

The Effect of the Plasma Treatment in ITO Film to reduce impurities in LCOS Imager

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Abstract

The reflective liquid crystal(LC) imager in one panel Liquid Crystal on Silicon(LCoS) System must have the properties such as fast response time, high contrast ratio(C/R) and voltage holding ratio(VHR) which are more related to the lifetime of imager than the others. As the high-output light including a short wavelength from UHP lamp is exposed to LCoS imager, the indium metal impurities, which decrease the C/R and VHR, are diffused from ITO thin film on glass. To ensure the high reliable LCoS imager for HD projection TV, we have studied the effects of the plasma treatment on ITO film to reduce impurities in imager.

Introduction

Liquid Crystal has many applications, Mobile, Projection TV, Projector, Note PC, Near to Eye, etc. Nowadays, because of the need for higher resolution display, Liquid crystal display is more focused on many display fields. LCOS(Liquid Crystal on Silicon) is a LCD display with reflective CMOS silicon plate. There are many modes for LCOS driving, as VA, OCB, ECB, MTN, IPS modes

For display imager, LCOS must have good qualities such as high contrast ratio, high voltage holding ratio(VHR) and fast response time. Also these properties must be maintained for reliable long operational life time. Generally, LC resistivity affects the VHR, current density and power consumption. Because VHR is affected by the purities of LC, low VHR causes the voltage of a pixel image to decay with

time and gives rise to undesirable image flickering for active-matrix LC display in lower frame rate. But higher frame rate, VHR is less important than lower frame rate, it is very important factor for long operation time of cell. Especially, Reflective LC mode has a twice light pass than transmissive LC mode, It may be more sensible to UV light.

This experiments is for the Plasma Treatment to reduce impurities from ITO to sustain VHR. After Plasma Treatment with CF₄ and Ar gas, we made the LCOS Cells with Plasma Treatment Glass and compared those VHRs with no treatment Cell.

Experiments

LCOS is one of microdisplay Panel which has active driving circuits. Fig 1 shows a cross-sectional view of LCOS imager. The display size is near 0.8 inch

(Diagonal) and has 1408 X 844 resolution. It has 12um pixel pitch and 16:9 aspect ratio for HD Projection TV. Retardation Film is for reducing the color dispersion in 1 Panel LCOS system.

