Novel Driving Scheme to remove residual image sticking in AMOLED

Kunjal Parikh, Joonhoo Choi, Kyusik Cho, Jong-moo Huh, Kyongtae Park, Byoungseong Jeong, Yong-Hwan Park, Tae-Youn Kim, Baek-woon Lee, Chiwoo Kim

LCD R&D Center, LCD Business Unit, Samsung Electronics Corp.
San 24, Nongseo-dong, Giheung-gu, Yongin-si, Gyeonggi-do, 449-711, S. KOREA
Contact # 82-31-209-7697 Email: kunjal.parikh@samsung.com

Keywords - ***Hysteresis, defect states, image sticking, solid phase crystallization, OLED, etc***

Abstract

We hereby report novel driving scheme to eliminate effect of "residual" image sticking (RRI) problem which arises due to hysteresis problem in Thin Film Transistor (TFT) in AMOLED Displays. The driving scheme applies "black" voltage after every data voltage period in order to drive AMOLED in uni-direction. The system can be easily implemented with 120 Hz driving scheme which is well matured in AMLCD industries. Our analyses show systematic evaluation of the problem and thereby solving it by simple methods which will be significantly effective of driving OLED towards mass manufacturing stage.

.

1. Background

Active Matrix Organic Light Emitting Diodes (AMOLED) have gained considerable attention from past couple of years due to high brightness, wide viewing angle, light weight, high contrast ratio compared to their LCD counterparts [1-3]. Their have been tremendous progress being made to drive high performance display and some of the challenges are still left behind to improve the image quality of the display. Though, several solutions have been figured out to improve the stability of the device, image sticking still stays the key issue for AMOLED to enter monitor applications market. This image sticking mainly arises due to hysteresis in TFT [4,5], temperature heating problems, etc. Mostly, for oxide based gate insulator which is widely popular for polysilicon based TFT systems, the charge trapping and detrapping time affects the video quality in the display and causes the past frame image to be continued over some period of time. This is key issue and not many practical solutions have been figured out to drive AMOLED from the research to the development phase. Couple of reports focuses on current driving scheme [6] instead of voltage driving but it requires additional TFT's for pixel circuits which will directly affects the yield during the mass production stage. Moreover, the driving with current at low gray scale has been proven difficult because of higher charging time through buslines. This will have a limitation for large size AMOLED application. Some process solutions are figured out to stabilize but those are not viable yet [7]. We present simple and systematic evaluation of the problem and present the driving scheme with the existing widely popular TFT process architecture used in industry. We demonstrate 120 Hz driving scheme which introduces black voltage every subsequent frame to nullify the effects of image sticking. 120 Hz driving scheme is much more accepted in AMLCD industry and will be more matured solution for removing image sticking in AMOLEDs.

2. Results

We have fabricated TFT using 6-mask process in Bottom Gate Staggered architecture. The additional mask compared to standard 5-maks process is used to define N+ region of our TFT. The process involves patterning of Mo gate metal on which gate oxide 1500 A and amorphous silicon is sequentially deposited using in house PECVD system. The active layer is crystallized by Samsung proprietary annealing process to produce defect free crystallized polysilicon. The additional mask set is used to define N+ region and after that the process is continued in conventional way for source-drain patterning, passivation and contacts. We use standard 2TFT-1 Capacitance structure with size of driving TFT to be W=50µm, L=5µm.

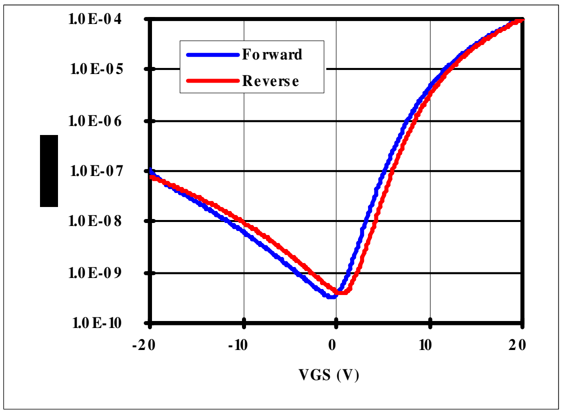

Fig. 1 TFT Hysteresis curve measured at Vds=10V for W=50µm, L=5µm.

