Nanoparticle Cleaning of AMLCD Backplane

J. H. Oh, D. H. Kang, M. H. Choi, S. H. Kim, B. K. Choo, J. H. Hur and J. Jang
Advanced Display Research Center & Dept. of Information Display, Kyung Hee University, Dongdaemoon-ku, Seoul 130-701, Korea
I. H. Kim
Samsung Fine Chemicals Co., Ltd, Namdong-ku, Incheon 405-310, Korea
Phone:+82-2-961-0270, E-mail: jjang@khu.ac.kr

Abstract

We have proposed a novel cleaning technology with organic nanoparticles for high-performance TFT array. The surface of the TFT layer becomes more hydrophilic after cleaning by the nanoparticles. This is concluded from the comparison of contact angles for the samples cleaned by various methods. It is found that the drain currents in the subthreshold and off-state regions are less than those for the TFTs cleaned with conventional method.

1. Introduction

Manufacturing technologies of TFT array are improving for the last 10 years, resulting in high throughput and large area process, for example 7th generational line for TFT-LCD. One of the critical issues is to have a simple cleaning technique. It is important to remove the contaminations such as organics, chemical contamination, and adsorbed particle on the surface of film [1-3]. Wet cleaning and plasma cleaning methods are usually employed for removal of organic contamination on substrate to make TFT arrays.

The removal of organic material such as lubricating oils or other processing aids, for example release agents, is routinely carried out as part of most multi-stage metal finishing process [4]. Commonly, aqueous-based or vapor phase solvent media are used which can effectively remove relatively weak bound organic materials. The aqueous-based media are often combined with agitation including ultrasonics for maximum speed and efficiency. The current study is, however, concerned with the removal of organic material from nano-patterned metal surfaces [5]. It is possible to effectively remove such material using the conventional cleaning procedures.

In particular, this paper focuses on the removal of nano-contaminant on film using the XNP-12 nanoparticles. We studied to achieve the simple manufacturing process for high performance TFT array for AMLCD backplane.

2. Results

The new nanoparticles cleaning agents (XNP-12, Samsung Fine Chemicals, Co., Ltd) were synthesized by emulsion polymerization process using modified cellulose emulsifier (Hydroxypropyl methylcellulose phthalate), initiator and acrylic monomer. Figure 1 shows the planar image of the particles, measured by scanning electron microscopy (SEM, JSM-5400, JEOL Co., Japan).

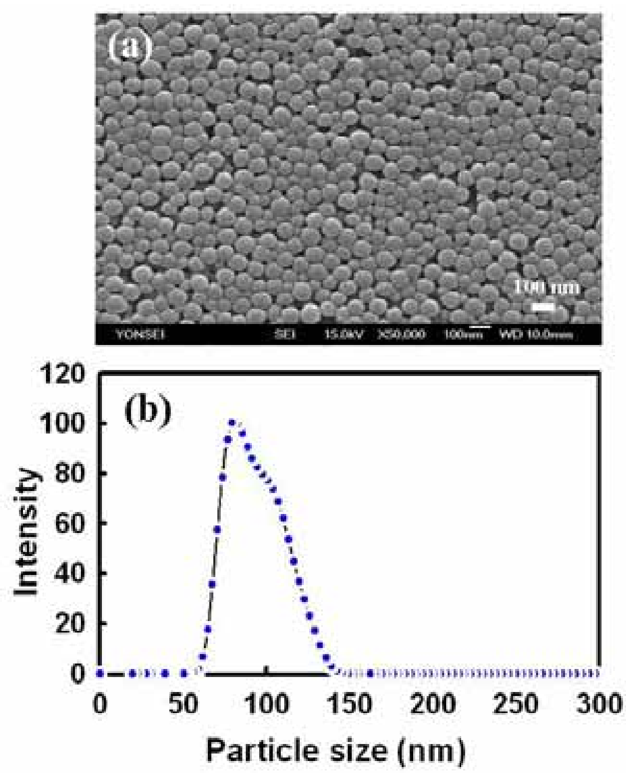

Figure 1. SEM image of the nanoparticles with cellulose emulsifier (a) and average particle size distributions of the XNP-12 (b).

Table 1. Characteristics of XNP-12 nanoparticles.

Name	XNP-12 nanoparticles	
Properties	Particle size	50 ~ 150 nm
	Molecular weight	100,000 (Mw)
	pH	13.00
	Electrolytes	120 mS
	COD (original liquid)	8,000 ppm
Characteristics	Contact angle	< 10 °
	Foam effect	Low
Conditions	Temperature	Room temp ~ 50 ℃
	Cleaning time	30 ~ 120 sec
	Cleaning method	Spray, U-sonic, Brush, Dipping

The average particle size was determined by using capillary hydrodynamic fraction (CHDF-1100, Metec Appl. Sci., USA).