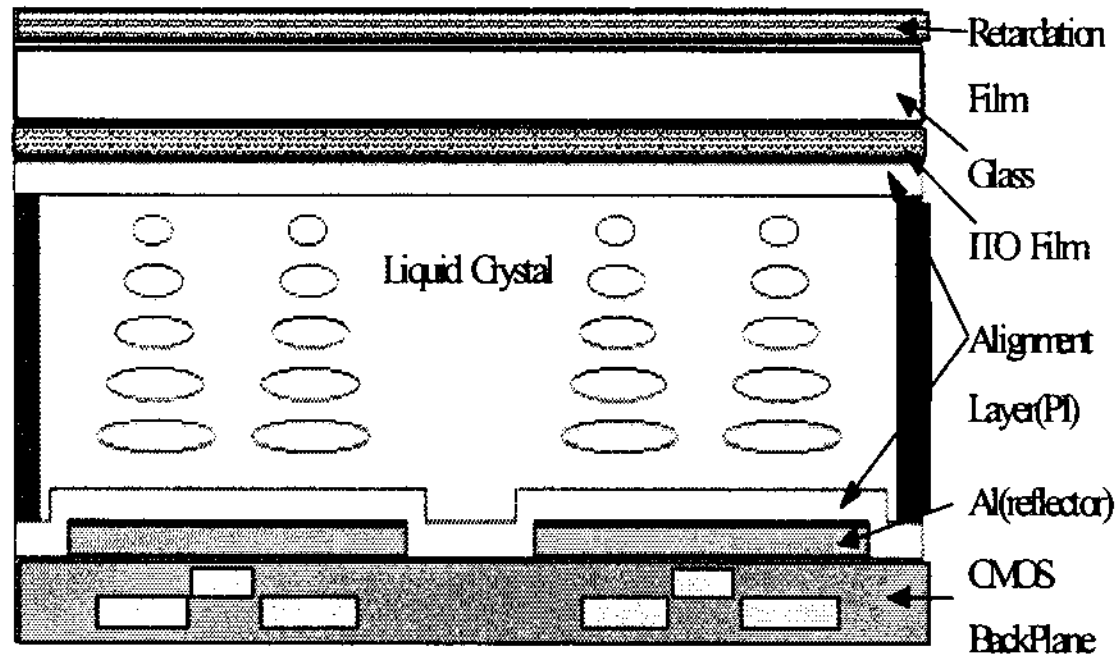


Fig. 1 Structure of LCOS imager

ITO glass and Plasma Treatment glass which is treated on ITO glass. Table 1 is the conditions of Plasma Treatment in this study. Plasma Treatment is usually used in wafer etching and cleaning process. But Some papers announce that special thin film by Plasma Treatment enhance the characteristic of original ITO film.

| | N | C22 | C24 | C62 | C64 | A22 | A24 |
|----------|----------|--------------|-----|-------|-----|-------------|-----|
| Gas | | CF4+O2 (1:1) | | | | Ar+O2 (1:1) | |
| RF power | ITO only | 200 W | | 600 W | | 200 W | |
| t(sec) | | 20 | 40 | 20 | 40 | 20 | 40 |

Table 1 Conditions of Plasma Treatment

Result and Discussion

We made the cell using the Merck LC and Nissan alignment material in same conditions. Just only glasses treated by optional Plasma Treatment are used. Table 2 shows the sheet resist of the ITO only and Plasma Treatment glasses. ITO only is the lower resistance than Plasma Treatment ITO glasses. C24,

C64 and A22 has similar resistance values.

| N | C24 | | C64 | | A22 | |
|------|------|------|------|------|------|------|
| 6.94 | 7.28 | 7.31 | 7.10 | 7.12 | 7.14 | 7.06 |

