The Injection of PDLC Solution Mixture in a Reduced Pressure

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Abstract

Polymer dispersed liquid crystal (PDLC) films consist of micro-droplets of liquid crystals dispersed in a polymer matrix. To make wide area PDLC filled devices, it is necessary to develop reliable method of vacuum injection of PDLC solution instead of the capillary injection. However, well-known 2-ethylhexylacrylate (EHA), main element of a prepolymer, exhibits the volatility problems, when the PDLC solution is placed under the low pressure. In this study, we developed the vacuum injection process to fill a wide area cell. Experimental results indicate that the V_{90} (turn-on voltage) of the PDLC cell made by a vacuum injection method are lower than that of the PDLC cell made by a capillary injection method.

1. Introduction

Polymer dispersed liquid crystal (PDLC) films have been studied for a wide variety of applications such as electrically switchable windows, optical shutters, flexible displays, diffractive optics, and photorefractive systems[1-4] due to their high light efficiency (no polarizer), easy processing (no rubbing process), wide viewing angle and flexibility. The conventional PDLC mixture is composed of 20% by weight of a prepolymer and 80% by weight of a liquid crystalline material of the type TL205 (Merck, Ltd.). The prepolymer consists of a monomer, a crosslinker, a photo initiator and a resin. In this work, 2-ethylhexyl acrylate(EHA) and 1,6-hexanediol diacrylate(HDDA) were used as a monomer and a crosslinker, respectively. Darocur4265(Ciba Inc.) was used as a photo initiator. Generally 2-ethylhexyl acrylate shows the highest vapor pressure in PDLC mixture, the initial PDLC mixture composition gradually varies to the EHA deficient composition under low pressure circumstance. So it is very difficult to get good controllability of PDLC composition at vacuum process. To avoid this problem, most PDLC cells are fabricated by using capillary filling method. However, to make wide area PDLC filled devices, it is necessary to develop reliable method of vacuum injection of PDLC solution instead of the capillary injection. In this work, we tried to develop stable vacuum injection process of PDLC solution.

2. Experimental

We fabricated empty PDLC cells and introduced homogeneous mixtures of 20% by weight of a prepolymer and 80% by weight of a liquid crystalline material of the type TL205 into a thin gap between two indium-tin-oxide (ITO) glass plates by using capillary and vaccum filling. The cell gap was controlled by using 6μm glass microsphere spacers. The films were then cured by using the UV irradiation from a mercury arc lamp for approximately 5minutes. A wavelength of the UV light is 365nm. The UV intensity was 2mW/cm^2, and the polymerization temperature was 25℃. During polymerization process, a phase separation between the liquid crystalline material and the polymer being formed takes place. The polymer-dispersed liquid crystalline phase is obtained by polymerizing.

In the case of vaccum filling, We filled the empty 80 X 80 mm cell by Dipping the cell into the mixture of TL205 and prepolymer in vaccum and enhancing pressure. And then, we heated the PDLC cell at the temperature above the phase separation temperature of PDLC before the UV curing to enhance the uniformity of PDLC cell.

The electro-optical properties of the PDLC films were measured with a He-Ne laser at 632.8nm and a photodetector. The PDLC morphology was studied using an optical microscope.

3. Results and discussion

To make PDLC filled cell under vacuum, the 50x50 mm cell was dipped into the mixture of TL205 and prepolymer in vacuum and then system pressure was gradually increased by feeding of N_2 gas. Before UV curing, the PDLC cell was heated up to the phase separation temperature of PDLC to enhance the uniformity of PDLC cell. The thermal treatment of PDLC cell, before UV curing, decreases the concentration gradient of PDLC mixture in the cell originated from the different viscosity between TL205 and prepolymer. Figure 1 shows transmission versus the applied voltage at 25℃ for the capillary and the vacuum filled PDLC cells respectively. Table 1 shows the electro-optical properties of the capillary and vacuum filled PDLC cells.

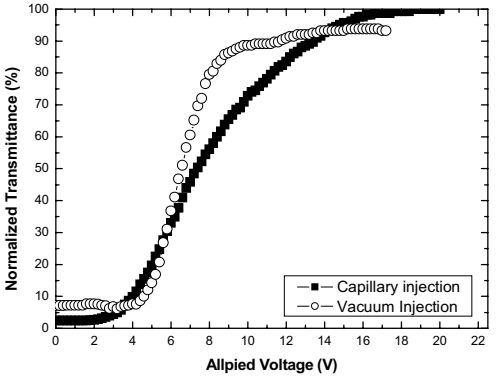

Fig. 1. Transmission versus the applied voltage at 25℃ for the capillary and the vacuum filled PDLC cells.