Our TFT hysteresis property looks like as shown in Fig. 1 We can distinctly see the difference of around 0.7V hysteresis voltage between forward and reverse direction. This mainly arises due to active and gate oxide, charge trapping and de-trapping mechanism. Because of hysteresis in TFT, it causes residual image sticking problem in AMOLED issue [4]. The previous image is being imprinted in the sequential driving which eventually disappears. As shown in Fig 2, we fabricated 14.1" WXGA panel at SEC and found on similar phenomenon of image sticking in our panels.

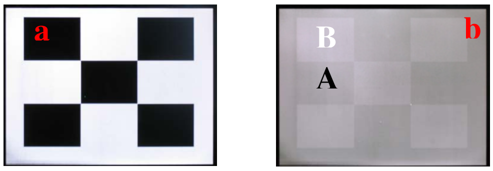

Fig 2 a) stress pattern for 1 min b) after stress removal – image sticking

As shown in Fig. 2, we stressed the panel with checker board pattern with White level = 400 Cd and Black level=0 for 1 min. Upon removing the stress and checking the panel in mid-gray region (Luminance = 200 Cd) we can distinctly see the image sticking of the stressed panel. Upon continuously monitoring for 5 minutes, we found out the stress patterned in completely removed.

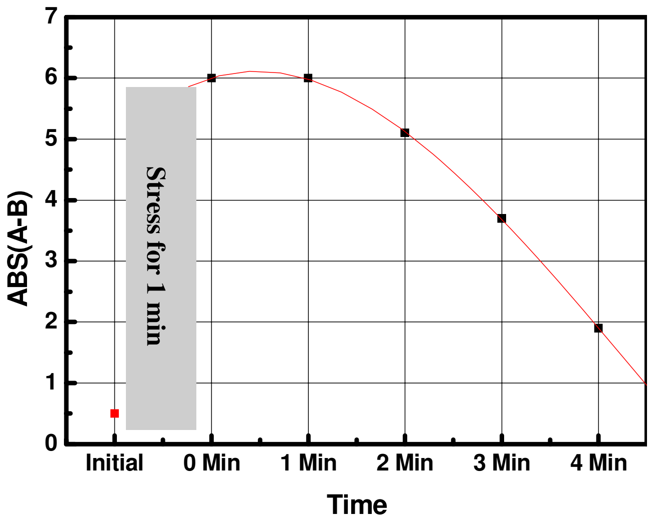

Fig. 3 Monitoring of stress pattern luminance difference (A & B) over period of time.

As shown in Fig 3, the careful monitoring of the difference in luminance between A (White) and B (Black) region is recorded with standard Minolta Luminance meter. We can clearly see the degradation of the curve and hence removal of image sticking over a period of time. The slope and degradation of the curve is highly process dependent but we found similar effects in several panels fabricated at SEC. This has been well-know problem known in AMOLED area and have been attributed mainly because of the hysteresis of TFT.

In order to investigate further, we measured stability of our device using constant current stress of 30μA at 40 C for several hours. After periodic cycle, we measured I-V curve and we concluded based on Fig 4 that stability is not an issue.

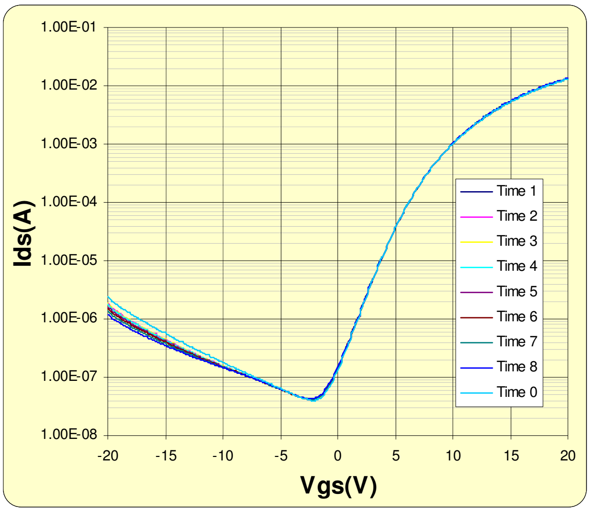

Fig. 4 I-V curves measured at different time instant upon stressing TFT for Constant Current stress =30μA at 40 C

