# Double Sheets Hybrid Compensation for VA LCDs

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## Abstract
*Accompanied by the demand of thin type TV, the application of the TFT LCD display device is more and more extensive. The key material which influences the optical performance of the TFT LCD is optical film. Due to the rapid development of the big size TFT LCD for the recent years, the supply has been unable to meet the demand for its relative material. Therefore, we bring up a alternate choice—the hybrid compensation film which could not only show well optical performance, but also lessen the quantity of usage in TAC in order to make the optical film free of shortage.*

## 1. Objectives and Background
Due to the tremendous growth of the global market share in TFT LCD for the recent years, the supply has been unable to meet the demand for its relative material. For instance, the backlight tube,optical film, glass.…etc. For the aspect of optical film, the significant material TAC used as protecting PVA is also facing the condition that the supply is unable to meet the demand. In the TN mode TFT LCD, its optical film—SWV film ,has developed from outside attached to the polarizer to directly attached to PVA layer of the polarizer ,which could decrease the quantity of usage in TAC.(See Fig. 1).

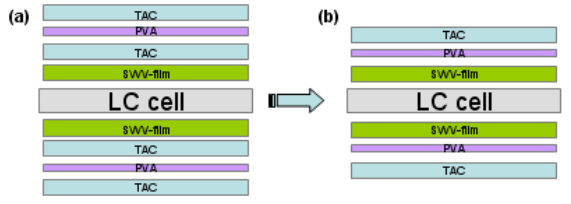


**Fig 1. Structure of the TN mode TFT-LCDs with wide-view film. (a)convential wide-view film, (b)current wide-view film.**

Because the area of TV product is several times to the middle-small size one like monitor and notebook, the quantity of TAC used in optical film had a big progress. It accelerated the speed of TAC supply which tends to shortage. In 2005, in order to decrease the quantity of usage in TAC ,the polarizer vendor offered compensation film with other material like COP film (see Fig.2).

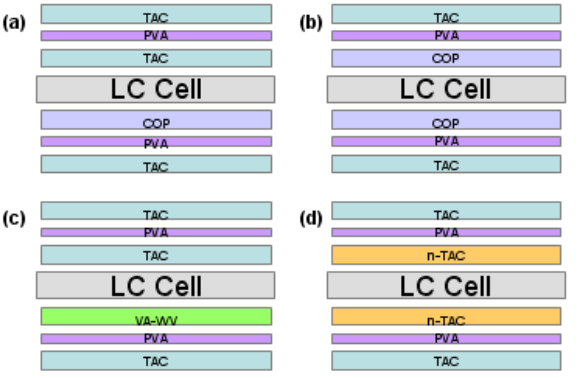


**Fig 2. Structure of the VA mode TFT-LCDs with compensation film.(a)single sheet COP film, (b)double sheets COP film, (c)single sheet VA-WV film, (d)double sheet n-TAC film.**

From the above alternative choices of compensation film material could substantially decrease the quantity of usage in TAC. Using double sheets compensation film could lowers the quantity of TAC at most among the above choices (See Fig.2(b), 2(d)). However, double sheets COP film and double sheets n-TAC have their own defects to overcome. The material of COP film is resin and it's not easy to be affected by the environment and to come into existence the corner mura. Furthermore, it has more precise axial orientation in stretch process, so it has better performance of contrast ratio and view angle. But color shift is relatively serious due to its material characteristic. On the other hand, the material of n-TAC has the advantage of simple process.

Because of the lower precision of axial orientation, its contrast ratio and view angle would be inferior compared with COP material. Besides, it's easily to be affected by the environment and cause severe phenomenon of corner mura.

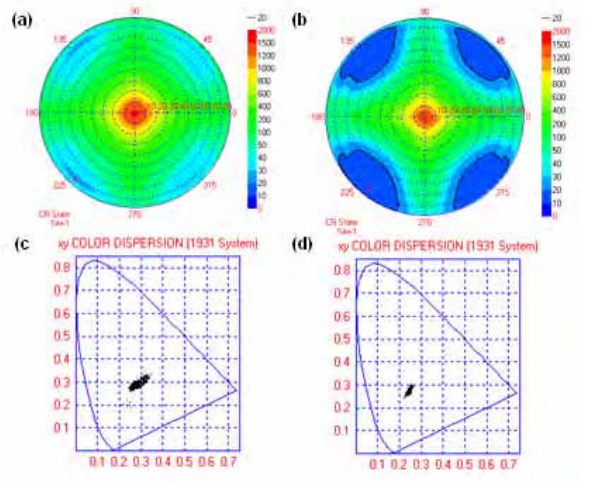


**Fig 3. The contrast ratio viewing cone and black color shift performance. (a)(c)COP film, (b)(d)n-TAC film.**

Fig.3(a) shows the contrast ratio viewing cone of COP compensation film. We highlight contrast ratio =20 contour ,and it can reach full cone contrast ratio more than 20. Fig.3(b) is viewing cone of n-TAC film. The broken area (CR<20) appears in obliqge direction. Fig.3(c), 3(d) show the black color shift performance of COP and n-TAC film. The color coordinates distribution disperses seriously with COP film, which means acute color shift in black color will present with COP film.