Table 2 Sheet resistance(Ω/\square) of ITO only and Plasma Treatment glasses

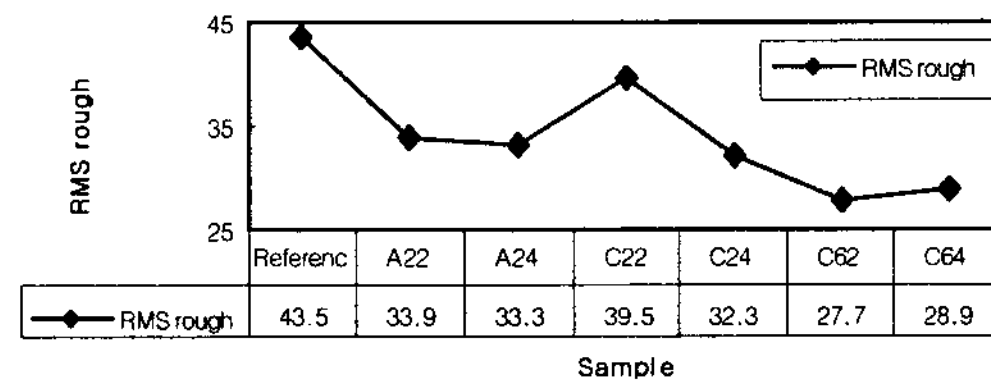


Fig. 2 Roughness by Plasma Treatment

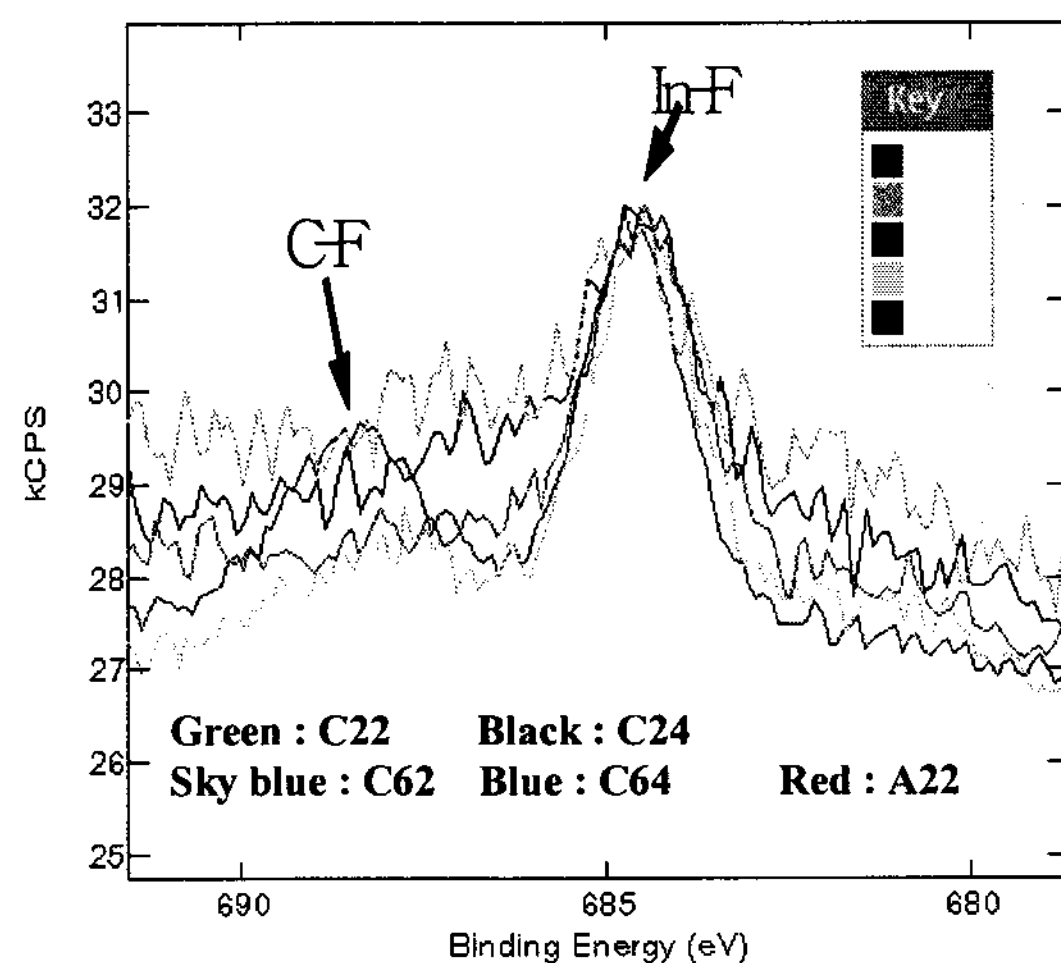
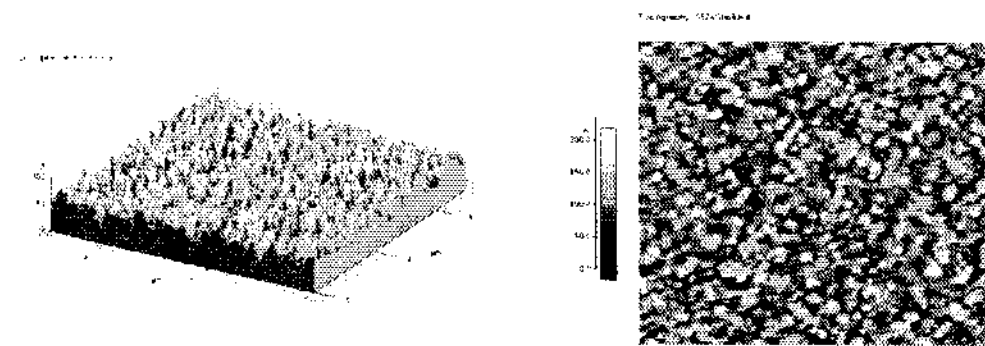


