The Investigation of flexible flat display in improving flexibility

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Abstract

In this study, it was mainly focused on the mechanism and reliability performances of PI/PET composites after many times of curving. We developed a new process of spacer for flexible display to improve the maintenance of cell gap. This new process used the laser carving technology, which is widely applied on printing press, to produce the pattern of spacers and shaped both of the alignment film and spacers simultaneously by press of pattern. Assembling the spacer-shaped film and plastic substrates together well and it shows an excellent performance on the maintenance of cell gap and reliability of curving.

1. Introduction

A plastic substrate for display, having little coloration and excellent in optical characteristics, heat resistance, resistance to thermal coloration and mechanical properties, and a display element using the same are provided. The development of flexible, th in displays is a much sought-after goal, and has attracted a great deal of research effort.[1–5] By inte grating, for example, the high information content of a traditional flat-panel liquid-crystal display ~ LCD! into a thin, flexible sheet of plastic, one co uld obtain a durable, lightweight product suitable for many applications in the growing market of p agers, cell phones, and personal digital assistants ~PDAs!, as well as future "electronic paper." By eliminating the need to rely on thin and fragile gl ass substrates, flexible displays should also bring benefits in the form of improved manufacturing yi eld, large area display capability, and lower mater ial and production costs. Flat panel displays represented by a liquid crystal display, an organic EL display, a plasma display, an electronic paper etc. are showing rapid growth as display elements for example in a flat panel television, a computer monitor, a notebook personal computer, a mobile telephone, and a car navigation device, exploiting features of a thin structure, a light weight, a low electric power consumption and the like. Glass has been employed as a substrate material for such display elements. However, glass is associated with drawbacks such as a large weight because of a high specific gravity, a difficulty in forming a thin substrate as it is easily cracked because of low impact strength, and a lack of flexibility. A display utilizing a plastic substrate is being actively developed principally in the liquid crystal display and the organic EL display, since such plastic substrate enables a thin and light-weight structure and is anticipated to lead to a flexible display.

2. Experimental

The PI solutions were coated onto original PET sheet and developed a new process of spacer for flexible display to improve the maintenance of cell gap. [Fig.1]. Then, the spacer-shaped film and plastic substrates together well and it shows an excellent performance on the maintenance of cell gap and reliability of curving successfully. A scanning electron microscopy (JEQL JSM-6300) was observing the morphologies of spacer-shaped film. In order to show anti-pressure durability of the spacer-shaped films were stability. To measured the spacer-shaped film of PI/PET composites at enhanced load. The spacer-shaped film of PI/PET composites was measured from 0 to 5060g for 1min.

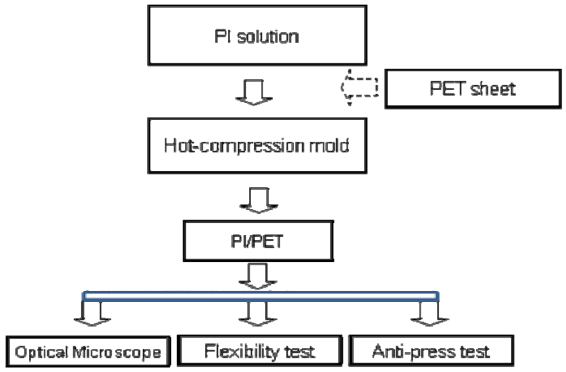

Fig. 1 The flowchart of spacer-shaped film formed on the PI/PET composite.

3. Results and discussion

3.1 Effect of temperature and pressure on spacer-shaped film formed for PI/PET composites.

The gap of LCD panels usually is between 5~20μm, and for getting shaped-well spacers in all panels we expected, we could control it by cloth shedding machine. Firstly, we could use the hot-compression-molded processes to produce the spacer for flexible display. In Fig. 2 was shown different pre-cured temperature (80℃, 110℃ and 130℃) on PI/PET composite. In Fig. 2(a), after 80℃ pre-cured, it was found remaining PI solution still at mold after main-curing. We obtained that it made the difficult forming of spacer, postpones time of main-curing and cost to advance. In addition, after 110℃ pre-cured, it was found that the easy forming of spacer after main-curing was shown in Fig. 2(b). Furthermore, it was found the PI cured ahead of time, caused the difficult forming of spacer. On the other hand, it also tended to lead to the happening of the PET plastic substrate warping phenomenon on high-temperature process, which was show in Fig. 2(c). Warping happened due to Tg temperature of PET, which has already exceeded in the high-temperature procedure. Consequently, in this process we could found that 110 degree Centigrade of pre-cure temperature was suitable for processing.

