A Novel Reactive Sputtered Passivation for Large Size TFT-LCD

Hong-Sik Kim[1], Joo-Soo Lim[1], Hyun-Seok Hong[1], Hee-Yong Kwack[2], Sung-Hoon Ahn[2], Sang-Jeon Yu[2] and Jong-Keun Shin[1]

[1]Advanced Development Division, LG Display, 162 Simi-dong, Gumi, 730-340, South Korea

TEL:82-54-711-7554, e-mail: hskim2013@lgdisplay.com

[2]Process Development Division, LG Display, 1007 Deogeun-ri, Wollong-myeon, Paju, 413-811, South Korea .

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Abstract

Amorphous silicon nitride (a-SiNx) passivation film as a passivation layer of TFT-LCDs was deposited by AC-reactive sputtering at low temperature. As a result, the electrical characteristics and reliability of TFT with novel passivation showed the same level as the conventional TFT. Finally, we have developed 47"Full HD IPS TFT-LCDs with sputtered amorphous silicon nitride. It is suitable for low temperature based applications such as OTFT and Flexible display.

1. Introduction

Over the past decade, a lot of studies have been made on passivation films using plasma enhanced chemical vapor deposition (PECVD) and reactive magnetron sputtering (dc-, ac-, and rf) systems. [1-4] Especially, silicon nitride films have been widely used in antireflective layers and passivation layers for solar cell and TFT-LCD applications, respectively. [5] So far, amorphous silicon nitride (a-SiNx) passivation films deposited by dc- and rf magnetron reactive sputtering with various Ar/N2 flow rate ratio. Reactive sputtering has good advantages for low temperature applications like TFT-LCD, flexible display and transparent LCD. On the other hand, in the low temperature process, it is hard to get good physical properties and electrical properties in comparison with current SiNx (:H) film deposited by PECVD. It is well known that the sputtered SiNx films have high defect density like silicon dangling bond and growth of columnar structure in the vertical direction. [6] Therefore, in order to be adopted as a passivation layer in thin film transistors, it is necessary to optimize the mechanical and electro-optical characteristics.

In this study, we have been investigated the deposition conditions, the properties of sputtered amorphous silicon nitride (a-SiNx), TFT-LCDs module fabrication, and the electrical characteristics of the 47" Full HD IPS TFT-LCDs.

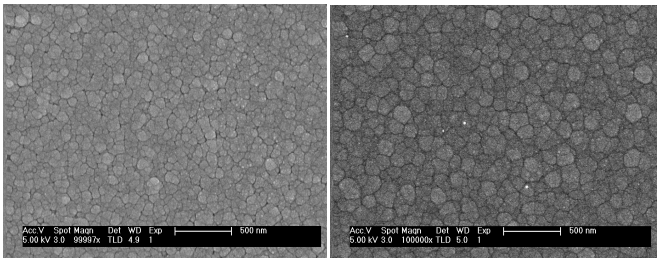
2. Experimental

Sputtered SiNx passivation layer deposited by ac reactive sputtering at lower 150℃ process temperature and B-doped poly-Si target with reactive gases like argon and nitrogen.

In order to compare TFT device Characteristics, deposited by ac reactive sputtering SiNx passivation and by PECVD SiNx passivation.

3. Results and discussion

The surface morphology of the SiNx films was observed by scanning electron microscope as shown in Fig. 1. The sputtered SiNx film showed nearly the same level of surface roughness as PECVD-SiNx (:H) film. The XPS spectra of 100-nm thickness sputtered a-SiNx film grown at 150 ^{o}C temperature, is shown in Fig. 2. In both cases, there is little difference in N/Si ratio. The oxygen contents of sputtered a-SiNx film is approximately 10^{16} ~ 10^{17}cm^{-3}, which is available to apply to amorphous Si TFTs application as a passivation layer.