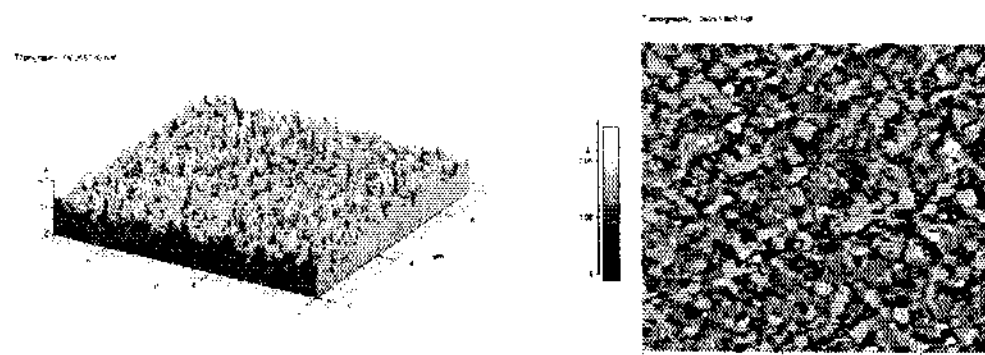
Fig. 3 XPS Spectrum for the surface of ITO only and Plasma Treatment glasses

In Fig 3, we can find that higher RF power and longer time of Plasma Treatment is applied to the ITO film on glass, higher ratio of In-Fx and C-Fx films are detected by XPS Analysis. It means that new films, In-Fx and C-Fx, are made easier as the high plasma power to help preventing the impurities attack to LC from the ITO. So, the impurities which may occur from ITO, after long

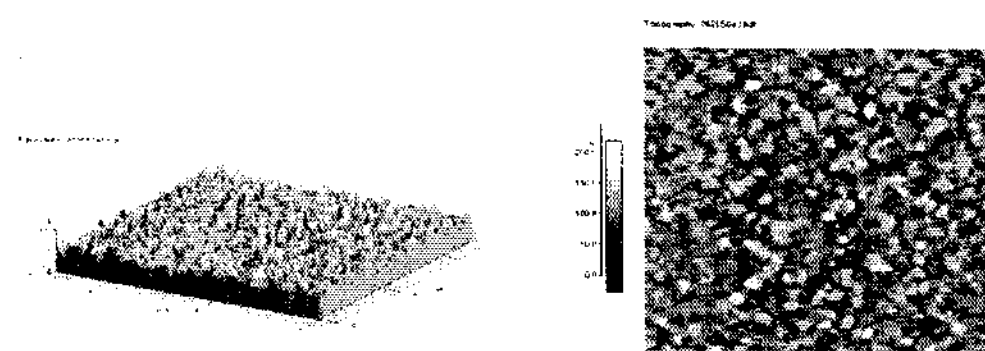
operating times, reduce the VHR and Contrast Ratio. Lower RF Power, only In-F film is produced. But in Ar Plasma Treatment, In-F detected is due to residual F from previous CF4 Plasma Treatment. Plasma Treatment is also good to reduce the roughness of surface. As RF power and time are increased, the roughness of surface is smoother.



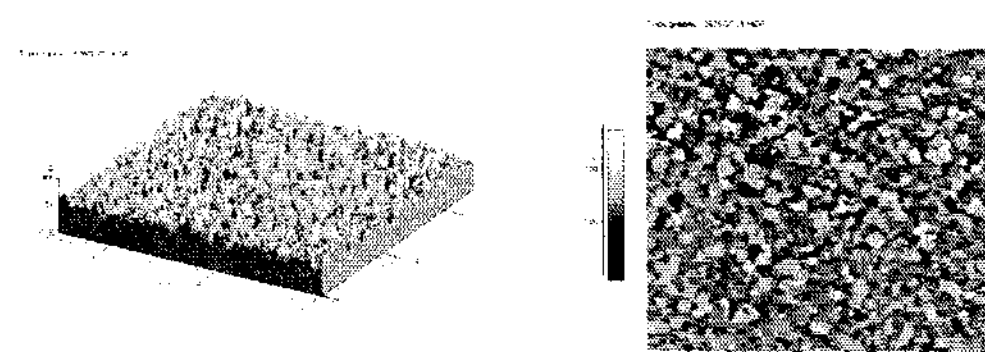
(a) No Treatment(ITO)



(b) CF4 Plasma Treatment(200W, 40sec)



(c) CF4 Plasma Treatment(600W, 40sec)



(d) Argon Plasma Treatment(200W, 20sec)

Fig.4 Surface after Plasma Treatment(AFM)

So, we tried to find the effect of film to prevent of impurities from ITO. We made the 2um cellgap LCOS imager. Fig. 6 is the test schematic diagram of long term testing with UV test. First, we tried to acceleration test cell exposed to Lamp without UV-IR Cut filter(Direct Condition). The result is Fig.5. We used the Merck LC and Nissan PI Alignment method is rubbing method.

