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Organic Thin Film Transistors fabricated by All Solution Processes

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1. Introduction

Solution processed organic thin-film transistors(OTFTs) have attracted a considerable attention due to their potential advantages in backplane of flexible displays and organic electronics such as e-paper and radio-frequency identification tags(RFIDs)[1-3]. The solution-based process enables a simple and non-vacuum fabrication of organic devices such that extremely low-cost electronics can be achieved. Recently inkjet printing method is widely used in organic electronics fabrication including organic light emitting diodes displays and organic transistors[4,5]. The inkjet printing method offers a fast and accurate patterning without any costly photolithography process.

Pentacene is one of the most promising organic materials, since it offers higher mobility, better on-off ratio and better reliability than most other organic semiconductors. However, it is not suitable for the solution-based fabrication. Because it isn't soluble in organic solvents. It can be overcame by adding bulky groups at the 6,13 positions of pentacene, Bis(triisopropylsilylethynyl) pentacene (TIPS pentacene)[6].

The purpose of this paper is to report development of all-solution processed OTFTs using inkjet printing technique. The silver ink is used for gate, source and drain electrodes. Silver ink has been extensively used for inkjet printing metallization[7,8]. We used poly-4-vinylphenol (PVP) for gate insulator and active layer is defined by using TIPS pentacene.

2. Experiments

The fabrication processes were as follows. The process flow for fabrication is shown in Fig. 1. We used inkjet printing machine, UJ 2400 , with 50μ m piezo-electric type nozzles to define electrodes and active layer. First, silver ink was printed directly onto the clean glass substrate for gate electrode and then cured at 140℃ for 30min. The poly-4-vinylphenol (PVP) was spin-coated as a gate insulator. PVP copolymer is mixed with poly-4-vinylphenol (PVP) and propylene glycol monomethyl ether acetate (PGMEA) and cross-linked by adding poly (melamine-co-formaldehyde). Spin condition is 1000rpm, 30sec and baking condition is 20min in 200℃ after 10min in 100℃. Source and drain electrodes were defined by the same way of gate electrode. Finally, Bis (triisopropylsilylethynyl) pentacene (TIPS pentacene) was jetted onto the channel. TIPS pentacene was dissolved 1wt% in various solvents , anisole and chlorobenzene. The average ink drop diameter was 35μ m , the average volume was 23 pl and the average drop velocity was 0.998m/s.

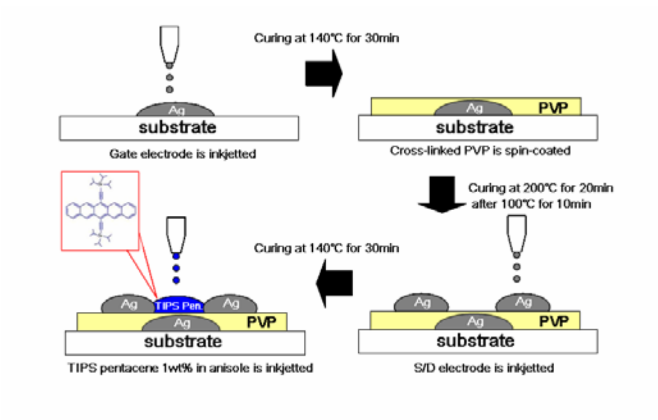
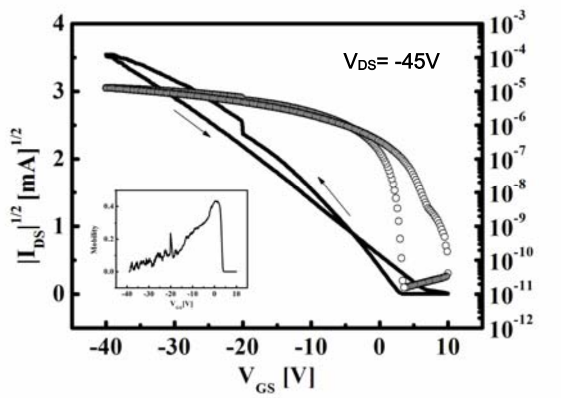


