Electrical Properties of OTFTs and Inverters by using Ink-Jet Printing with Polyvinylphenol Insulator and TIPS-Pentacene Semiconductor

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Abstract

In this paper, we report electrical properties of OTFTs by using ink-jet printing with polyvinylphenol (PVP) for gate insulator and bis(triisopropylsilylenthynyl) pentacene (TIPS pentacene) for semiconductor. OTFTs produced the excellent performance with the mobility of 1.27 $cm^2/V.s$ for top contact structure(TCS) and inverter consisting of two OTFTs exhibited the gain of 6.75.

1. Introduction

Ink-jet printing has rececoived special attention as a direct patterning technique for the cost-effective fabrication of organic electronic devices such as orcganic light-emitting diodes (OLEDs), organic field-effect transistors (OTFTs), organic solar cells (OCSs), and radio frequency identification devices (RFIDs).[1]

Especially, ink-jet printing is characterized by low cost process attributed to non-lithography process and conservation of expensive materials. [2] The ink-jet printing is actively under development for application to OTFTs however we can see a big advancement yet. The main reason is that the process should be optimized to the specific materials used for the application, which means that there is not a general rule applicable to the general applications.

In this paper, we report electrical properties of OTFTs by using ink-jet printing with PVP for gate insulator and TIPS pentacene for semiconductor.

2. Experimental

The PVP ink was formed by mixing PVP polymer with propylene glycol monomethyl ether acetate (PGMEA) and cross-linking agent of poly (melamine-co-formaldehyde). The PVP ink was jetted on Al gate electrode through a nozzle with 50 um orifice to make a uniform gate insulator layer. It was difficult to deposit the square shaped PVP layer with the uniform thickness because the layer was composed of many round shaped drops with the average size of 163 um. Thus, the drops should be overlapped each other and then combine together to form the uniform flat layer before drying in air. Subsequently, the PVP layer was cured at 200 ^oC for 20 min. PVP layer is shown in Fig.1.

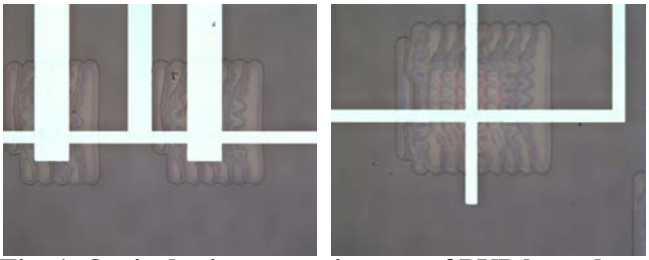

Fig. 1. Optical microscope images of PVP layer by inkjet printing.

The crystallinity of TIPS pentacene was quite different depending on the solvents we used. We examined the crystallinity of TIPS mixed with the various solvents such as anisole and chloroform. TIPS mixed by 1wt% with anisole produced the best crystal. The jetted TIPS drops exhibited 96 um diameter.

Two types of OTFTs were fabricated with bottom source/drain(S/D) contact structure (BCS) and top contact structure (TCS). Al used for gate electrode and Au for S/D contacts. HMDS treated on PVP surface. In addition inverter consisting of two OTFTs was also fabricated as shown in Fig. 2.

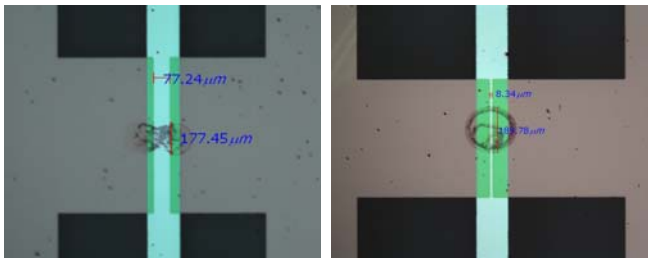

Fig. 2. Optical microscope images of a) top contact structure and b) bottom contact structure

3. Results and discussion

The electrical Properties of OTFTs and Inverters by using Ink-Jet Printing with Polyvinylphenol Insulator and TIPS-Pentacene Semiconductor are presented in Fig. 3. for TCS and in Fig. 4. for BCS. The performance parameters are summarized in Table 1. For TCS, the field effect mobility is 1.27cm^2/V.s, on/off ratio is 5.45 x 10^5, threshold voltage is 0.89V, sub-threshold slope is 3.24V/dec and off state current is 0.063pA/μm. For BCS, the field effect mobility is 0.69cm^2/V.s, on/off ratio is 1.59 x 10^6, threshold voltage is 0.62V, and sub-threshold slope is 0.34V/dec and off state current is 0.048pA/μm. The inverter produced the gain of 6.75 as shown in Fig. 5.

