A Novel Evaluation Method for Short-Residual Image of AMOLED Display

Conference Paper · January 2020

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Abstract

The hysteresis behavior in TFTs caused short-residual image of AMOLED Display. Hysteresis and optical method are two kinds of traditional evaluation methods. In the practical operation, hysteresis method is not sufficient, and optical method need a product after module process, which has some limitations, such as high production costs, long cycle. In this paper, we provide a novel evaluation method, which can match well with the results of hysteresis and optical method. The novel evaluation has an advantage in accuracy, production costs and cycle, compared with traditional method.

Author Keywords

Short-Residual Image, Hysteresis, AMOLED

1. Introduction

Active matrix organic light emitting diodes (AMOLED) has gained much attention due to its high contrast, wide-viewing angle, quick response speed [1]. In actual use, AMOLED display has some problems, such as brightness degradation, color shift, burn-in etc. Burn-in phenomenon means that screen display a image for a time, and apparently observed in subsequent image. If residual image can't disappear, the non-recoverable residual image called long-residual image. If residual image disappears gradually over time, the recoverable residual image called short-residual image. Short-residual image is easier to occur in AMOLED display. It is necessary to quickly and accurately evaluate the level of short-residual image, in order to solve the problems [2].

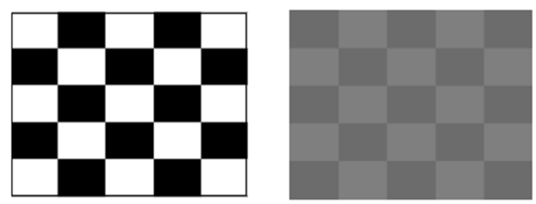
According to the cause of hysteresis, we provide a novel evaluation method, which can simulate the voltage-current changing rule in working process of TFT. This method can match well with the level of short-residual image, and has an advantage in accuracy, production costs and cycle.

2. Evaluation Method

The short-residual image can be explained by hole trapping in the oxide trap states and interface trap states between the poly-Si layer and the gate insulator. The hole trapping and detrapping can occur repeatedly, depending on the applied voltage. If the gate voltage for a high drain current is applied, the hole trapping is induced and the threshold voltage increases, which results in the decrease of the drain current[3][4]. When applying the gate voltage for a low drain current, the trapped charges are detrapped and the drain current increases.

Figure 2.1 shows the short-residual image phenomenon. Fig. 2.1a shows a chessboard image composed of a black and white pattern for evaluating the image sticking. The chessboard image is displayed for a few minutes, then the signal of a uniform middle gray image is applied to the display panel. The image sticking is induced according to the hysteresis phenomenon, as shown in Fig. 2.1b. The image sticking is observed for a few minutes or several tens of seconds and then disappear. The brighter image sticking occurs in the area where the black pattern of the chessboard image was displayed. The darker image sticking occurs in the area of the previous white pattern.

Figure 2.2 shows the hysteresis phenomenon of p-type TFT. The transfer curve exhibits a hysteresis and difference in drain current at the same gate voltage depending on the gate sweep direction. Fig. 2.2b shows the root cause of short-residual image. The white pattern (L_{255}) and black pattern (L_0) switch to middle gray (L_{48}). Their output current is Ids' and Ids'' because of hysteresis. AMOLED is self-emission device, and its brightness is proportional to current density. The difference between Ids' and Ids'' caused short-residual image. The short-residual will disappeared with the prolonging of time.

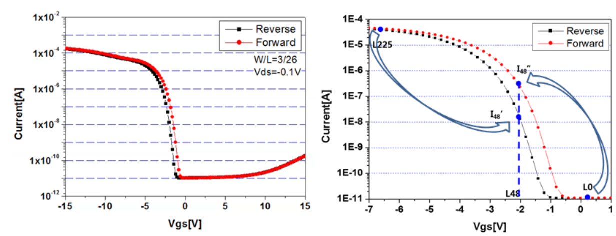


(a) (b)

Fig 2.1. Residual image of AMOLED

(a) The chess board pattern displayed

(b) The middle gray pattern following the chess board pattern



(a) (b)

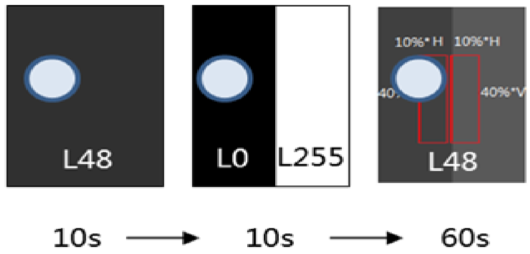
Fig 2.2. Hysteresis phenomenon of p-type TFT

