A STUDY OF THE HYSTERESIS MECHANISM OF ORGANIC THIN FILM TRANSISTOR WITH POLY(4-vinylphenol) GATE INSULATOR

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Introduction

Organic thin film transistors (OTFTs) are attracting attention because of their potential use as a low-cost electronic device [1]. Particularly, the pentacene-based OTFTs are becoming widely popular and have already demonstrated their potentials toward organic electronic applications such as flexible display, bio sensor, and radio frequency identification (RFID) [2]. OTFTs have many unique advantages for example, light weight, flexibility, low cost of fabrication, and solution processability [3]. Amongst the other polymer based gate dielectrics reported in the literature, poly(4-vinylphenol) (PVP) based devices have perhaps the highest mobility [4]. An insulator is an important component of OTFTs. The surface characteristics of the insulator strongly influence the quality of the insulator-semiconductor interface, significantly affecting the performance of the device.

Experimental

We used glass substrates cleaned by a standard cleaning procedure i.e. acetone, isopropylalchol, and deionized water sequentially in an ultrasonic bath for 20 min, respectively. For bottom gate electrode geometry, Al gate electrode was first deposited on the glass surface upto a height of 80 nm by thermal evaporation. PVP gate insulator was mixed with the cross-linking agent (CLA)-poly(melamine-co-formaldehyde) and the solvent propylene glycol monomethyl ether acetate (PGMEA). We mixed different ratios of CLA concentration which affected the performance of the OTFTs (6 wt% CLA, 9 wt% CLA and 50 wt% CLA, respectively). The final mixture was then spin-coated at 4500 rpm, for 35 sec on the substrate. Spin coated, cross-linked PVP substrate was cured in the conventional oven at a temperature of 100 ^{o}C for 10 min to remove the solvent and 200 ^{o}C for 60 min to make final cross-linking. For active layer, pentacene was deposited to about 70 nm through a patterned shadow mask by high vacuum thermal evaporation at a rate of 0.1 Å/s, on the substrate with a temperature of 85 ^{o}C. The source/drain Au electrodes were patterned to about 100 nm by thermal evaporation using shadow mask (channel width 1000 μm, length 100 μm). Fig.1 indicates the schematic cross-sectional view of OTFT. Electrical performance of OTFTs was analyzed with Keithley 236.

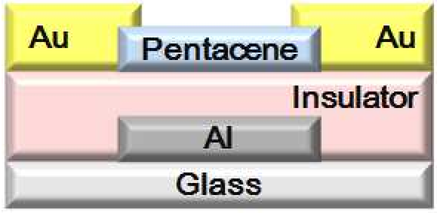

Fig. 1 The structure of organic thin film transistor.

Result and discussion

In this work, we studied the hysteresis characteristic of an OTFT device with cross-linked PVP mixed with different concentrations of CLA. Fig.2 shows that as the CLA concentration increases, the characteristics of hysteresis in OTFT changes. The hydroxyl group (OH group) in cross-linked PVP gate insulator gets affected due to the presence of CLA. Fig.2 (a) shows hysteresis characteristic of OTFT with 6 wt% CLA concentration in cross-linked PVP. When negative voltage is applied to gate electrode, the injected electron gets trapped at OH group; as a result, hysteresis occurred in OTFT. As the viscosity of CLA is high, the thickness of insulator layer depends on the CLA concentration. Therefore the thickness of insulator with 6 wt% CLA in PVP is low which increases the leakage current. The on/off ratio is smaller by two orders of magnitude than the performance of OTFT with 9 wt% CLA and 50 wt% CLA. However, increased 9 wt% CLA concentration is able to reduce hysteresis characteristic as shown in Fig.2 (b), because of reduced OH groups in PVP dielectric insulator. In addition, more high concentration of CLA i.e. 50 wt% results in hysteresis in opposite direction. High concentration of CLA leads to injection of holes from pentacene layer to PVP layer.

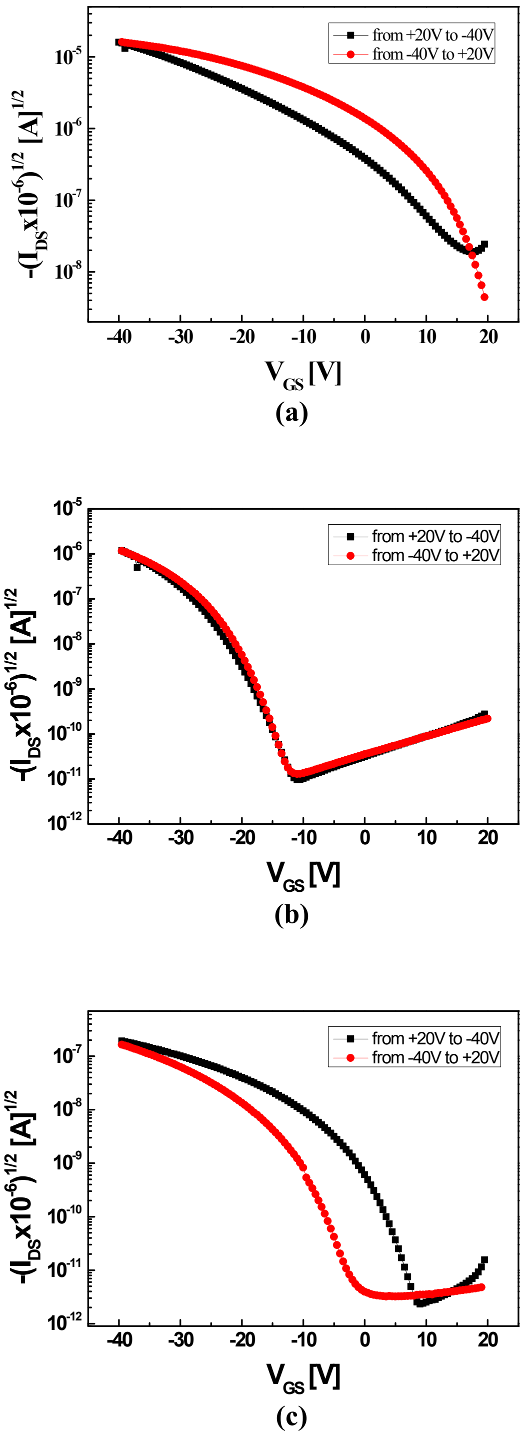

Fig. 2 Hysteresis characteristic of organic thin film transistor with different concentration of CLA ((a) 6 wt% CLA, (b) 9 wt% CLA, (c) 50 wt% CLA).

Conclusion

We fabricated a OTFTs device on glass substrate using PVP gate insulator mixed with different amounts of CLA (6 wt%, 9 wt%, 50 wt%). Pentacene served as an active layer while Au and Al acted as a source/drain and gate electrode respectively. The presence of OH groups in PVP, traps electron which leads to hysteresis on OTFT performance. Trapping of electron can be reduced by addition of appropriate concentration of CLA. As the concentration of CLA increases, the characteristics of hysteresis changes in OTFT dielectric insulator.

References

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