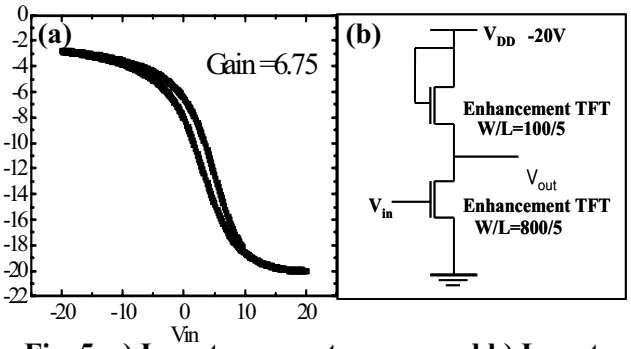

Fig. 5. a) Inverters ouput curves and b) Inverters logic circuit

Table 1. electric parameters

	Mobility (cm^2/V·s)	On/Off ratio	Vth (V)	SS (V/dec)	Off state current (pA/μm)
Top-contact	1.27	5.45×10^5	0.89	3.24	0.0626
Bottom-contact	0.69	1.59x10^6	0.62	0.34	0.048

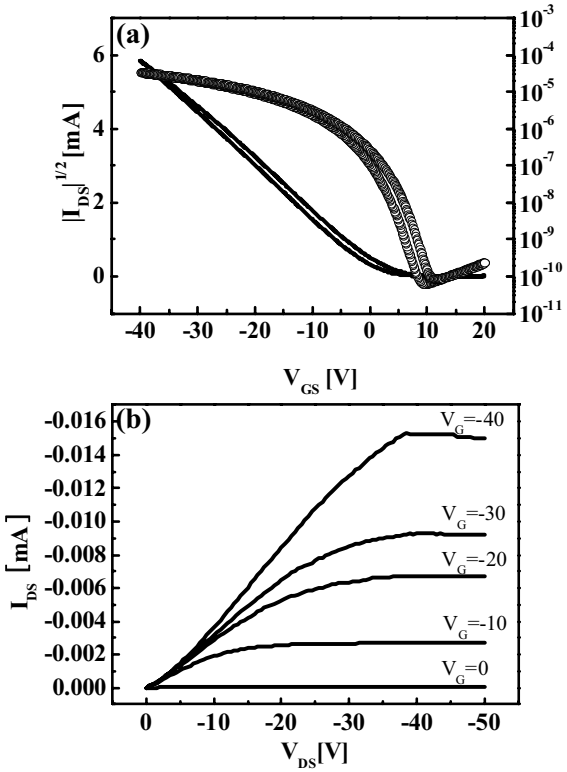

Fig. 3. a) Transfer characteristics and b) ouput characteristics for top-contact OTFTs fabricated by ink-jet printing method.

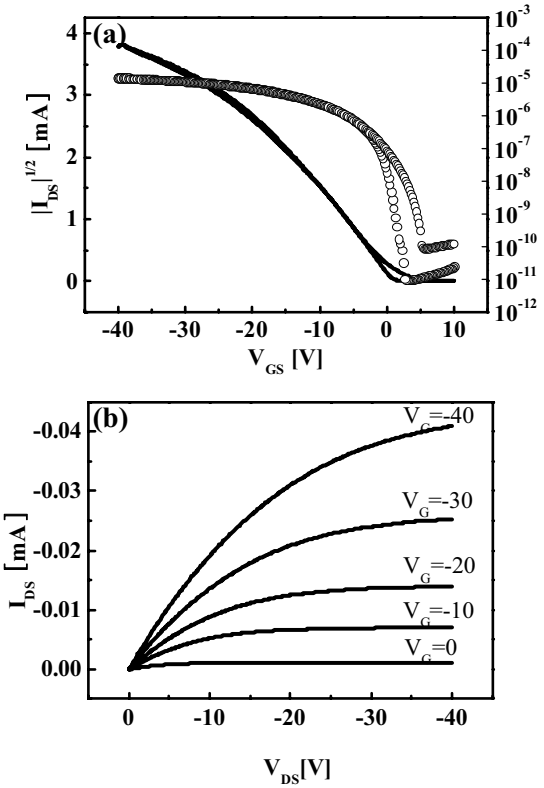

Fig. 4. a) Transfer characteristics and b) ouput characteristics for bottom-contact OTFTs fabricated by ink-jet printing method.

4. Summary

We fabricated OTFTs and inverters by using ink-jet printing with PVP for gate insulator and TIPS-pentacene for semiconductor. OTFTs produced the excellent performance with the mobility of 1.27 cm^2/V.s for TCS and inverter consisting of two OTFTs exhibited the gain of 6.75.

5. Acknowledgements

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6. References

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