We have proposed the nanoparticles in this work to clean the contamination of the film surface for high-performance a-Si:H TFT array. Tables 1 show the characteristics of the XNP-12 nanoparticles. Removal of organic contamination on layer could be achieved with cleaning time of 30 ~ 120sec by spray, U-sonic, brush and dipping methods.

Figure 2 shows the schematic view of a cleaning mechanism with the XNP-12 nanoparticles for glass (a) and nano-patterned layer (b). The ultrasonic agitation in super-purity acetone is typically used for cleaning. Then, the sample is immersed in boiling aqueous alkaline cleaner with mechanical agitation for a period of 20 min. On the other hand, the proposed cleaning method with the nanoparticles has shorter cleaning time of about 1 min and simple cleaning process compared with that of the conventional cleaning one.

Figure 3 shows the contact angles of water on oil contaminated glass before cleaning (a), after conventional cleaning (b) and after nanoparticle cleaning (c). The initial angle was 68.21 ° and decreased to 13.57° by conventional cleaning and to 7.17 ° by nanoparticle cleaning, indicating the effective cleaning of the surface by the proposed method.

To confirm the advantage for this cleaning method we fabricated inverted staggered a-Si:H TFTs with 3 different cleaning methods of conventional, only DI water and nanoparticles.

Figure 4 shows the fabrication process of the a-Si:H TFT array for AMLCD manufacturing. To make TFT array on glass we cleaned the surface with nanoparticles 12 times.

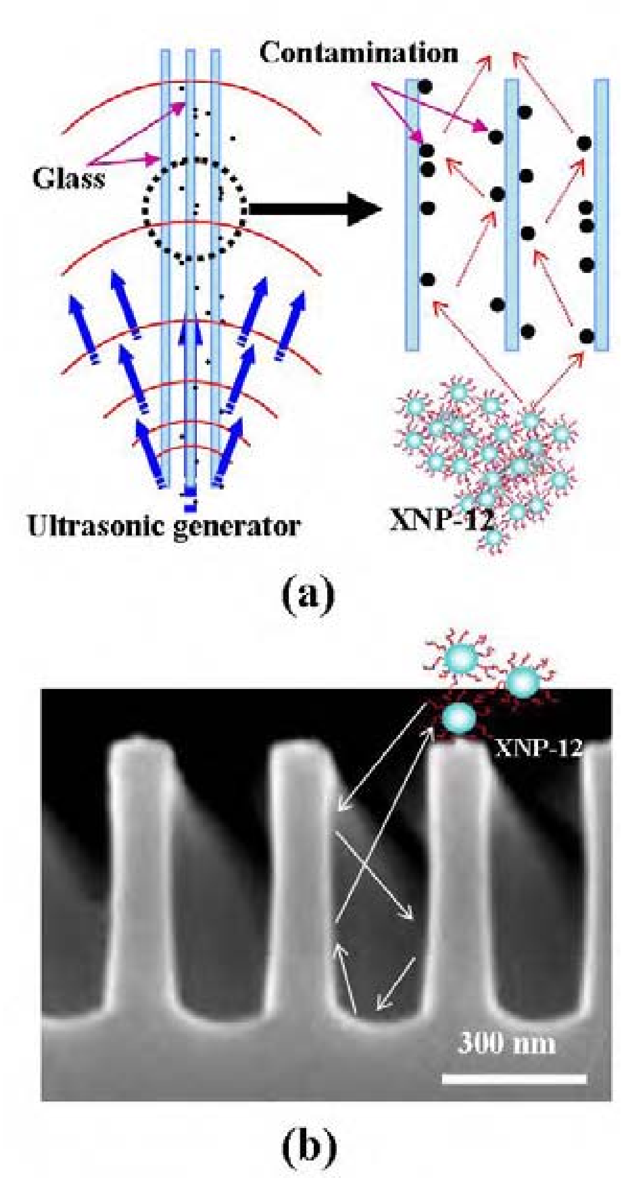

Figure 2. Cleaning mechanism of glass by XNP-12 nanoparticles (a) and of nano-patterned layer on glass (b).

