) current effect, which tends to disturb the molecular alignment. The ionic current induces a turbulent flow in the main chain of LCP. This turbulent flow collapses a well-organized smectic layer into many small fragments and causes a

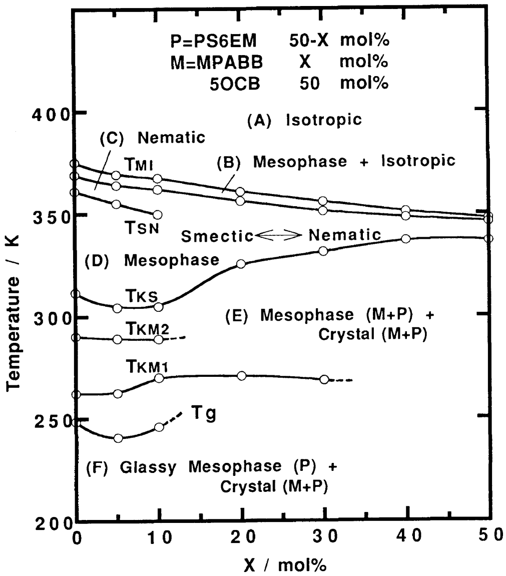

Figure 2. The phase diagram of the PS6EM/MPABB/5OCB composite system.

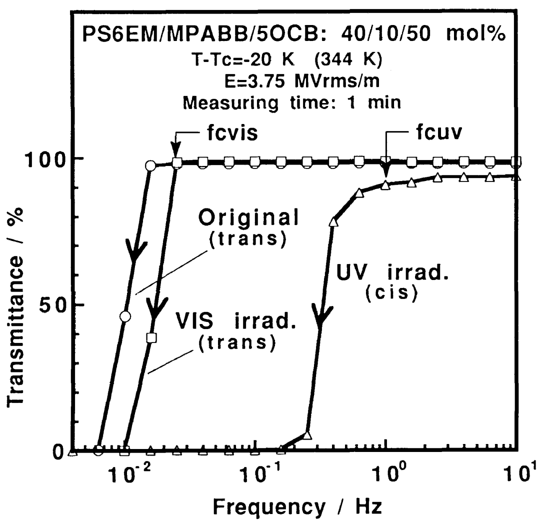

Figure 3. Transmittance–frequency characteristics upon irradiation with UV and VIS light.

turbid, light scattering state. The magnitude of ionic current effect is proportional to 1/(frequency). The other force is an electric field effect which tends to align liquid crystal molecules well. The electric field effect is independent of the frequency of the applied electric field. If the frequency of applied electric field is lower than a critical value, the electric current effect is stronger than the electric field effect, then the cell becomes turbid. However, when an electric field with a frequency above a critical value is applied, the cell is a transparent state. The contrast ratio between the transparent and turbid states was about 300 for the PS6EM/MPABB/5OCB(40/10/50 mol%) composite system.

When the configuration of MPABB is a *trans*-form, the liquid crystal molecules and mesogenic groups of SCLCP in the smectic layer are packed tightly in a lateral direction and a higher power is required to destroy their alignment. The critical frequency upon irradiation with VIS light, $f_{c,VIS}$ of the transparent-turbid transition is, therefore, low. When the MPABB is *cis*-form, the bulky shape of the MPABB molecules induces structural defects in the smectic layer. Since such disordered structure is easily destroyed by the ionic current effect, the critical transition frequency upon irradiation with UV light, $f_{c,UV}$ is high.

For an actual optical writing process, the cell is forced into the transparent state by applying a 1 kHz electric field at first. Second, the frequency of applied electric field is kept between $f_{c,VIS}$ and $f_{c,UV}$. Third, the cell is irradiated with UV light and changes from transparent to turbid state.

We reduced optical write time with the third harmonic generation (THG) of a YAG laser as a light source. The YAG laser used was a Q-SW attached pulse laser (Continuum, NY-60, 20 mJ per pulse). The flashing frequency of the YAG laser was 50 Hz. The beam diameter was spread to 50 mmϕ with a concave lens in order to prevent the heating effect of the YAG laser.

It was found that transmittance of the cell changed from transparent to turbid state in 3 seconds though it had taken over 10 minute to perform the optical write with a high-pressure Hg lamp of 1.4 mW cm^{-2}.[5]

SUMMARY

The optical writing characteristics for the (liquid crystalline polymer/photoisomerizable molecule/low molecular weight liquid crystal) ternary composite system were improved. A reading contrast ratio of 300 was realized by using an induced smectic component system to strengthen the aggregation of the ternary system. By means of YAG laser, an optical writing time was remarkably reduced to a few seconds, which is about 1/200 in the case of a conventional system using a high-pressure Hg lamp.

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