TABLE 1. The electro-optical properties of the capillary and the vacuum filled PDLC cells.

	Capillary filling	Vacuum filling
V10 (V)	4.25	5.04
V90 (V)	13.49	8.72
Contrast Ratio	41.09 : 1	13.13 : 1
τ_{on} (msec)	10.22	16.04
τ_{off} (msec)	66.04	75.88
t (msec)	76.26	91.92

The LC droplet sizes of the capillary and the vacuum filled PDLC cells are 1.75μm and 2.03μm on the average, respectively as shown Figure 2.

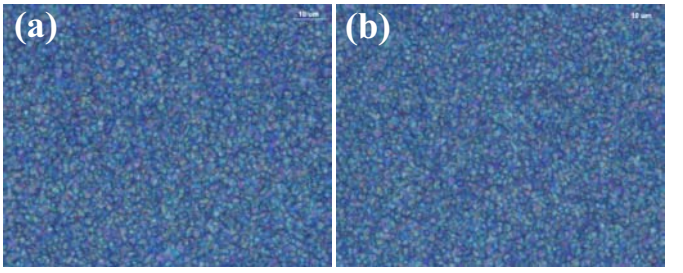

Fig. 2. The optical microscope images of (a) the capillary and (b) the vacuum filled PDLC cells. The droplet radius are (a) 1.75 μm (b) 2.03 μm.

In case of the vacuum filled cell, the V_{90} (turn-on voltage) and contrast ratio (CR) are lower than that of the capillary filled PDLC cell. The response time (τ_{on} + τ_{off}) is higher than that of the capillary filled PDLC cell. These results mean that LC/prepolymer ratio of vacuum filled PDLC cell is relatively higher than one of capillary filled PDLC cell because of the high volatility of the EHA monomer during the vaccum filling. Also, the decreased V_{90}, CR and the increased response time in the vacuum filled cell comparing with the capillary filled cell are because the LC droplet size of the vacuum filled sample is bigger than that of the capillary filled sample. As the LC/prepolymer ratio in the vacuum filled PDLC cell is increasing, the LC droplet size is increasing. Consequently, the V_{90} and CR of vacuum filled cell are decreased and the response time is increased in vacuum filled cell comparing with the capillary filled cell. The steep incliantion of the vacuum filled PDLC cell in V-T curve is probably due to the increased LC droplet size.

Figure 3. shows Off/On-state operating pictures of the vaccum filled PDLC cell.

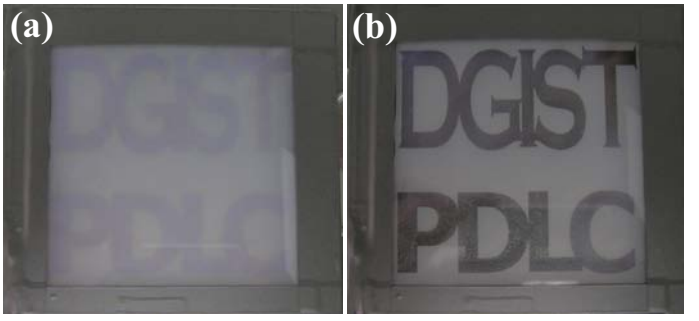

Fig. 3. (a) The Off-state(0V) picture and (b) the On-state(10V) picture of the vacuum filled 80x80 mm PDLC cell.

4. Summary

In this work, we fabricated PDLC cells which is introduced homogeneous mixtures of 20% by weight of a prepolymer and 80% by weight of a liquid crystalline material of the type TL205 into a thin gap between two indium-tin-oxide (ITO) glass plates by using capillary and vaccum filling. The vaccum filled PDLC cell works at relatively low V_{90} of 8.72V comparing with the capillary filled PDLC cell. And the decreased V_{90}, CR and the increased response time in the vacuum filled cell comparing with the capillary filled cell are due to the bigger LC droplet size of the vacuum filled cell than that of the capillary filled cell according to the increased LC/prepolymer ratio in the vacuum filled PDLC cell. We successfully fabricated a PDLC cell showing V_{90} of 8.72V by using vacuum filling process. This work was supported by the Korean Ministry of Science and Technology (MOST) research fund.

5. References

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