Extended Abstracts of the 2002 International Conference on Solid State Devices and Materials, Nagoya, 2002, pp. 668-669

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Pentacene TFT using SiN_x as Gate Insulator

Yong Xian Xu and Chung Kun Song*

Dong-A Univ., Div. of Electrical & Electronics & Computer Eng.
840 Hadan-dong, Saha-gu, Busan 604-714, Korea
Phone: +82-51-200-7711, Fax: +82-51-200-7712, * E-mail: cksong@daunet.donga.ac.kr

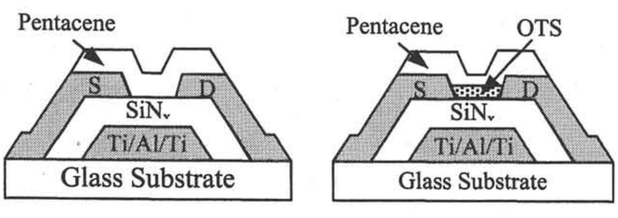
1. Introduction

Organic thin film transistor(OTFT) is attracting much attention due to the possible application to flat panel display(FPD). In the present FPD LCD-TFT display is dominant, in which poly-Si TFTs are used for driving LCD pixels. However, for the application of flexible display the poly-Si TFTs have the potential limitation due to the intrinsic solid-state property. Meanwhile, OTFTs have an essential advantage in the application of flexible display because of the intrinsic organic material properties such as its flexibility although the technologies related to OTFTs are not developed enough to implement it yet.

In this paper we fabricated OTFTs on the glass substrate which is currently used for LCD display. The OTFTs used pentacene as the organic semiconductor and SiNx as the gate insulator. We examined the electrical characteristics of OTFTs if they can be employed to drive LCD pixels.

2. Fabrication of OTFTs

On the glass substrate Ti/Al/Ti alloy was deposited as gate metal. Ti metals were used for a good adhesion with glass substrate and to avoid the oxidation of Al. The SiNx gate insulator was prepared on gate metal by sputtering process. Subsequently, source and drain metals were evaporated and patterned by lift-off process. At the process of pentacene deposition two types of devices were fabricated depending on whether a self-assembly material such as octadecyltrichlorosilane (OTS) is employed or not prior to pentacene deposition. The final structure of OTFTs were presented in Fig.1.

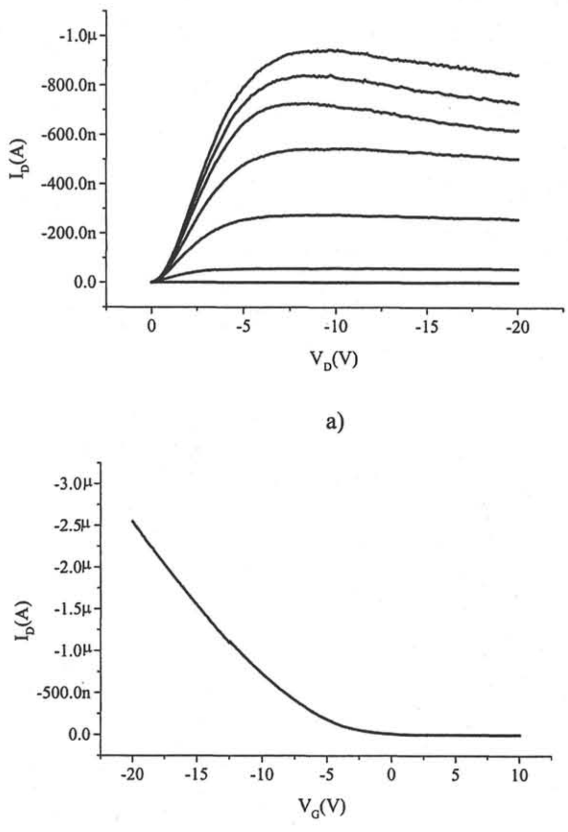


a) b)

Fig. 1. The structure of pentacne TFTs a) without OTS, and b) with OTS layer.