## 2. Experimental procedure

Because COP and n-TAC film all have their own defects in their optical characteristics, if we could combine them with each other, we will get the optical characteristics between the both. In this experiment, we chose three kinds of compensation film--COP film, n-TAC film, VA-WV film to combine mutually and then to compared the result of the optical characteristics.

See the experimental combination as Fig.4.

Fig. 4(a), 4(b) are the original double sheets compensation film. Fig.4(c) is the hybrid compensation with COP and n-TAC film. Fig. 4(d) shows the hybrid compensation with n-TAC and VA-WV film.

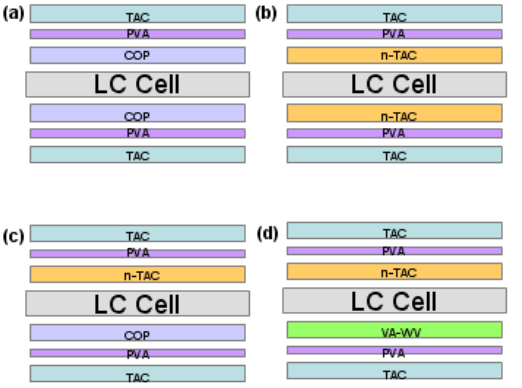


**Fig 4. The structure of the VA mode TFT-LCDs with double sheets compensation. (a)COP +COP film, (b) n-TAC + n-TAC film, (c) n-TAC + COP film, (d) n-TAC + VA-WV film.**

## 3. Results

### 3.1. Optical performance

The viewing angle performance sees Fig.5(a) ~5(d). Double sheets COP films gets the best performance of view angle among the combination. The next one is hybrid compensation combined by n-TAC and COP film. The third one is double sheets n-TAC films. Hybrid compensation combined by n-TAC and VA-WV film gets the worst.

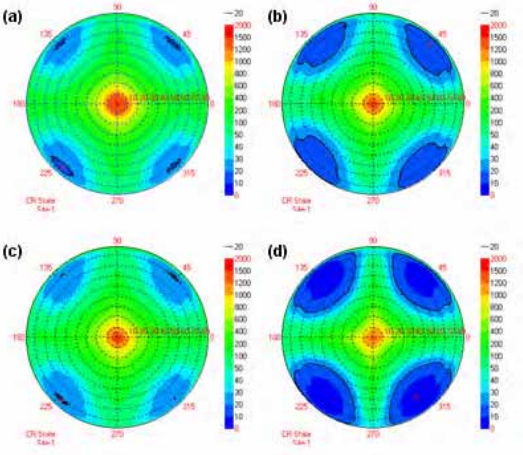


**Fig 5. The contrast ratio viewing cone performance of double sheets compensation. (a)COP +COP film, (b) n-TAC + n-TAC film, (c) n-TAC + COP film, (d) n-TAC + VA-WV film.**

Currently VA-WV film provided by Fujim film is single sheet compensation film, thus its Rth value isn't suitable for the combination of hybrid compensation, which could be meet to our expectation as well. The part of color shift in the black color, the performance of hybrid compensation combined by n-TAC and COP film is pretty good (polar angle $\theta$ = 60 deg , azimuth angle $\varphi$ = 0～360 deg). The performance of its color shift almost does well as same as double sheets n-TAC compensation and gets rid of the severe color shift that uses double sheets COP compensation. See the result as Fig. 6

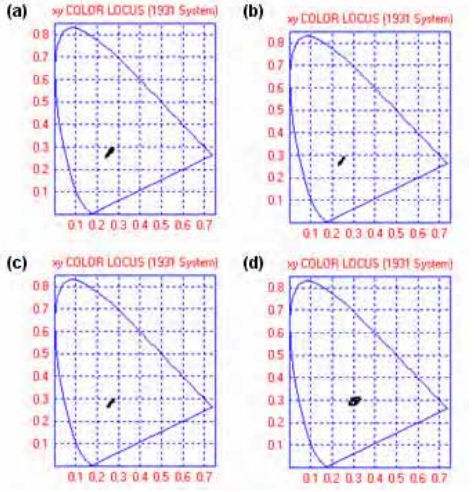


**Fig 6. The black color shift performance of double sheets compensation. (a)COP +COP film, (b) n-TAC + n-TAC film, (c) n-TAC + COP film, (d) n-TAC + VA-WV film.**

