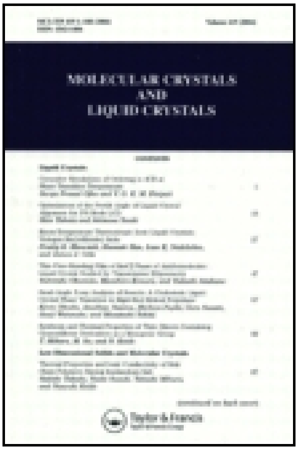

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Temperature Dependence of the Electro-Optical Properties of the (Polymer/Liquid Crystal) Composite Film for Projection Display

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TEMPERATURE DEPENDENCE OF THE ELECTRO-OPTICAL PROPERTIES OF THE (POLYMER/LIQUID CRYSTAL) COMPOSITE FILM FOR PROJECTION DISPLAY

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Abstract The (polymer/liquid crystal:LC) composite film having continuous liquid crystal domains in a three dimensional spongy network of polymer network shows a light transmission - light scattering upon on electric field ON and OFF states, respectively. The composite film can be used as a light valve for active matrix display. The electro-optical properties of the composite film strongly depended on the temperature of panel and the physical properties of the polymer matrix of the film. The orientation of the LC was anchored by the interface between LC and polymer.

INTRODUCTION

In recent years, new types of liquid crystal display which contrast based on light scattering have been emerged.[1-3] The (polymer/liquid crystal) composite film having continuous liquid crystal domains in a three dimensional spongy network of polymer network shows a light transmission - light scattering upon on electric field ON and OFF states, respectively. The composite film can be used as a light valve for active matrix display. The contrast of the composite film based on the light scattering of the composite film. The light scattering of the composite film is basically caused by mismatch in the refractive indices of the matrix polymer and liquid crystal molecules and also the spatial distortion of the nematic directors in the three dimensional polymer network.[3] The transmission of the composite film upon an electric power ON state is influenced by the relationship in mismatch of ordinary refractive index and refractive index of matrix polymer. It is expected that the electro-optical properties of the composite shows the temperature dependence, because the physical properties of the liquid crystal and polymer depends on the temperature. And the thermal stability of the composite film is very important for the projection display using high power lamp. The composite film-projection display derived by thin film transistor has a potential for new type TV.[4-6]

In this study, the temperature dependence of the electro-optical properties, such as deriving voltage, hysteresis, voltage holding ratio and contrast ratio of the composite film was investigated. And also, the change of the electro-optical properties of the composite film according to the variation of physical properties of the polymer was investigated.

EXPERIMENTAL

The (polymer/liquid crystal) composite films were prepared by using the polymer induced phase separation method starting from a homogeneously mixed solution of nematic liquid crystal (TL205: T_{NI}, 87°C) and prepolymer (PN393) having a photoinitiator. As a crosslinking agent, trimethylolpropane triacrylate(TMPTA) was used. The weight percent of the liquid crystal in the composite film was 80 all of the cases. After sandwiching the mixture between two transparent glasses coated with indium thin oxide, polymerization was initiated by UV radiation from a high-pressure mercury source. He-Ne laser(wavelength 632.8nm). was used as a light source to measure the electro-optical properties of the composite film. The refractive indices of the LC and polymer was measured by Abbe refractivemetory.

RESULTS & DISCUSSION

Figures 1 and 2 show the temperature dependence of the voltage versus transmittance of the (PN393/TL205) and (PN393/TMPTA/TL205) composite films respectively. The voltage versus transmittance(V-T) curves of composite film at 20, 40, 60 and 70 ° C seen in Figures 1 and 2 show different shapes. And the driving voltage of the composite films in figures 1 and 2 showed maximum at 40 °C. The variation of the diriving voltage of the composite film in figure 1 larger than that of composite film in figure 2. The driving voltage of the liquid crystal cell usually decreases with the temperature under the nematic phase because the viscosity of the liquid crystal decreases with the temperature. The temperature dependence of the driving voltage of the composite film might be influenced by the matrix polymer in the composite film.

