Low Reflection Automotive Display for Driving Safety

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ABSTRACT

Driving Safety requires high performance display possessing a good readability under high brightness ambient light. In order to improve the visional effect, a specially designed module structure was applied to OLED display so the reflectivity can be reduced to an excellent value of 0.918%.

1 INTRODUCTION

As more and more vision was occupied by the continuously developing display, people keep pursuing more fantastic and peculiar presentation, which promote new technical display development greatly. Owing to its flexibility, high NTSC, and extremely high contrast ratio, OLED is widely used in many areas such as artificial reality, mobile phone, wearable devices [1-2]. Undoubtedly, automotive market was also attracted.

Automotive display applications have a wide market prospect. It can apply to car dashboard, CID(car information device) and rear view mirror etc. Each panel used in automotive field is much more expensive than the one used in consumption field although they are in the same size. While strict specification on reliability was required for driving safety at the same time. How to improve reliability of automotive panel is a challenge for every display manufacturer.

However, OLED display shows pool visional effect under high brightness ambient light comparing with LCD since the metal electrode surface of OLED display has a high reflectivity. Intense reflection is a serious drawback especially for automotive application against driving safety. Reflectivity of OLED Panel was 40~50% which was only about 5% of LCD [3]. In order to reduce the reflectivity of OLED panel, circular polarizer was used to alleviating reflection in general, which lead to serious reduction of brightness.

A strong demand for touch control should be considered especially for CID. If module has touch function, the reflectivity of module will be very bad. The big difference in refraction coefficient between the material of touch sensor film and other films will augment reflection. Fig.1 show normal structure of module and reflectivity of each film. R3 and R4 that caused by touch film has a large reflectivity value.

In this study, Reflectivity of module with touch function can reach excellent value of 0.918% that can satisfy requirement of automotive display.

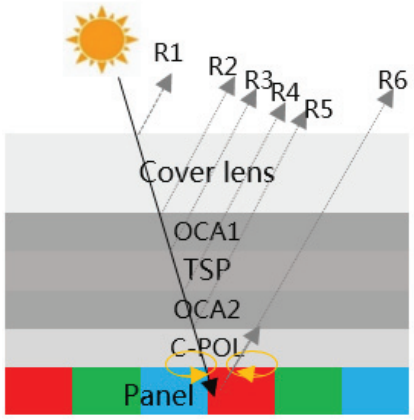

Fig.1 Module structure with touch function reflectivity of each film

2 EXPERIMENT AND RESULTS

In order to decrease the reflectivity of OLED display, a series of experiments were conducted. S1 series modified refraction coefficient of partial module materials to lessen the refraction coefficient difference of the two materials in contact. The structure of S1 is shown in Fig.2.

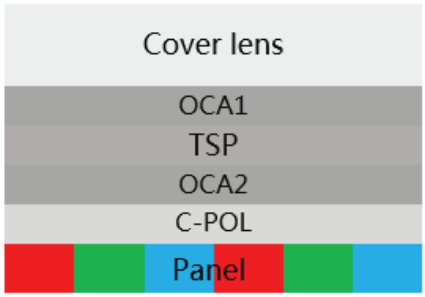

Fig.2 Module structure of S1 Series

According to Fresnel reflection equation, the lower refraction coefficient discrepancy was reached, the lower reflection can be achieved.

As shown in table 1, the reflectivity of S1-1 and S1-2 module structures are 1.787% and 1.698% respectively. S1-2 has a good compatibility in refraction index between contacted layers comparing with S1-1, therefore S1-2 shows a better performance on reflectivity.

Table 1. Reflectivity result of Series 1 module structure

Structure Type	Reflectivity (%)
S1-1	1.787
S1-2	1.698

Fig.3 shows the reflectivity spectra of S1-1 and S1-2. S1-2 shows a lower reflectivity in short wavelength. However human eye is insensitive to short wavelength, thus the reflection difference between two structures can't be recognized.

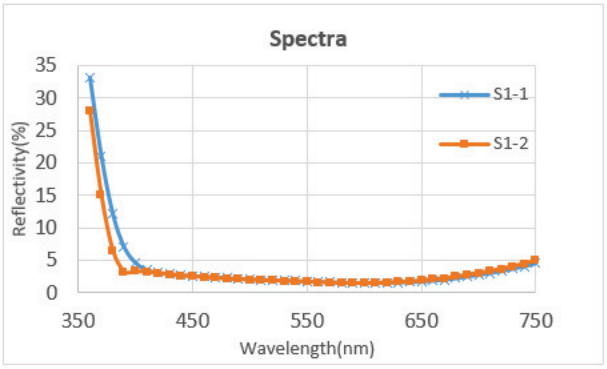

Fig.3 Reflectivity Spectra of Series 1 module structure

Fig.4 shows the actual performance of Series 1 module structure under ambient light. The figures are photographed from different viewing angle including perpendicular and horizontal direction. The actual observation of S1-1 and S1-2 shows a rare difference because of the small reflectivity difference.