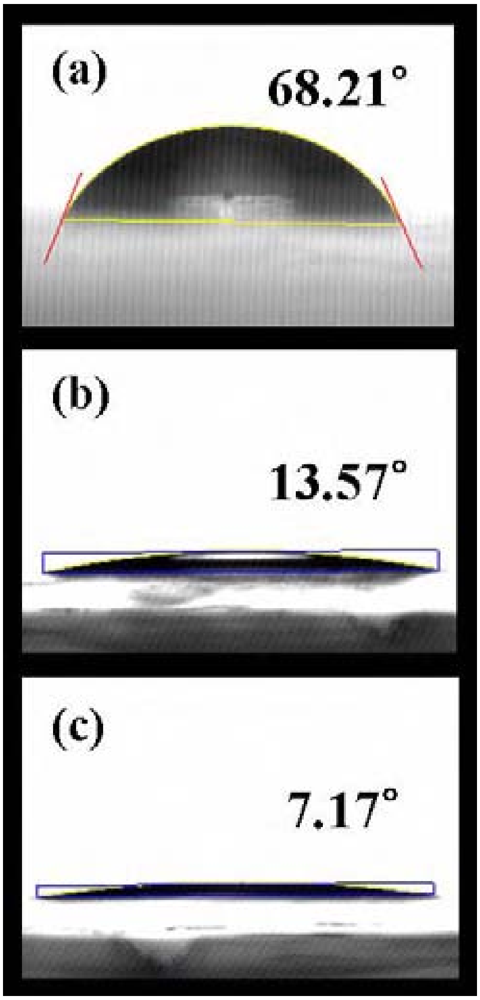

Figure 3. The contact angles of water on the oil contaminated glass: before cleaning (a); after conventional cleaning (b); after nanoparticle cleaning (c).

A 100 nm thick Cr was deposited on glass and patterned for gate electrodes. The three layers of SiN_x, a-Si:H and n^+ a-Si:H were deposited consecutively in a PECVD (Plasma Enhanced Chemical Vapor Deposition) reactor at the substrate temperature of 280 ℃. The a-Si:H films are used for the active layers of TFT and the SiN_x is utilized as a gate insulator of the switching TFT and as a passivation layer. The n^+ a-Si:H layer was deposited with a mixture of SiH_4 and PH_3 [6]. The RF power for the a-Si:H and n^+ a-Si:H depositions was fixed to be 50 W. The islands for TFT layers were defined by NF_3 plasma etching. A chrome layer (150 nm) for data lines and source/drain contacts of the TFTs was deposited by DC sputtering. Then, the n+ a-Si:H layer on the TFT channels were etched away. Passivation layer, SiN_x, was deposited by PECVD and patterned to form via-holes by RIE (Reactive Ion Etching). Finally, a 50 nm IZO film for a pixel electrode was deposited by magnetron DC sputtering and patterned.

Figure 5 shows the transfer characteristics of the a-Si:H TFTs using only DI water cleaning (a), conventional cleaning (b) and nanoparticles cleaning (c). With nanoparticles cleaning, the currents in the subthreshold and off-state regions are less than those of the TFTs with other cleaning methods. This is due to the perfect cleaning of the back surface by the nanoparticles. Therefore, it is possible to clean the back channel of a-Si:H TFT by the nanoparticles for high-performance AMLCD backplane. Table 2 summarizes the characteristics of the a-Si:H TFT with different cleaning techniques.

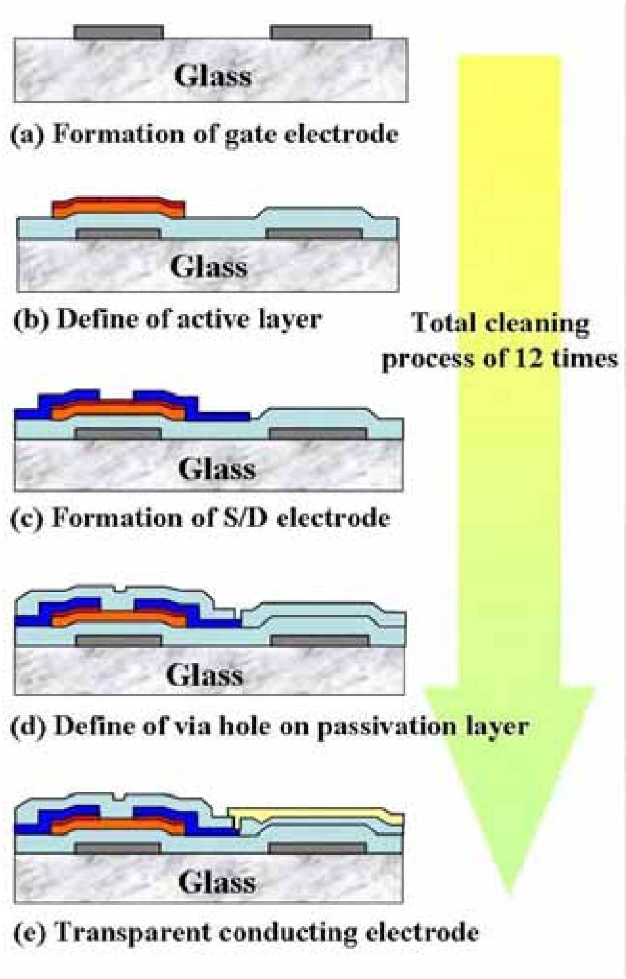

Figure 4. Fabrication process of a-Si:H TFT array using nanoparticle cleaning.

