Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Layer-Structured Photorefractive Composite Containing Nematic Liquid Crystal(E7)-C_{60}-PVK (Poly(N-Vinylcarbazole))

Su-An Choi [a] , Junho Mun [b] , Choon Sup Yoon [b] & Jong-Duk Kim [a]

[a] Department, of Chem. Eng., KAIST, 373-1 Kusong-Dong, Yusong-gu, Taejon, 305-701, Korea

[b] Department, of Physics, KAIST, 373-1 Kusong-Dong, Yusong-gu, Taejon, 305-701, Korea

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 1999, Vol. 337, pp. 329-332
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SU-AN CHOI[a], JUNHO MUN[b], CHOON SUP YOON[b] and JONG-DUK KIM[a]

[a]*Department. of Chem. Eng and* [b]*Department. of Physics, KAIST, 373–1 Kusong-Dong, Yusong-gu, Taejon, 305–701, Korea*

We present layer-structured photorefractive composite which contains nematic liquid crystal(E7), C_{60} and PVK(poly(N-vinylcarbazole)). The evolution of the grating formation in composites was probed by a He-Ne laser.

Keywords: Photorefractive; Liquid crystal; Two-beam coupling gain

INTRODUCTION

Photorefractive(PR) effect is defined as the modulation of the index of refraction in response to an optically induced charge distribution. The reversible holographic grating formation in PR material has potential applications in optical data processing, optical data storage, optical computing and several other areas[1]. Recently a variety of PR materials have been developed and proposed[2,3,4]. Each of them has its own design strategy to improve optical quality, PR performance, and commercial availability. Dye doped nematic liquid crystals as a PR composite have been investigated

extensively for the last couple of years because liquid crystals possess many unique physical, optical, and electro-optical properties[5].

In this paper, we propose a novel type of PR composite in which sensitizer(C_{60})-doped nematic liquid crystal is injected between charge transporting layers.

EXPERIMENTAL

Poly(N-vinylcarbazole) (PVK) as a photoconductor and fullerene(C_{60}) as a photosensitizer are commercially available and were pruchased from Aldrich. The nematic liquid crystal mixture E7 was obtained from Merck.

The PVK photoconducting layer was spin coated onto indium-tin-oxide glass substrates. The C_{60} concentration used in this study was 0.05% by weight relative to E7. The schematic geometry of layer-structured PR composite and two beam coupling experiment are shown in Fig. 1.

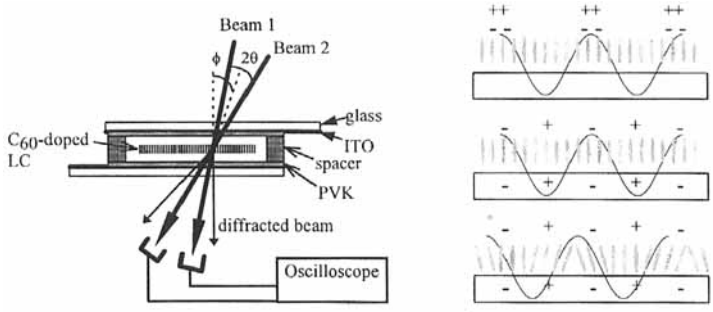

FIGURE 1. Schematic illustration of layer-structured PR composite and geometry of 2BC($\theta = 3.17^{\circ}$, $\phi = 33.17^{\circ}$ Λ(grating spacing) = 5.72μm).
FIGURE 2. Illustration of orientational photorefractive grating formation in LC molecules(right).

Holographic gratings are written by irradiation of two laser beams from a linearly polarized He-Ne laser operating at 632.8 nm. The energy transfer

between two beams is observed by monitoring the intensity of one beam when the other beam is switched on and off while the field is applied. Two beams of almost equal intensity of 5mW were not focused and had a diameter of 2 mm at the sample surface. In Fig. 2, the process of holographic grating formation in the PR composite used in this study is illustrated.

RESULTS AND DISCUSSION

Since in this study, $\Lambda^2 >> d\lambda$ (d: cell gap, λ: optical wavelength of writing beams), the diffraction is of Raman-Nath type. Therefore we were able to observe the transmitted inputs (±1 beams) and their diffractions (±3 beams) in the exit side of the LC cell.

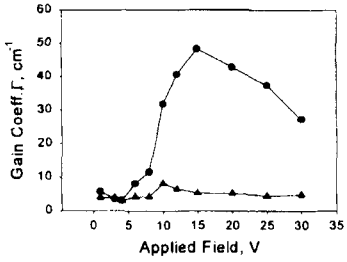

FIGURE 3. Gain coefficient as the applied dc filed (●; Case 1, ▲; Case 2).

In order to confirm the effect of PVK layer, we compared the gain coefficient of the sample cell with PVK layer (Case 1) to the sample cell without PVK layer (Case 2). Fig. 3 shows the electric field dependence of the gain coefficient for the two cases, which was measured by two beam coupling method. It is clear that the more stable asymmetric energy exchange in two beam coupling occurred in Case 1 than in Case 2. Since the PVK layer may play a role of a charge transporter and provide trapping sites, it is expected that stable energy exchange would take place in the sample with a PVK layer.

As shown in Fig. 3, the gain coefficient shows a maximum at a certain field strength. It seems odd that the gain coefficient decreases at higher field strength. The change in birefringence of the sample cell as a function of external dc field was investigated and it was found that the dependency of the birefringence of the liquid crystal on external field was almost same as that of the gain coefficient. Since the gain coefficient is directly proportional to the birefringence of the liquid crystal, the variation of the gain coefficient would follow suit to that of the birefringence. The diffraction from the sample cells used in this study is of the Raman-Nath type and the first-order diffraction efficiency is expressed as $\eta \approx (\Delta n \pi d/\lambda)^2$. Using the equation and four-wave mixing measurements, the refractive index modulation Δn was estimated to be 1.02×10^{-3}. The large refractive index modulation comes from the modulation of the birefringence of the liquid crystal through the spatially periodic poling effect.

CONCLUSION

A novel type of orientational PR composite consisted of photoconductive polymer layer (PVK) and liquid crystal doped with charge generating molecule (C_{60}) was presented. The two beam coupling gain coefficient of the sample cell containing the photoconductive layer was much larger than the sample cell without the photoconductive layer.

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