소스/드레인 전극의 두께변화에 따른 TIPS-pentacene 트랜지스터의 전기적 특성 연구

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Study on the electric characteristics of TIPS-pentacene transistors with variation of electrode thickness

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Abstract : We investigated the electrical properties of tris-isopropylsilylethynyl (TIPS)-pentacene organic thin-film transistors (OTFTs) employing Ni/Ag source/drain electrodes. The gap height between the gate insulator and S/D electrode was controlled by changing the thickness of Ag under-layer(20, 30, 40 and 50nm). After evaporating the Ni under-layer, TIPS pentacene channel material was dropping the gap between the gate insulator and S/D electrodes. The electrical proprieties of OTFT such as filed-effect mobility, on/off ratio, threshold voltage and subthreshold slope were significantly influenced by the gap height.

Key Words : TIPS-pentacene, solution process, electrodes thickness

1. Introduction

Organic thin-film transistors (OTFT) have attracted increasing attention in the last twenty years, as they promise a low-cost, simple processing of flexible and large-area electronic devices. However, OTFTs showing the best performance up to date are mostly based on pentacene and gold electrode with a costly vacuum-deposition process, it makes difficulty for OTFTs to move forward and true building blocks for low-cost and large-area electronics.[1,2] But being solution-process, a functionalized pentacene derivative called tris-isopropylsilyl(TIPS)-pentacene has thus generated a new forecast, moreover an optimized solution-processed pentacene based OTFT using a flexible substrate enables a simple and non vacuum fabrication of organic devices making possible extremely low-cost electronics that can be manufactured using recently techniques.[3,4]

2. Experiments

For our experiments, bottom-contact OTFT device, as schematically shown in Fig. 1. Device employing adhesion layer 4nm thick Ni was deposited on 10wt% cross-linked poly-4-vinylphenol (CPVP)gate insulator by thermal evaporator and for a comparison, Ag layer was varied 20, 30, 40 and 50nm using S/D electrodes. A gap is created between the PVP gate insulator and Ni/Ag electrode. The TIPS pentacene was dropped by using micro-pipet and filling the gap forming a channel layer. For the active layer, concentrations 2wt% of TIPS-pentacene solution in chlorobenzene was prepared and device processing steps were done in an air ambient. followed by Annealed at 110℃ for 8min. The transistor characteristics were measured by using a Keithley 4200/SCS in ambient air.

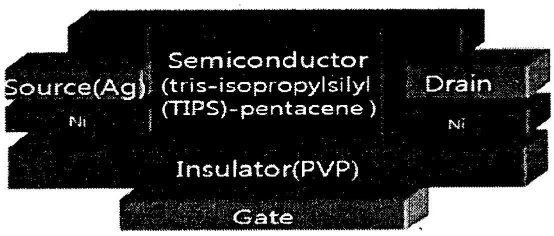
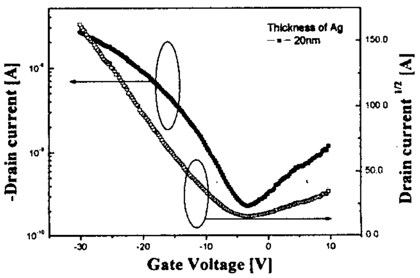


Fig. 1. A schematic diagram of an OTFTs

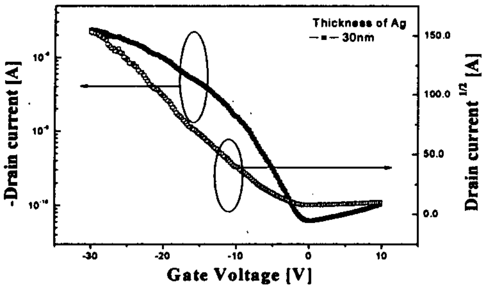
3. Results and discussions

Fig. 2. shows the current voltage characteristics of drop-casted TIPS pentacene with different thickness of Ag. The curves of transfer characteristics show the subthreshold slope, field -effect mobility and current on/off ratio, which are listed along with our device characteristics in Table 1. We fabricated OTFTs S/D electrodes thickness of Ag and founded optimized thickness of Ag by drop-casted method without expensive machine like high-cost vacuum equipment or roll to roll inkjet machine.

(a)



(b)



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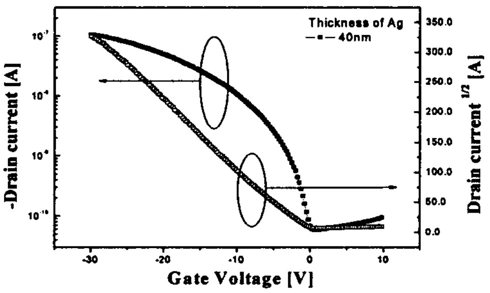
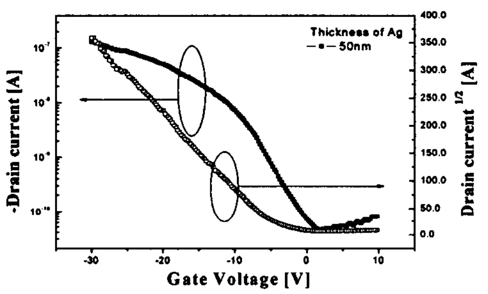


(d)



(e)

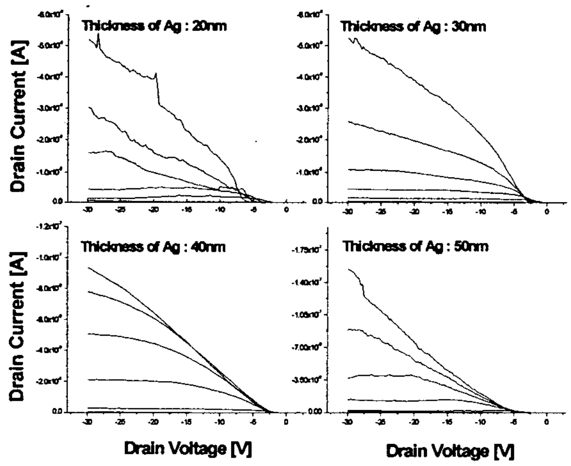


Fig. 2. The Log I_D and square root of the drain current as a function of V_G (from 10 V to -30 V) at V_{DS} = -30 V (a) thickness of Ag 20nm, (b) 30nm, (c) 40nm and (d) 50nm. Plots of the drain current vs. the source - drain voltage as a function of gate voltage on thickness of Ag (e).

Channel length [μm]	60			
Channel width [μm]	300 (W/L=5)			
Adhesion layer thickness	Nickel 4nm			
S/D thickness	Silver 20nm	Silver 30nm	Silver 40nm	Silver 50nm
Threshold voltage [V]	-5	-5	0	-4
Subthreshold slop [V/decade]	8	6.75	1.8	4.2
On current [A]	2.65×10^{-8}	2.34×10^{-8}	1.06×10^{-7}	1.28×10^{-7}
Off current [A]	2.30×10^{-10}	6.18×10^{-11}	5.86×10^{-11}	4.50×10^{-11}
On/off ratio	$\sim1.1\times10^{2}$	$\sim3.7\times10^{2}$	$\sim1.8\times10^{3}$	$\sim2.8\times10^{3}$
Mobility [cm^2/Vs]	~0.0016	~0.0017	~0.0056	~0.0063

Table. 1. OTFTs parameters extracted from the transfer curves of OTFTs different S/D electrodes thickness.

4. Conclusion

In conclusion, we think cause of characteristic difference with variation of electrode thickness is the effect of contact barrier between source and drain channel, which is related to pentacene crystallization and graining.

Acknowledgements

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