The morphology of the composites was very important for the cell gap at different temperature. In Fig. 3, the SEM morphologies showed that the height of the spacer-shaped on the PI/PET composites was decreased with increasing temperature. The height of the spacer-shaped was obviously as the temperature was raised (Table 1) for the PI/PET composites.

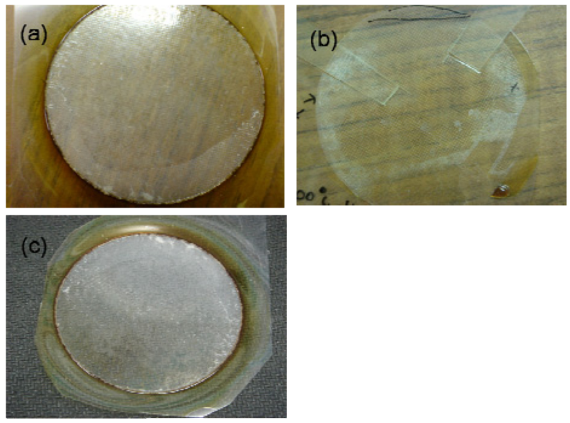

Fig. 2 Photographs various temperature of spacer-shaped film formed for PI/PET (pressure: 20 Kg/cm^2) composites. (a) 80℃ ; (b) 110℃ ; (c) 130℃.

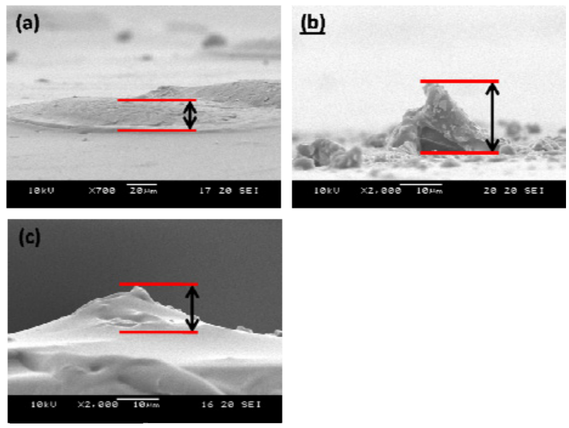

Fig.3 SEM morphologies various temperature of spacer-shaped film formed for PI/PET (pressure: 50 kg/cm^2) composites. (a) 60℃ ; (b) 130℃ ; (c) 150℃.

Table 1 Height of the spacer-shaped film at different temperature for PI/PET (pressure: 50 kg/cm^2) composites.

Temperature(℃)	Height of spacer-shaped (μm)
60	20.1
130	17.85
150	10.66

3.2 Effect of pressure on spacer-shaped film formed for PI/PET composites.

In Fig. 4 and Table 2 were shown that the height of spacer as a function of pressure for PI/PET composites with various pressures was observed. As the pressure becomes lower, the spacer-shaped film of PI/PET composite is lower. As we increase the pressure to 60 kg/cm^2, the height of spacer-shaped film also becomes higher. When the pressure is up to 80 kg/cm^2, the height of spacer-shaped film is about 17.8 μm. When comparing with other pressure of spacer-shaped film, there is no apparent change of height. Base on previous result, we could suggested that the spacer-shaped film of PI/PET composite between 15~18 μm.

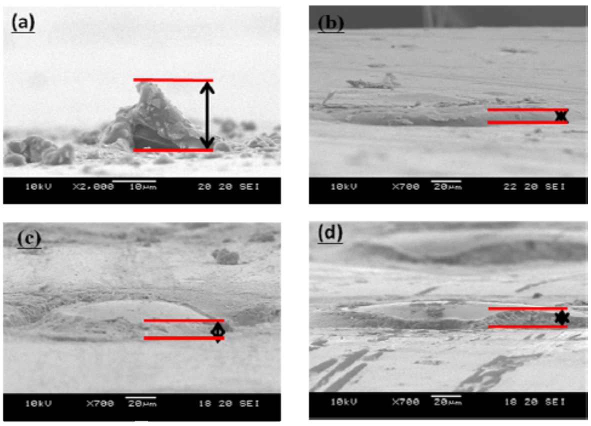

Fig.4 SEM morphologies various pressure of spacer-shaped film formed for PI/PET (temperature:130℃) composites. (a) 50 kg/cm^2 ; (b) 70 kg/cm^2 ; (c) 90 kg/cm^2 ; (d) 110 kg/cm^2.