(a) Sputtered SiNx (b) PECVD SiNx

Fig. 1. Surface morphology of a-SiNx passivation films grown at low temperature

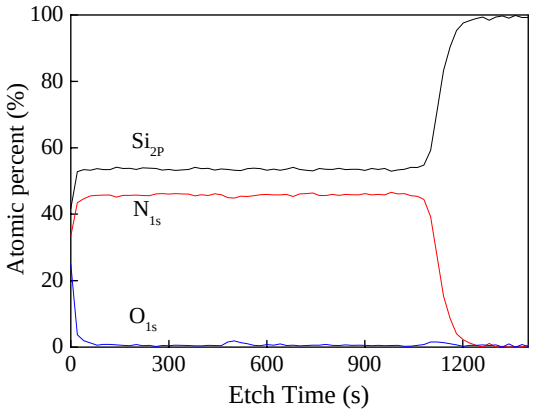


Fig. 2. X-ray photoelectron spectroscopy spectra of 100nm-sputtered a-SiNx film

The electrical characteristics of a-Si TFTs with sputtered a-SiNx passivation layer is shown in the Fig. 3 and 4. 70nm-thickness silicon nitride passivation layer was deposited by AC reactive sputtering; a-Si TFTs with sputtered SiNx passivation layer showed excellent electrical characteristics. Especially, we could obtain low threshold voltage variation and back channel off current as low as ~10^{12}A, through optimization of the interface properties between a-Si: H and a-SiNx passivation layer. As a whole, the electrical properties of a-Si TFT with sputtered SiNx passivation layer were nearly similar to the characteristics of current mass production products.

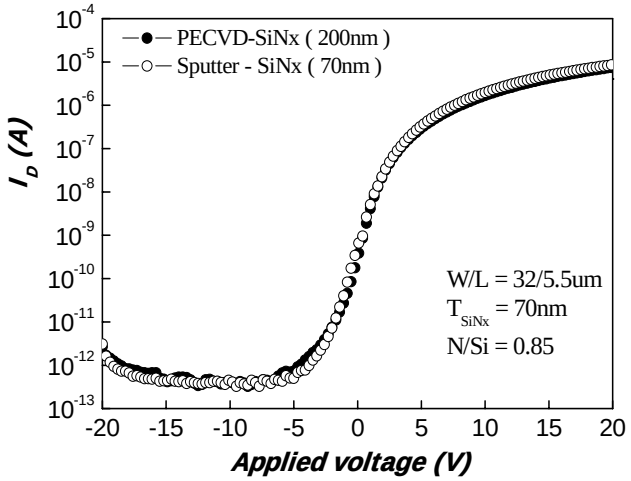


Fig. 3. I_D-V_D transfer characteristics between sputtered a-SiNx and PECVD SiNx.

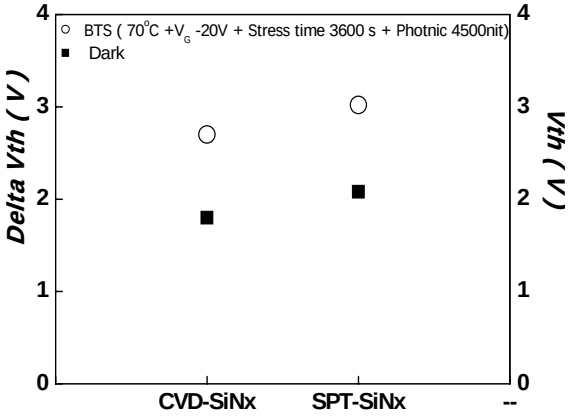


Fig. 4. Threshold voltage shift (Δ Vth) of passivation layer at the same TFT structure. CVD-SINx was defined as current mass production sample

We have applied the sputtered a-SiNx passivation layer to fabricate 47" Full HD IPS TFT-LCD, as shown in Fig. 5.

Fig. 5. Image of 47" Full HD IPS module with sputtered a-SiNx passivation layer.

4. Summary

In this work, we have investigated the properties of sputtered SiNx passivation films and fabricated high quality a-Si thin film transistors at low temperature for large size applications. Under optimized AC reactive sputtering conditions, the electrical characteristics showed high drain current

and reduced off-current of up to 10^{12} ~ 10^{13}A. In addition, the sputtered SiNx films presented fair uniformity over the large area and showed good thermal stability under high reliability conditions. Consequently, we note that ac reactive sputtering method is suitable for low temperature based display applications.

5. References

1. W.D.Sproul, D.J.Christie, D.C.Carter, Thin Solid Film 491, p1-17 (2005)
2. G.Brauer, J.Szczyrbowski, G.Teschner, Sur. Coat. Technol. 94-95, p658-662 (1997)
3. H.Brartzsh, B.Bocher, Pfrach, K.Goedicke, Sur. Coat. Technol. 174-175, p774 -778 (2003)
4. I.Radovic, Y.Serruys, Y.Limoge, N.Bibic, S.Poissonnet, O.Jaoul, M.Mitric, N.Romcevic, M.Milosavljevic, Mat. Chem. Phy. 104, p172-176 (2007)
5. J-W.Lee, S.C.N.Cheng, Thin Sloid Films 358, p215-222 (2000)
6. M.Vetter, M.Rojahn, Mat. Sci. Eng. B71, p321-326 (2000)