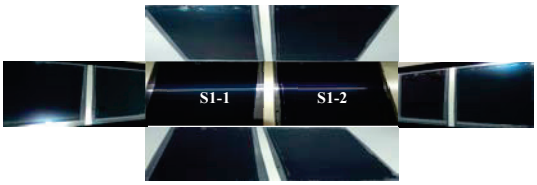

Fig.4 Performance of Series 1 Module Structures under Ambient Light

Refraction index of touch sensor has an obvious difference compared with other module materials in module structure. In order to achieve lower reflectivity of OLED display, series 2 structures were constructed. The structure of S2 is shown in Fig.5.

New structures modified the sensor material and the sequence of layer stack. S2-1 and S2-2 use same touch sensor material, while S2-3 and S2-4 applied different materials.

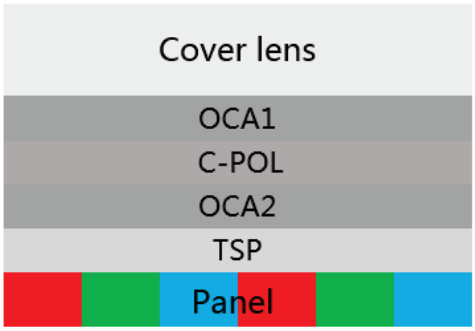

Fig.5 Module structure of S2 Series

Table 2 demonstrated the reflectivity of series 2 module structures. Reflectivity of S2-1 to S2-4 is 11.956%, 9.832%, 0.918%, 0.981%, respectively. S2-1 and S2-2 has a very high reflectivity in contrast to S2-3 and S2-4. Since the anisotropy of touch sensor in S2-1 and S2-2 weakened the extinction capability of polarizer.

Table 2. Reflectivity result of Series 2 structure

Structure Type	Reflectivity (%)
S2-1	11.956
S2-2	9.832
S2-3	0.918
S2-4	0.981

Fig.6 show the reflectivity spectra of Series 2. Reflectivity of S2-1 and S2-2 is higher than S2-3 and S2-4 during the whole wavelength range. Spectra of S2-1 and S2-2 fluctuate in visible light range especially in long wavelength.

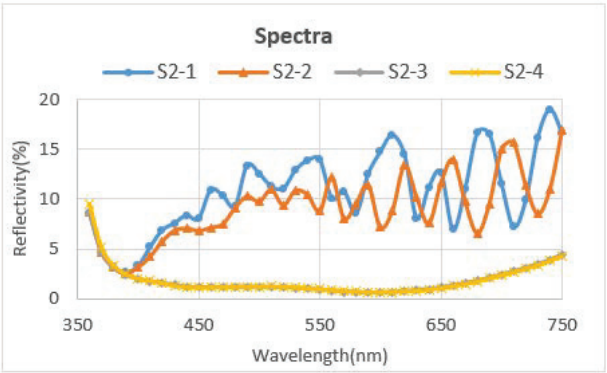

Fig.6 Reflectivity Spectra of Series 2 Module Structure

Fig.7 shows the actual performance of series 2 module structures under ambient light from perpendicular and horizontal direction. S2-1 and S2-2 has a poor visional effect from any direction coinciding with previous measure

result. S2-3 and S2-4 has excellent visional effect from front or any other viewing direction.

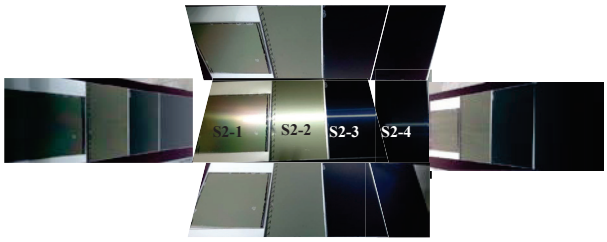

Fig.7 Performance of Series 2 Module Structures under Ambient Light

3 CONCLUSION

In conclusion, the relationship between module structure and reflection of OLED display is investigated in this work, which makes a contribution to outdoor readability research of OLED display. Based on theorem of Fresnel reflection and optical anisotropy of module material, S4-3 structure is designed and gets a very low reflectivity of 0.918%. OLED displays with low reflectivity provide a good display performance under ambient light, resulting in more safety driving environment.

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