We measured using standard HP 4156 instrument and I-V data are measured at Vdd=10V with Vgs sweep from -20 to +20 V. We aper can clearly see no shift in Vth and mobility of our device. This also implies that upon driving the TFT in one direction there is no significant shift in Vth. Henceforth, we thought of driving our 14.1" WXGA panel in uni-direction to rule out any hysteresis Vth voltage which arises due to bidirectional driving of video voltages. To realize this scheme, as shown in Fig. 5 we introduced black voltage at the beginning of every data cycle. In order to avoid the flickr issue, we drive our panel at 120 Hz wherein we have alternate cycle of data and black voltage. In order to maintain constant luminance out of AMOLED panel, data voltage is driven at twice the normal voltage.

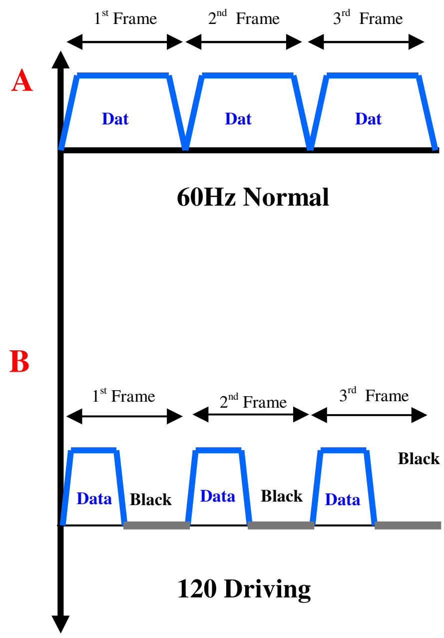

Fig.5 a) Normal 60 Hz driving scheme b) proposed 120 Hz driving scheme with black insertion

120 Hz driving scheme was easily realized using standard board available in AMLCD industries to remove blur problems in LCD panels. The result is shown in fig 6. We could completely remove the image sticking from the previous data upon introduction of the black voltage.

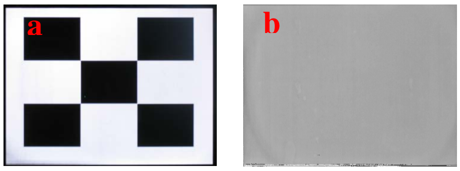

Fig. 6 a) 14.1" WXGA panel with stressed black board pattern b) after stress removal – no image sticking

3. Conclusion

We present novel driving scheme in form of 120 Hz to drive OLED to remove image sticking which has been prime issue to realize AMOLED for monitor based applications. We present systematic evaluation of the problem and present simple solution which will be widely accepted by industry standards to drive for production. The stability of polysilicon based system is excellent in uni-direction. Henceforth, solution focuses in driving OLED in uni-direction to take an advantage of the excellent stability of TFT backplane.

4. References

[1] C. W. Tang: Symp. Dig. SID (1996) p. 181

[2] G. Gu and S. R. Forrest: IEEE J. Sel. Top. Quantum Electron. 4 (1998) 83.

[3] R. Dawson, S. Van Slyke, J. C. Sturm, et. Al. IEEE, 1998, p. 875.

[4] Byeong-Koo Kim et. al. "Recoverable Residual Image Induced by Hysteresis of Thin Film Transistors in Active Matrix Organic Light Emitting Diode Displays" JJAP, **Vol 43**, 4A, p. L482 (2004)

[5] Jae-Hoon Lee, Min-Koo Han, et.al. "Experimental Study of the Hysteresis in Hydrogenated Amorphous Thin-Film Transistors for an AMOLED" J. Kor. Phys. Soc., **Vol 48**, p. S76 (2006)

[6] Jae-Hoon Lee, Min-Koo Han, et. al. "A new Poly-Si TFT Current-Mirror Pixel for AMOLED" IEEE, **Vol 27**, p. 830 (2006)

[7] Tean-Sen Jen et. al. "Effect of Plasma Treatment of a-SiOxNy/a-SiNx Gate Insulators on a-Si:H Thin-Film Transistor" EDMS'94, 1-2-5 (1994)