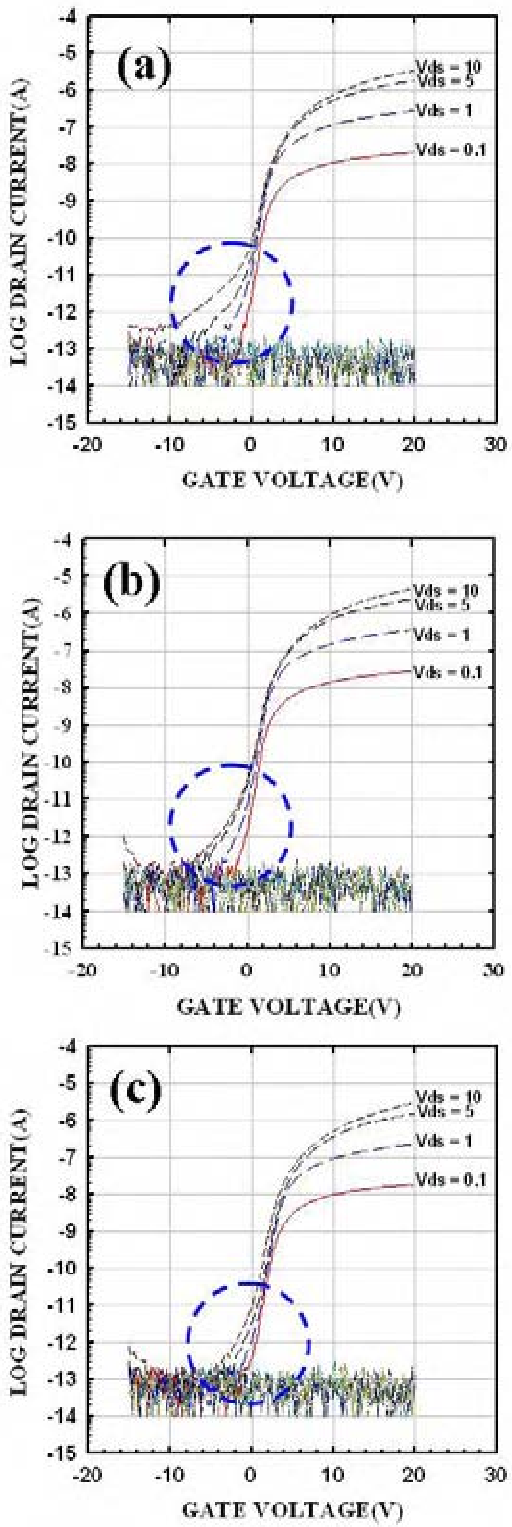

Figure 5. The transfer characteristics of the a-Si:H TFT with only DI water cleaning (a), conventional cleaning (b) and XNP-12 nanoparticles cleaning (c).

Table 2. The characteristics of the a-Si:H TFTs made with different cleaning techniques.

	Only DI water cleaning	Conventional cleaning	XNP-12 nanoparticles cleaning
Mobility (cm^2/V.s)	0.48	0.65	0.68
Threshold voltage (V)	3.5	3.5	3.4
Subthreshold swing (V/dec.)	0.91	0.89	0.87

3. Conclusion

We developed a new cleaning method of AM backplane to reduce the process step and to improve the electrical performance by using nanoparticles. The contact angle of water can be reduced by using the proposed method. The proposed method gives lower currents in the subthreshold and off-state regions. The TFT in the array exhibited a field-effect mobility of 0.68 cm^2/Vs, threshold voltage of 3.4 V and subthresold swing of 0.87 V/dec.

4. Acknowledgements

The authors would like to thank Professor J. H. Kim of chemical engineering in Yonsei University for SEM measurement and data analysis of XNP-12 nanoparticles.

5. References

[1] S. R. Kasi, M. Liehr, P. Thiry, H. Dallaporta, M. Offenberg, Appl. Phys. Lett. **59**, 108 (1991).

[2] K. Saga and T. Hattori, Appl. Phys. Lett. **71**, 3670 (1997).

[3] T. Hattori et al, Ultra Clean Surface Processing of Silicon Wafers (Springer, Berlin, 1998). Chaper 2.

[4] P.G. Sheasby, R. Pinner, The surface treatment and finishing of aluminum and its alloys (Finishing Publications Ltd, New Jersey, 2001). Chapter 1 & 2.

[5] R.E. Litchfield, G.W. Critchlow, S. Wilson, Int J Adhesion & Adhesives **26**, 295 (2006).

[6] S. W. Lee, K. S. Cho, B. K. Choo, and J. Jang, IEEE Electron Device Lett. **23**, 324 (2002).