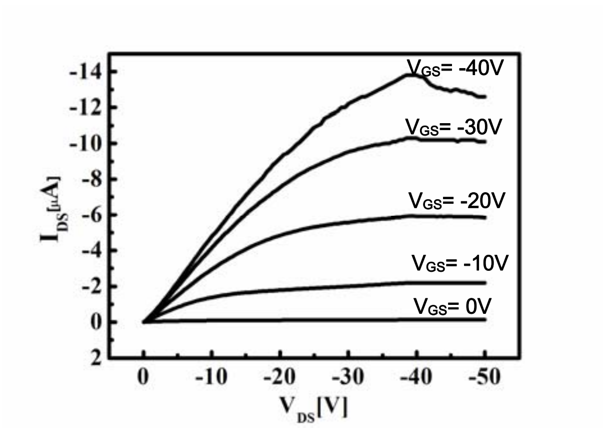
Fig.1 Process flow for fabrication of all-solution processed OTFTs. Inset image is Bis (triisopropylsilylethynyl) pentacene (TIPS pentacene).

3. Result and discussion

The electric parameters were summarized in Table 1. The square-root I_{DS}-V_{GS} curves and output curves of TIPS pentacene 1wt% in anisole are shown in Fig. 2, Fig. 3 respectively. The field effect mobility is 0.43cm^2/V·s, on-off ratio is 7.31x10^5, threshold voltage is 2.66V, sub-threshold slope is 0.51V/dec and off state current is 0.118pA/μ m. The electric characteristics were measured in dark and air-ambient environment. Especially, the results of using anisole as a solvent are more excellent than chlorobenzene. Fig. 3 shows the optical microscope image of TIPS pentacene 1wt% in anisole. We can observe dendrite structure.



(a)



(b)

Fig. 2 (a) Transfer characteristics and (b) Output characteristics of Bis (triisopropylsilylethynyl) pentacene (TIPS pentacene) 1wt% in anisole OTFTs and mobility (inset) with L = 5μ m, W = 146μ m at V_{DS}= -45V

Table 1. electric parameters

Channel W/L (μ m)	Mobility ($cm^2/V{\cdot}s$)	On/Off	V_{TH} (V)	SS (V/dec)	Off state current (pA/um)
146/5	0.43	$7.31x10^5$	2.66	0.51	0118

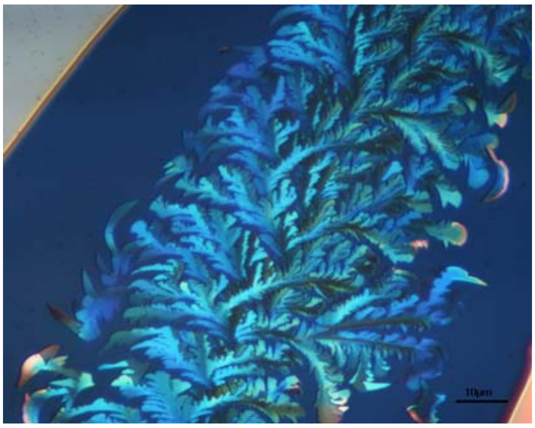


Fig. 3 Optical microscope image (1000X) of TIPS pentacene film drop-casted from 1wt% in anisole solution.

4. Conclusions

We fabricated all-solution processed OTFTs using the inkjet printing method and extracted the electric parameters. The field effect mobility is $0.43cm^2/V{\cdot}s$, on-off ratio is $7.31x10^5$, threshold voltage is 2.66V, sub-threshold slope is 0.51V/dec and off state current is 0.118pA/μ m. These results are similar to vapor deposited OTFTs but the cost was much lower than those.

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References

[1] T. Kawase, H. Sirringhaus and T.Shimoda, *Adv. Mater*. **13** (2001) 1601
[2] Z. Bao, Y.Feng, and A.J. Lovinger, *Chem. Mater*. **9** (1997) 1299
[3] R. Parashkov, E. Backer, G. Ginev and W. Kowalsky, *J. Appl. Phys*. **95**, 1594
[4] Y. Liu, K. Varahramyan and T. Cui, *Macromol. Rapid Commun*. **26** (2005) 1995
[5] S. K. Volkman, S. Molesa, B. Mattis, P. C. Chang and V. Subramanian, *Mat. Res. Soc. Symp. Proc*. **769** (2003) 11
[6] J. Chen, J. Anthony and D. C. Martin, *J. Phys. Chem. B* **110** (2006) 16397
[7] F. Xue, Z. Liu, Yi Su and K. Varahramyan, *Macroelec. Engin*. **83** (2006) 298
[8] S. Sanaur, A. Whalley, B. Alameddine, M. Carnes, and C. Nuckolls, *Org. Electro*. **7** (2006) 423