(a) Hysteresis of transfer curve

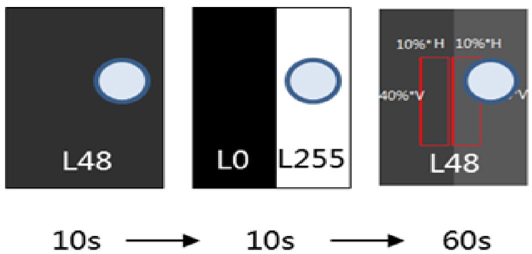
(b) Short-residual image caused by hysteresis

Optical Method: Figure. 2.3 shows the optical method for residual image of AMOLED. First, display remain middle gray pattern (L48) for 10 seconds, then switch to chess board pattern lasts 10 seconds, after that display switch to middle gray pattern lasts 60 seconds. We utilize CA210 to monitor brightness change (L1) of left part, just like Fig. 2.3a. Repeating the process above. We utilize CA210 to monitor brightness change (L2) of right part, just like Fig. 2.3b. We can deal with test data by formula (1) to calculate JND. We think short-residual image disappeared when JND ≤ 0.004.

$$JND = \frac{L1 - L2}{L1 + L2} \qquad (1)$$



(a)



(b)

Fig 2.3. Optical method for residual image

(a) First test of optical method

(b) Second test of optical method

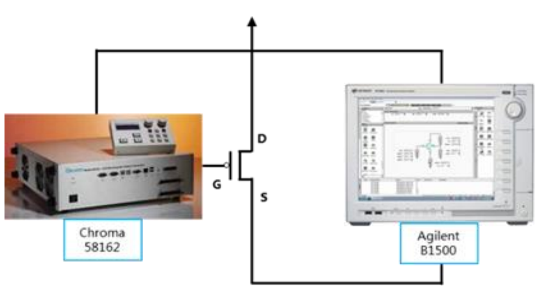
Electricity Method **（*Novel Evaluation Method*）:** Fig. 2.4 shows an experiment setup to simulate actual working condition of drive TFT. Chroma signal generator offer Vgs. B1500 semiconductor analyzer offer Vds and record the change of current.

Shown in Fig. 2.5. First, Chroma 58162 provide Vgs from L255 to L48, meanwhile, Agilent B1500 record the change of current (I255). Repeating the process above. Chroma 58162 provide Vgs from L0 to L48, meanwhile, Agilent B1500 record the change of current (I0), we can deal with it by formula (2) to calculate ΔIds. We think short-residual image disappeared when ΔIds ≤0.01.

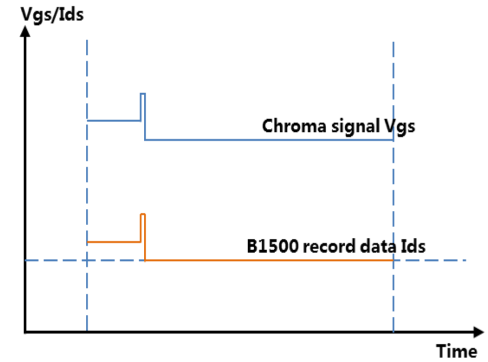
$$\Delta\, Ids = \frac{abs\,(I0-I255)}{abs\,(I0+I255)} \qquad (2)$$

In order to verify its correctness, we choose two different groups of sample to compare their distinction between traditional method and novel method.

First group include four splits (Split1, Split2, Split3, Split4), assessing distinction between optical method and electricity method. Second group include four splits (Split A, Split B, Split C, Split D), assessing distinction between hysteresis method and electricity method.



(a)

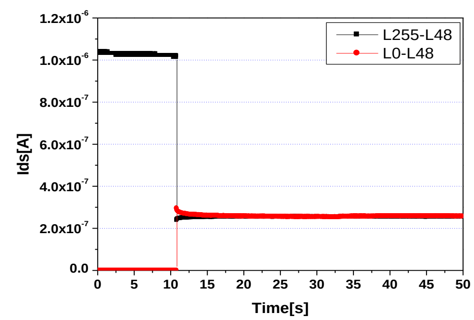


(b)

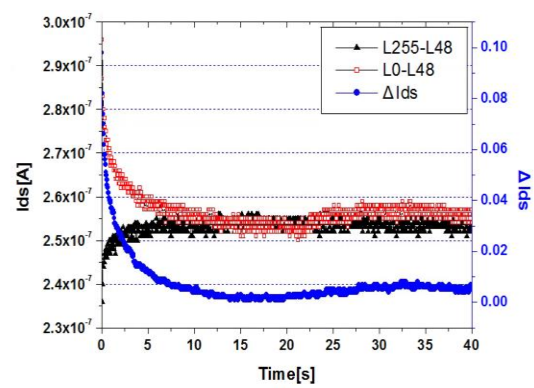
Fig 2.4. Schematic diagram of the experimental system