3. Results

The current-voltage characteristics of OTFTs were depicted in Fig.2, and they produced the typical I-V characteristics of p-type FET. The performance parameters are extracted from Eq.1 and summarized in Table 1.



b)

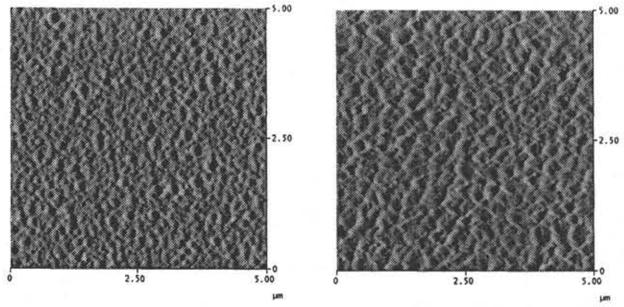
Fig. 2. The characteristics of pentacne TFTs on Glass a) I_D-V_D b) I_D-V_G .

$$I_{D,sat} = \frac{Z\mu_{FET}C_O}{2L}\left(V_G - V_{th}\right)^2 \qquad (1)$$

The field effect mobility, □FET produces about 10^{-3} $cm^2/V.sec$. The relatively low mobility is attributed to the small grain size of pentacene thin film. As indicated by AFM images of Fig. 3, the small grain is ascribed to the rough surface of SiN on which pentacene is deposited. In addition, the rough surface increases the scattering when

Table 1. The summary of performance parameters of Pentacen OTFTs on glass substrate

Insulator	Pentacene		Length(μm)	μ_{FET}(cm^2/V·s)	Ion/Ioff	SS(V/dec)	Vth(V)	Off-State current(A)
SiNx (4500Å)	700Å		10	3.93X10^{-3}	1.90X10^{4}	2.78	4.8	3.36X10^{-8}
			40	6.71X10^{-3}	3.10X10^{3}	3.86	3.2	1.73X10^{-7}
			10	1.37X10^{-3}	2.86X10^{4}	2.1	1.9	2.5X10^{-11}
			40	8.80X10^{-3}	1.71X10^{4}	2.1	3.6	8.81X10^{-11}
SiNx (2000Å)	1000Å	N	10	4.95X10^{-3}	4.71X10^{5}	0.7	-0.6	1.1X10^{-11}
		O	20	7.81X10^{-3}	2.35X10^{4}	1.64	-0.5	1.87X10^{-10}
		N	50	1.14X10^{-2}	3.06X10^{3}	2.3	-0.2	8.32X10^{-10}
		O	30	3.50X10^{-3}	3.07X10^{5}	0.82	-0.8	3.76X10^{-12}
		T	40	3.88X10^{-3}	5.04X10^{4}	1.17	-2	9.15X10^{-12}
		S	50	3.96X10^{-3}	2.31X10^{5}	0.68	-2.1	2.51X10^{-12}



a) b)

Fig3. a) The AFM images of SiNx, b) The AFM images of pentacene deposited on SiNx.

the carriers transport along the channel, resulting in the decrease of mobility. The mobility slightly increases with the channel length. The increase is due to the edge effect of source and drain contact around which the grain size is much smaller than in the middle of channel. As the channel length increases, the contribution of edge effect to the whole current is reduced.

Meanwhile, the on/off current ratio and the sub-threshold slope deteriorate as the channel length increases. It is ascribed to the increase of off-state leakage current. The large leakage current makes the devices difficult to attract carriers in the channel and to be switched into the on-state.

The surface roughness of gate insulator can be smoothed by coating with an organic layer such as OTS prior to pentacene deposition as shown in Fig.1 and the performance is usually enhanced [1,2],. However, during the self-assembly process of OTS for 24 hrs, the Al gate metal was stripped off from the glass substrate. The solvent of THF for OTS may be the reason. The adhesion of gate metal with glass substrate is not good enough for OTS process. Therefore, OTS was coated by spin process. In the process some defects were found in OTS layer and they may be the cause of the small mobility even though OTS layer was deposited on the gate surface. But the variation of parameters along the channel length is reduced and it elucidate that the edge effect is reduced by deposition of organic layer on the gate surface.

4. Conclusion

The pentacene TFTs using SiNx as the gate insulator have been fabricated and the electrical characteristics were examined. The field effect mobility was about 10^{-3} cm^2/V.sec and varied with the channel length. By spin-coating of OTS layer on gate insulator prior to pentacene deposition, the edge effect of contact were reduced and the performance parameters exhibited the relatively uniform values independent from the channel length although the parameters were not much improved. Provided the OTS process is improved, OTFTs using SiN can be applied to the flexible LCD display.

Acknowledgments

The work has been supported by Ministry of Science and Technology in Korea.

References

[1] D.J. Gundlach, C.C. Kuo, S.F. Nelson and T.N. Jackson, 57th Device research Conf. Dig., p164, June (1999)

[2] C.K. Song, B.W. Koo, S.B. Lee, D.H. Kim, Jpm. J. Appl. Phys., Vol. 41, No.4B (2002)