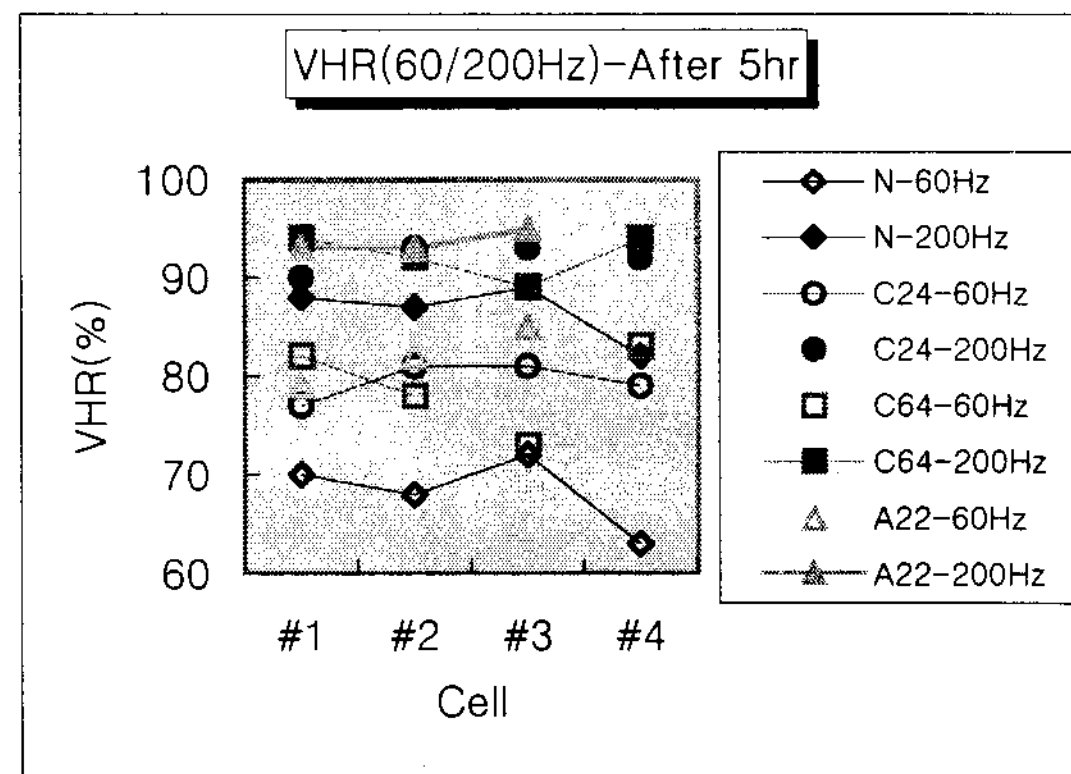


Fig. 5 VHR after Acceleration UV Test

We find that the C64 is higher VHR condition in 60Hz/ 200Hz by Autronic Melcher VHR Meter. Now also, tried long term test as shown Fig 7.