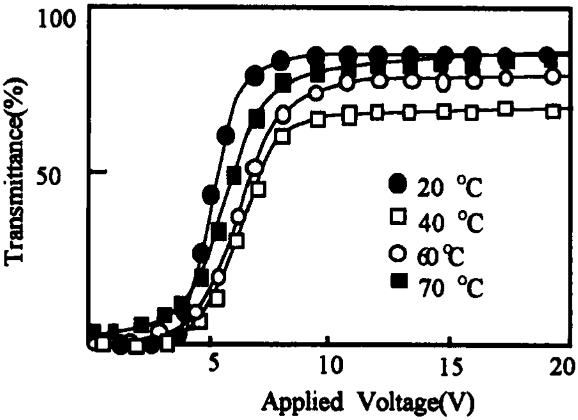

FIGURE 1 Applied voltage-transmittance curve for the (PN393/TL205=20/80 wt%) composite film

Figure 3 shows the temperature dependence of the maximum transmittance of the (PN393/TL205) and (PN393/TMPTA/TL205) composite films. The maximum transmittance of the (PN393/TL205) composite film decreased with the temperature till 40°C and then increased with temperature. But the maximum transmittance of the (PN393/TMPTA/TL205) was almost same within all range of the temperature. In traditional liquid crystal cell, for example twisted nematic cell, the maximum transmittance does not change within the nematic temperature range.

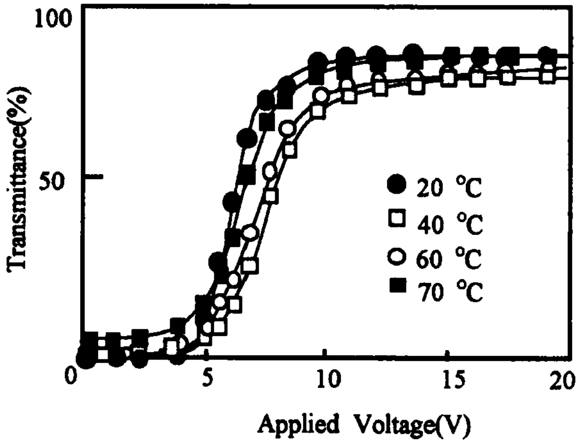

FIGURE 2 Temperature dependence of the applied voltage-transmittance curve for the (PN3 93/TMPTA/TL205=19/1/20wt%)composite film

The maximum transmittance of the composite film upon an electric field ON

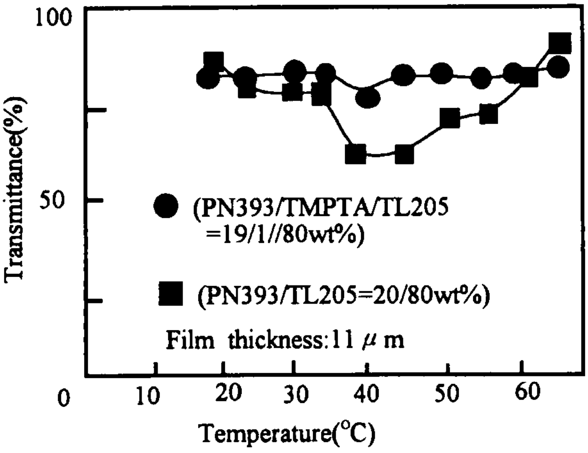

FIGURE 3 Temperature dependence of maximum transmittance of the (PN393/TL205 =20/80wt%) and (PN393/TMPTA//TL205=19/1/80wt%) composite films

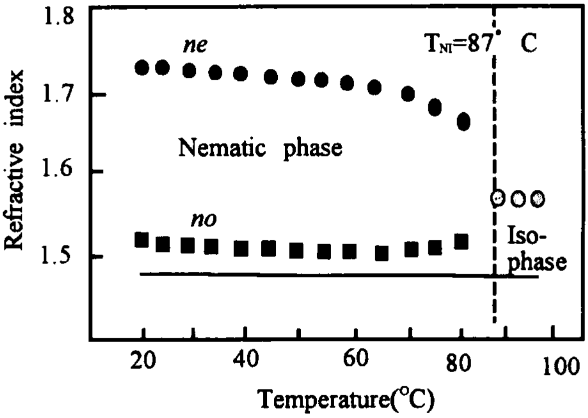

FIGURE 4 Temperature dependence of the ordinary(*no*) and extraordinary(*ne*) refractive index of TL205 and refractive index of PN 393 by Abbe refractivemetory

state is related with the magnitude of mismatich of refractive indices between LC(ordinary) and matrix polymer. If all of the LC molecule is oriented to the electric field direction in the composite under the power ON state, the light scattering by the distortion or random orientation of nematic directors will be disappeared. And then the light scattering in the composite film upon an electric field ON state happens on the interface between LC and polymer.