(a) Experiment layout

(b) Logic of test



(a)



(b)

Fig 2.5. Result of Electricity Method

(a) Current-Time curve

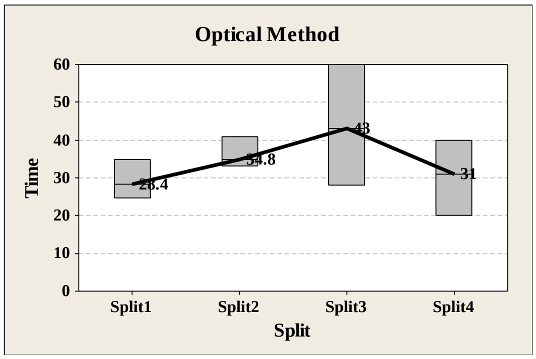
(b) ΔCurrent-Time curve

3. Result

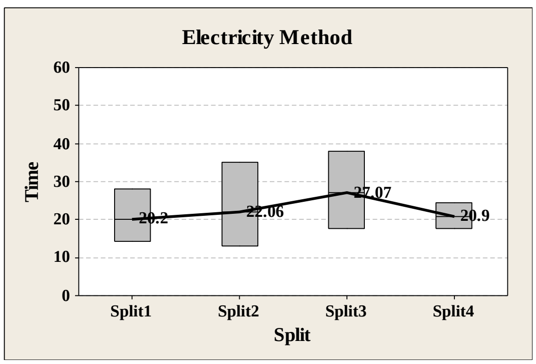
Table. 3.1 And Fig. 3.1 shows the test result about first group. According to the result of different method, we can come to a conclusion that two different method have same change trend. Time differences between two methods caused by different current densities. The selected experiment condition that used in electricity method is much higher than actual condition, limited by precision of B1500, which caused short-residual image last a shorter time.

Table 3.1.

Split	Electricity Method/s (Ave.)	Optical Method /s (Ave.)	Quantity
Split1	20.20	28.4	18 pc/Split
Splt2	22.06	34.8	
Split3	27.07	43.0	
Split4	20.90	31.0	



(a)



(b)

Fig 3.1. Result of First Group

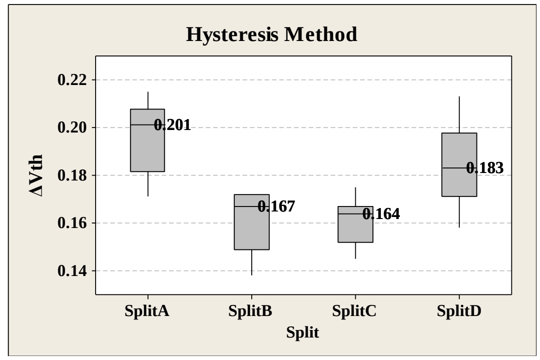
(a) Optical Method

(b) Electricity Method

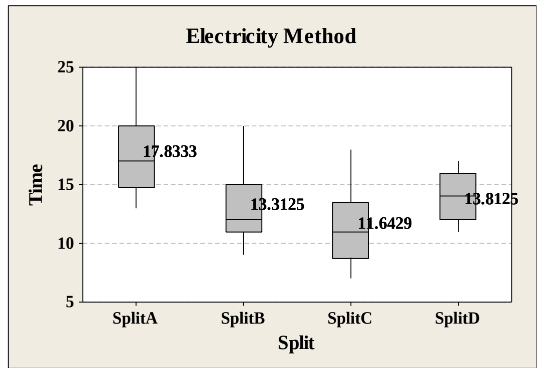
Tablet. 3.2 And Figure. 3.2 shows the test result about second group. According to the result of different method, we can come to a conclusion that two different method have same change trend, electricity method can match hysteresis method very well.

Table 3.2.

Split	Δ Vth/V (Ave.)	Electricity Method/s (Ave.)	Quantity
Split A	0.201	17.83	18 pc/Split
Split B	0.167	13.31	
Split C	0.164	11.64	
Split D	0.183	13.81	



(a)



(b)

Fig 3.2. Result of Second Group

(a) Hysteresis result

(b) Electricity Method

Depending on the result of electricity method, we determine the orientation of the improvement and improve the level of short-residual image, finally. Tablet. 3.3 shows the final result, which evaluate by optical method.

Table 3.3.

Split	Max/s	Min/s	Ave/s	Quantity
Split 1	16.5	9.4	11.3	10pc/Split
Split 2	9.8	4.0	7.1	
Split 3	12.0	3.0	7.4	

4. Conclusion

The novel evaluation method, electricity method, can match result of hysteresis and optical method. Compared with traditional method, the novel evaluation has an advantage in accuracy, production costs and cycles. We can improve the efficiency of research and development by electricity.

5. References

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