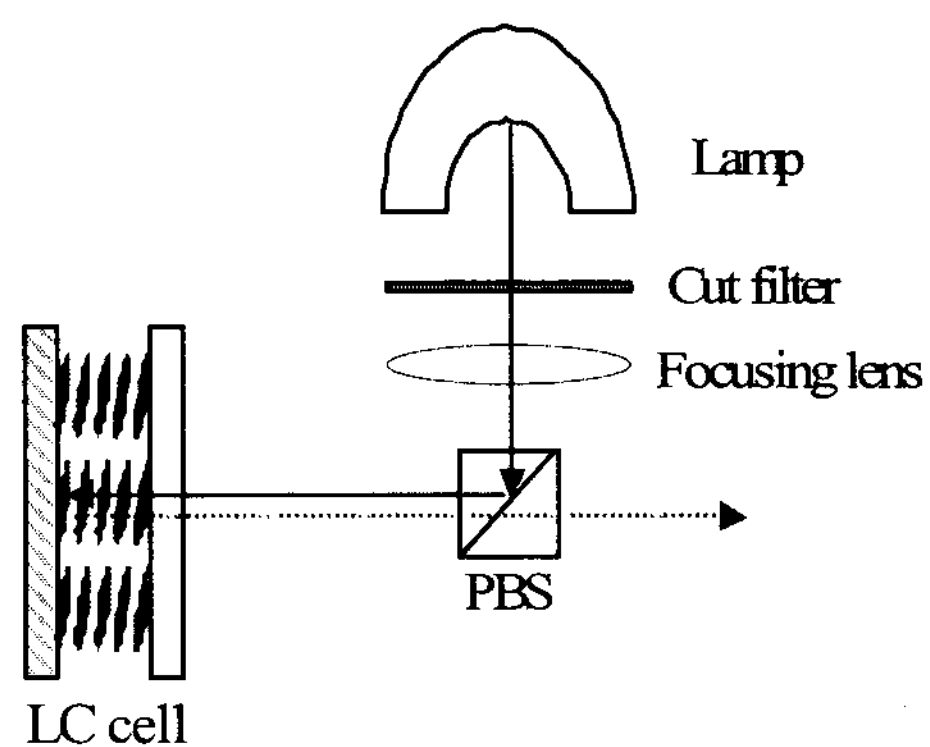
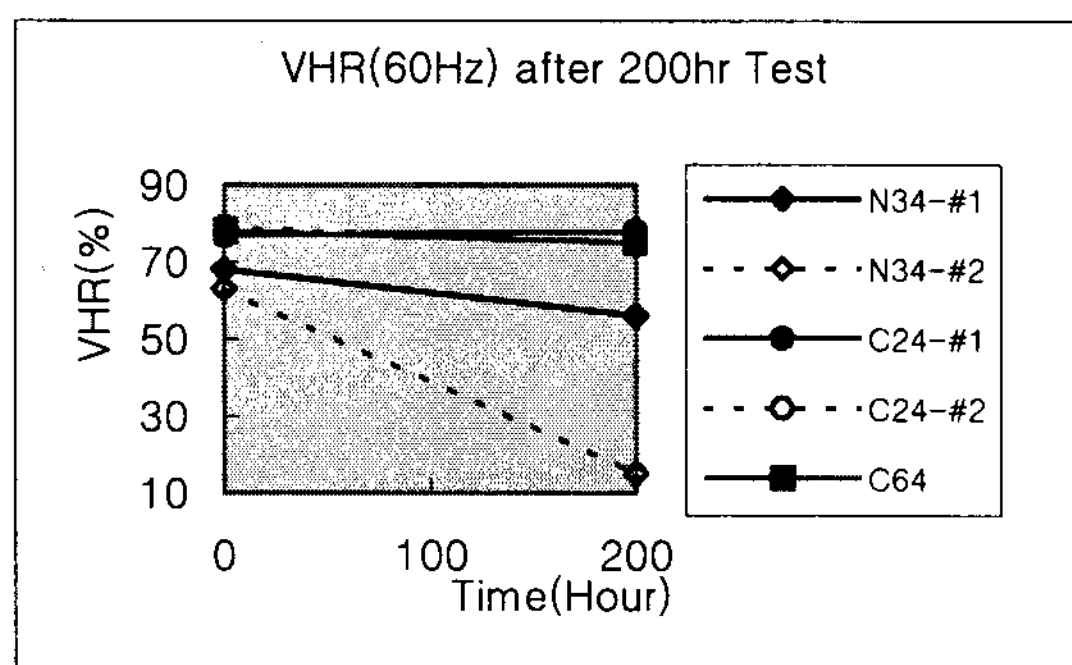


