A Novel Pixel Structure for High Transmission TFT-LCD

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Keywords : Transmittance, Column Spacer, Storage Capacitance

Abstract

We have developed a LCD Panel that form storage capacitance for pixels between pixel electrode of bottom glass and common electrode of top glass. This method could make higher transmission and higher production yield than before by removing storage electrode line and capacitance on the bottom glass by simplifying bottom pixel structure.

1. Introduction

TFT-LCD usually forms the storage capacitance in etch pixels for improving display quality badness with flicker, cross-talk, stain and so on. These storage capacitance (Cst) generally reduces the aperture ratio of pixel because it is made by overlap with common electrode line crossing pixels and pixel electrode on the bottom glass. This Cst is responsible for decreasing yield rate on the manufacturing by making complex the pixel structure especially organic inter-insulator 4mask process as well as reduce aperture area of pixels.

Usually, Liquid crystal display modes like TN, VA [1] and so on control a behavior of LC by using fringe fields between top and bottom electrode. Therefore, These LCD have a stable common electrode on the top glass. Therefore, We could use it to form storage capacitances by top and bottom electrode instead of bottom electrode only as before.

2. Column Spacer Cst Panel

Figure 1 shows the structure of Cst and It can be compare size by It's configuration type.

If we suppose the size of the reference Cst that is made by p-SiNx/g-SiNx for inter-insulator of Cst between common electrode line and pixel electrode on bottom glass is 1.0.

And compare with reference, In case of Cst that is made by PI on top and bottom electrode for controlling arrangement state of LC for inter-insulator has a size of 1.87. Therefore, the capacitance that is made by PI for inter-insulator that is lower than reference thickness of inter-insulator firm can form more greatly size of capacitance when It is formed by same area.

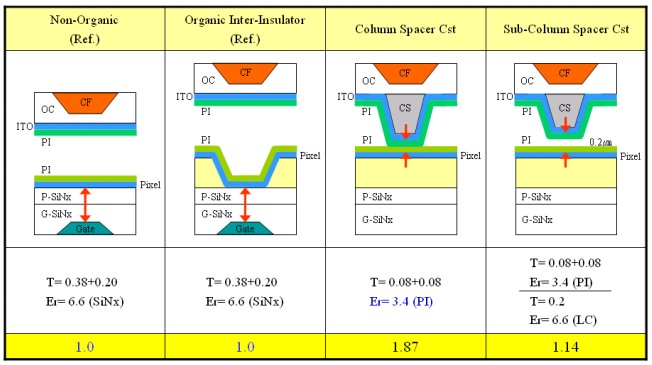


Fig. 1. The comparison of Cst size by Cst structure

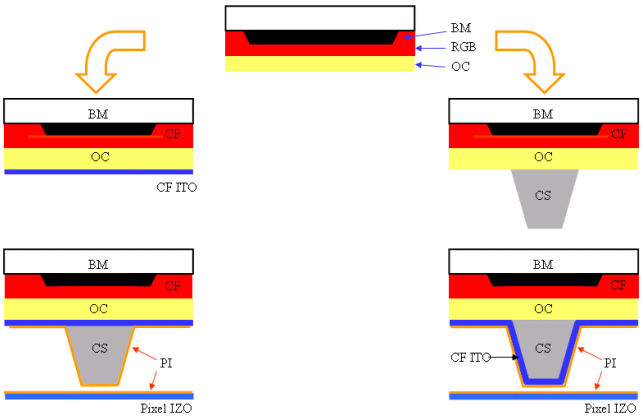
Usually, most of LCD Display has a PI on the surface of top and bottom glass for LC arrangement. It can has available role of insulation film because the thickness of PI is about 800Å individually. It means that Cst is formed between top and bottom electrode without a little leakage current.

Therefore, It is possible to form a Cst of size that is equal by smaller dimension than before in pixel as applying above method. And It can also make a improvement of transmittance by using reducing dimension of Cst to aperture area.

These new method of Cst formation is developed in process that do not need additional process compare with existing process. For this with Figure 2, We could form a Cst by using a new column spacer formation process that is changed from CS process next to CF-ITO to CF-ITO next to CS process. It means that the new column spacer process does not

need additional photo lithography process and that is just change a process order.

However, this new method avoids need of addition process for forming Cst by using column spacer using for purpose keep cell gap for LC between top and bottom electrode in TFT-LCD.



(a) (b)

Fig. 2. The comparison of CS and CF-ITO process order: (a) CF-ITO → CS, (b) CS → CF-ITO.

In case of using the one drop LC filling (ODF) process with column spacer, the contact area with column spacer and bottom glass is closely related to ODF process margin. As there have photosensitivity like column spacer has limit about elasticity in material.