Table 2 Height of the spacer-shaped film at different pressure for PI/PET (temperature :130℃) composites.

Pressure (kg/cm^2)	Height of spacer-shaped (μm)
50	16.67
70	15.1
90	18
110	17.8

3.3 Anti-pressure durability and curving measurement for spacer-shaped films of PI/PET composites.

In this investigation, it was mainly focused on the mechanism of spacer-shaped film formed for the PI/PET composites, which were passed through the anti-pressure durability and the reliability performances after many times of curving. The testing results of composites were shown in Table 3 and Fig. 5. It confirmed that developed a new process of spacer for flexible display to improve the maintenance of cell gap. And then, the PI/PET composites with the spacer-shaped films had the same height of spacer-shaped. Because the spacer-shaped films owned better anti-pressure durability, the height of spacer-shaped will be controlled well. Assembling the spacer-shaped film and plastic substrates together well, an excellent performance on the maintenance of cell gap and reliability of curving will be shown in the Fig. 6.

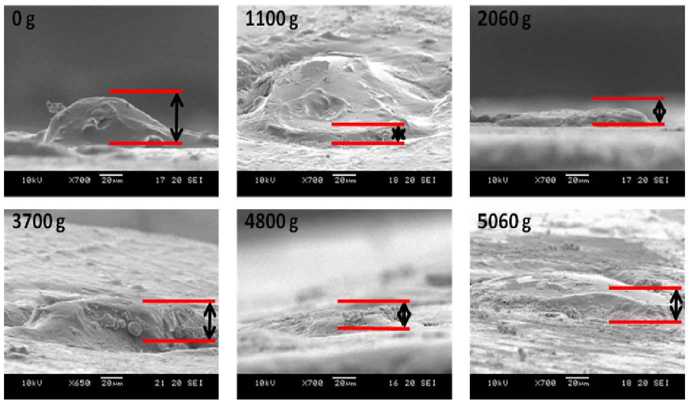

Fig. 5 SEM morphologies various load of spacer-shaped film formed for PI/PET (130℃; 110 kg/cm^2) composites.

Table 3 The height of spacer-shaped film formed at different load for PI/PET (130℃; 110 kg/cm^2) composites.

Load (g)	Height of spacer-shaped (μm)
0	17.8
1100	14.88
2060	13.33
3700	18.8
4800	18.1
5060	18.21

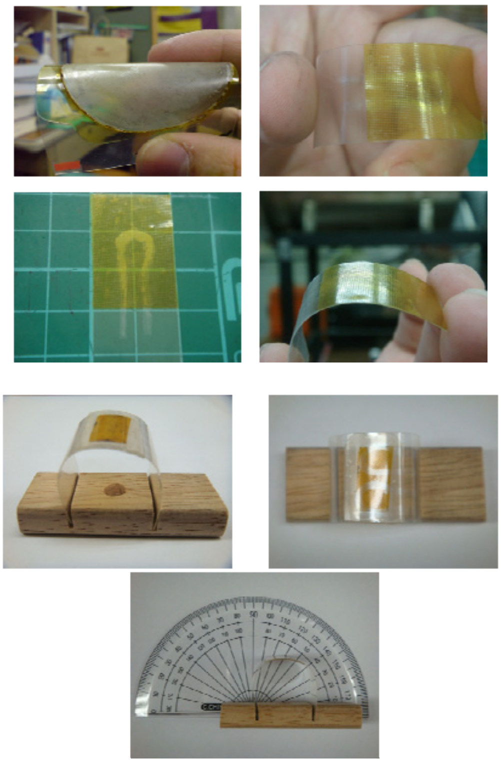

Fig. 6 Reliability curving measurement for spacer-shaped films formed of PI/PET composites.

4. Summary

In this study, it was mainly focused on the mechanism and reliability performances after many times of curving. We developed a new process of spacer for flexible display to improve the maintenance of cell gap. In this process, it was found that 110 degree Centigrade of pre-cure temperature was suitable for processing. Compare other pressure of spacer-shaped film, there is no difference. It was suggested that the spacer-shaped film of PI/PET composite between 15~18μm. Assembling the spacer-shaped film and plastic substrates together well and it shows an excellent performance on the maintenance of cell gap and reliability of curving, successfully.

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5. References

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