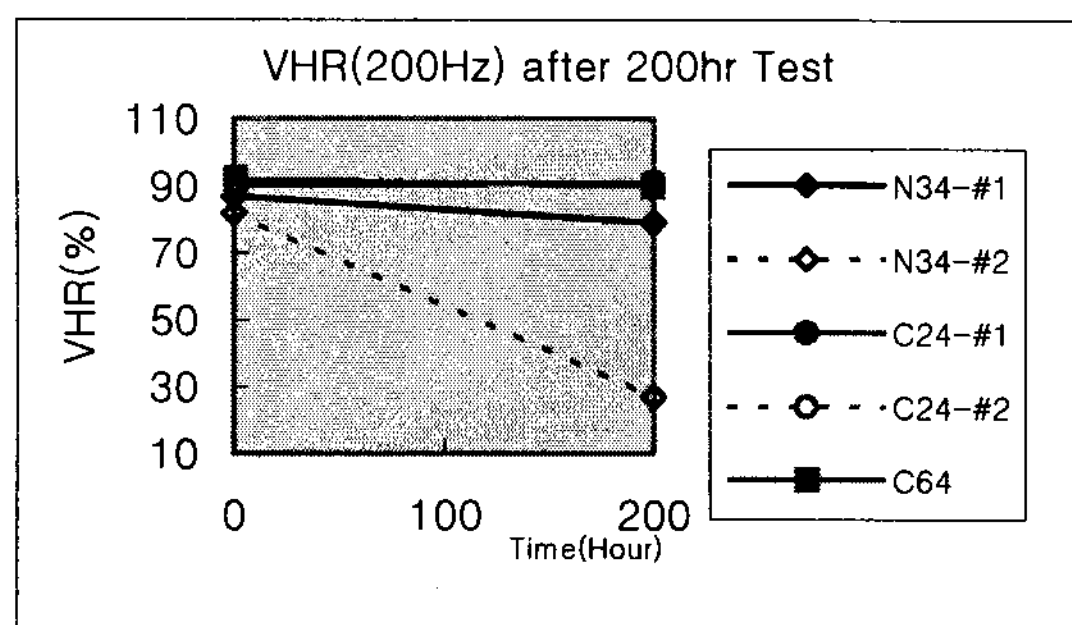
Fig. 6 Schematic Diagram for Testing

Each Cell is located in the same light intensity. After 200hr, the result is Fig 7. At 60Hz, VHR decreases more than 200Hz. In 1 Panel LCOS, VHR is

very important for brightness and C/R. In lower VHR, brightness and C/R also are low. If the system is 3 panel system, VHR is more important factor for brightness and contrast ratio. It is evidence that Plasma treatment influences to the VHR of LC which is affected by impurities. As long usage of LCOS cell, the impurities from ITO Film increases. It means that the cell life is depend on impurities from ITO film during operating. Plasma Treatment makes additional film on ITO which prevent impurities from it.



(a)VHR change after 200hr at 60Hz



(b)VHR change after 200hr at 200Hz

Fig. 7 VHR changes after 200hr Test

Conclusion

In 1 Panel LCOS System for HD-Televisions, R/T and VHR is very important for very high speed driving, higher C/R and Brightness. To prevent impurities from ITO film on glass in LCOS imager, we made several test cells with no treatment ITO glass and Plasma Treatment glasses according to RF power, kinds of gas,

time. In higher power and time, we can find the new C-Fx and In-Fx film on ITO film. Plasma Treatment also affects the roughness of film and sheet resistances. The new films which are produced on ITO by Plasma Treatment affect the characteristic of ITO film to prevent impurities from ITO during long operation of cell by accelerating test and with UV cut filter test. From the test, we can understand that new films help to reduce the impurities from ITO film by checking VHR. Lower impurities from the ITO film, Longer Cell lifetime. Therefore CF4 Plasma Treatment is very useful process in LCOS for the reliable long life and keeps the good qualities in operating cells.

References

1. M. Hatanaka et al., Proceedings of IDW '97, pp.793
2. Hisashi Abe, High Reliable Poly-Si TFT LCD Light Valves for High-Definition TV, IDW '00 pp. 247
3. I.Hasegawa et al., Diest of Technical Paers of AM LCD'00, pp.17
4. Shin-Tson Wu, Reflective Liquid Crystal Displays, pp. 39