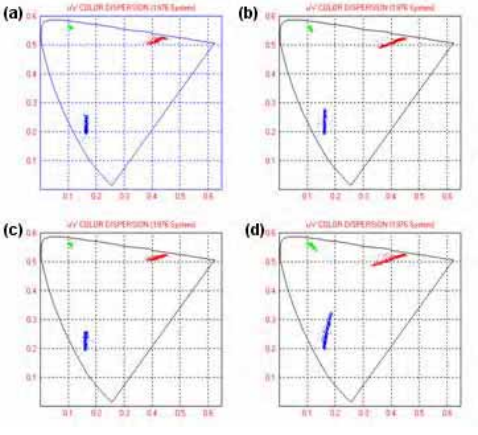


**Fig 7. The RGB color shift performance of double sheets compensation. (a)COP +COP film, (b) n-TAC + n-TAC film, (c) n-TAC + COP film, (d) n-TAC + VA-WV film.**

Fig.7 shows the RGB color shift of double sheets compensation. The performance of hybrid compensation combined by n-TAC and COP film is excellent and getting rid of severe color shift that uses double sheets n-TAC compensation RGB.

**Table 1.** Summary of the optical performance

| | Double COP | Hybrid compensation | Double n-TAC |
|---|---|---|---|
| CR | ◎ | ○ | △ |
| Vie angle | ◎ | ○ | △ |
| Color shift (black) | △ | ◎ | ◎ |
| Color shift (WRGB) | ◎ | ◎ | △ |
| NTSC | ○ | ○ | ◎ |

Table 1 shows the summary of the overall optical performance. As we use double sheets compensation by COP film, we'll get excellent performance of contrast ratio and viewing angle, but serious color shift. Comparatively , as we use n-TAC for double sheets compensation, we'll get great color shift performance but lower contrast ratio and viewing angle. By using combination of n-TAC and COP film for hybrid compensation, we get good optical performance over all optical characteristic.

### 3.2. Visual evaluation

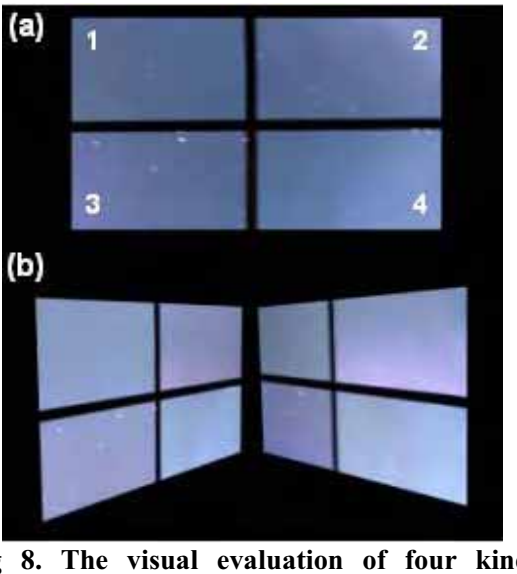


**Fig 8. The visual evaluation of four kinds double sheets compensation. 1(a)~4(a) are the**

**front viewing angle, (b)is the side viewing angle. [1(a) n-TAC + COP film , 2(a) n-TAC + VA-WV film, 3(a) COP+ COP film, 4(a) n-TAC + n-TAC film.]**

Fig.8 shows the visual evaluation. In the front viewing angle, there is almost no different between four kinds of double sheets compensation. By using double sheets COP film for compensation, it appears reddish in the left and right side viewing angle. When we use hybrid compensation made by combination of n-TAC and COP film or double sheets n-TAC film for compensation, less color shift as the viewing angle changed.

## 4. Conclusion

By using the hybrid compensation made by combination of n-TAC and COP film ,we could retain the advantage of COP film—contrast ratio and viewing angle. We could also get good optical performance by using n-TAC to lower the degree of black color shift. Besides, for the acquirement of optical film source, we could relief TAC from the phenomenon of supply less than demand by decreasing the quantity of usage in TAC.

## 5. Acknowledgements

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## 6. References

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