Therefore, when form Cst in etch pixels using column spacer, there is shortcoming that ODF process margin is fallen rapidly because contact area with column and bottom glass increase more than 3 times.

This is the reason why we improved the Cst formation structure to have about 0.2um intervals without contacting perfectly between column spacer and bottom glass like before. This method is similar with current Sub-CS. This Sub-CS is usually used to improve smear defects in TFT-LCD when pressure was imposed from outside as do not reduce ODF process margin because do not increase contact area by keeping about 0.2um distance between Sub-CS and bottom electrode.

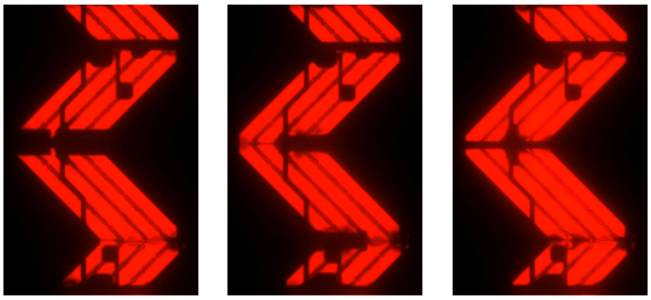
Therefore when we use Sub-CS for Cst, the size of the Cst is just 1.14 times than Ref. It is similar with Ref Cst and less than CS Cst as Figure 1.

But, because CS/Sub-CS is generally formed on none aperture area in pixels, It is still possible to increase transmittance by using Sub-CS Cst compare with reference it.

3. Results and discussion

We could make panels that is quarter 32”HD 60Hz by using new pixel structure that have Sub-CS Cst where is our R&D Line that is applying 300×400mm Glass and organic inter-insulator process.

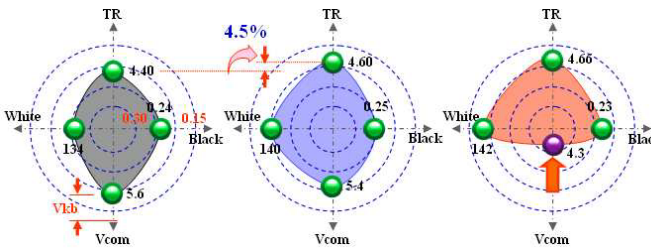
We made three kinds of panel to compare display characteristics and to confirm effect about new Cst formation method. There are (a) Reference, (b) Sub-CS Cst, (c) Cst-less panel as shown in Figure 3.



(a) (b) (c)

Fig. 3. Driving pixel images by Cst structure: (a) Reference, (b) Sub-CS Cst, (c) Cst-Less pixel

Figure 3 are pixel pictures that is three kind panels explained above sentence when is driving to red color with full gray, (a) Reference has a Cst that was formed by overlap with storage line and pixel electrode on bottom glass in center position of pixel, (b) Sub-CS pixel has a Sub-CS Cst that was formed by overlap with Sub-CS of top glass and pixel electrode of bottom glass in same position as (a), But we can get a notice that Cst size is small comparing with (a), (c) Cst-Less pixel removed Cst that was formed in pixel’s center position unlike (a) and (b).



(a) Reference (b) Sub-CS Cst (c) Cst-Less

Fig. 4. Display characteristics by Cst structure: White and black brightness, Transmittance ratio and Most suitable vcom voltage

The result of display characteristics about three kind panels is Figure 4.

As the compare about transmittance ratio, Cst-Less panel have a good result because It has a high aperture ratio in pixel design. And We could see that next is Sub-CS Cst and then Reference. However, we can get important information that the transmittance ratio of Sub-CS Cst panel was improved about 4.5% compares with Reference's.

And as the compare about most suitable vcom voltage that is approved to panel, Reference and Sub-CS Cst panel seems to each other similar but Cst-Less increased fairly. We could analyze the Cst size through Vkb voltage because It may be calculated by Cst size as usual method [2], [3]. Therefore, the result of above show us that the Cst formation method by using Sub-CS is possible because the Vkb voltage of Sub-CS Cst panel sees as similar thing with Reference's.

4. Summary

We made panels by using new pixel structure in a development line of R&D institute. It is quarter 32"HD 60Hz panel by using organic inter-insulator process. We have accomplished improvement of transmission ratio about 4.5% by new Cst forming method that could reduce size of Cst. It forms Cst between top and bottom electrode using PI by insulator film.

This method could higher transmissions and higher production yield than before by removing common electrode line crossing the pixels on the bottom glass.

Especially It could more effective in case of the pixel has high density column spacer area ratio like TFT-LCD for mobile display. It is possible to increase transmittance more than 10% by the relative ratio in case of 130PPI pixel size and diameter 28um column spacer by calculator.

(a) Reference (b) Sub-CS Cst (c) Cst-Less

Fig. 5. Display image by Cst structure

5. References

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