Figure 4 shows temperature dependence of the ordinary(*no*) and extraordinary(*ne*) refractive index of TL205 and refractive index of PN393 by Abbe refractivemetory. The refractive index of the matrix polymer,PN393, gradually decreased with temperature. The ordinary(*no*) refractive index of TL205 gradually decrease with temperature and increased after showing the maximum at 60° C. As a result, the value of mismatch between ordinary(*no*) refractive index of TL205 and PN393 showed minimum at near 60° C. Then the maximum transmittance of the composite film should appear at near 60° C. The fact that the temperature dependence of the maximum transmittance of the composite film upon an electric field ON state does not matched with the results of figure 4 means that there are another light scattering factors in the composite film upon an electric field ON state.

The maximum transmittance of the composite film may have resulted from the temperature dependence of the physical properties of LC and polymer in the composite film. Particularly, the temperature dependence of the compatability between liquid crystal and polymer on the interface can be an important factor for the electro -optical properties of the composite film. If the thickness of the interface mixed by liquid crystal and polymer in the composite film increases, the anchoring power of the polymer for the liquid crystal molecules will increase as the number of the anchored liquid crystal molecules increases. The increase of the anchoring power of the polymer for the liquid crystal molecules might be one of the reason of increase of the driving voltage and decrease of the maximum transmittance of the composite film upon an electric field ON state during the temperature increases.

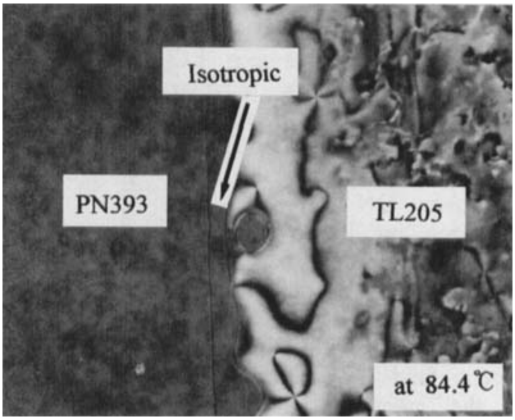

FIGURE 6 Polarizing micrograph of the composite film(polymer: PN393, liquid crystal: TL205)

The smaller variation of the maximum transmittance and the driving voltage of (PN393/TL205) composite film than that of (PN393/TMPTA/TL205) composite film can be a clue for the role of interface in the composite. Figure 5 shows the polarizing micrographic of the interface between liquid crystal, TL2 05 and polymer, PN393 at near isotropic temperature(84 °C) of TL-2 05. The picture shows the isotropic temperature of TL205 on the polymer is lower than that of TL205 which is far aparted from polymer surface. The figure 5 shows the isotropic temperature of the TL205 on the polymer wall decreased by the effect of the polymer chains in the liquid crystal because of the compatibility between PN393 and TL205. The isotropic temperature of the TL205, 84.4 °C, in the PN393was lower than that(84.9 °C) of TL205 on the crosslinked PN393 by TMPTA. This result means that the LC molecules on the PN393 more easily anchored by polymer chain than on the crossliked PN393. The anchored number of LC molecules will be increased if the compatability between TL205 and matrix polymer on the interface is increased. Then, the driving voltage of the composite film will increase as the temperature increases. The increase of the interface layer can be a decrease of the maximum transmittance of the composite film.

CONCLUSION

The temperature dependence of the electro-optical properties, such as deriving voltage, hysteresis, voltage holding ratio and contrast ratio of the composite film was investigated. The compatibility between LC and matrix polymer on the interface layer strongly affects the electro-optical properties of the composite film. The isotropic temperature of the TL205 on the matrix polymer lower than original value of TL205 and depended upon the kind of matrix polymer. It may be possible to get thermally stable electro-optical properties of the composite film by controlling the physical properties of the matrix polymer in the composite film.

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