P3HT와 IZO 전극을 이용한 thin film transistors 제작

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Fabricated thin-film transistors with P3HT channel and NiO_x electrodes

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Abstract : We report on the fabrication of P3HT-based thin-film transistors (TFT) that consist of indium-zinc-oxide (IZO), PVP (poly-vinyl phenol), and Ni for the source-drain (S/D) electrode, gate dielectric, and gate electrode, respectively. The IZO S/D electrodes of which the work function is well matched to that of P3HT were deposited on a P3HT channel by thermal evaporation of IZO and showed a moderately low but still effective transmittance of ~25% in the visible range along with a good sheet resistance of ~60Ω/□. The maximum saturation current of our P3HT -based TFT was about 15μA at a gate bias of –40V showing a high field effect mobility of 0.05cm^2/Vs in the dark, and the on/off current ratio of our TFT was about 5×10^5. It is concluded that jointly adopting IZO for the S/D electrode and PVP for gate dielectric realizes a high-quality P3HT -based TFT.

Key Words : P3HT, thin-film transistors, indium-zinc-oxide, poly-vinyl phenol, Ni

1. 서 론

Organic thin-film transistors (OTFTs) are now widely investigated as switching devices for active-matrix displays and integrated circuits such as radio-frequency identification tags (RF-IDs) [1,2]. Various fabrication techniques are currently used to develop high performance OTFTs such as vacuum deposition, ink-jet printing, screen printing and rubber stamp printing. OTFTs with vacuum deposited organic semiconductors exhibit the highest performance but from the manufacturing cost point of view, printing based technology is more favorable.

2. 실 험

The gate electrode has been made of 100 nm-thick Ni, deposited at room temperature by using radio-frequency (RF) magnetron sputtering. Dual layer of poly-vinyl phenol (PVP) /SiO_2 was used as a gate dielectric, which improves the electrical properties of the OTFT device. The thickness of PVP and SiO_2 films were 40 and 210 nm, respectively. As source/drain electrode, sputtering deposited indium-zinc-oxide (IZO) (100 nm) with thermally annealing used. After defining the source and drain electrodes, O_2 plasma and self-assembly-monolayer (SAM) treatments of oxide layer were followed sequentially.

Poly (3-hexylthiophene) (P3HT) was used after purification process with tetrahydrofuran (THF) and acetonitrile to increase the head-to-tail regioregularity. Later, P3HT was dissolved in chloroform with a concentration of 0.2 wt% and then spin coated or rubber stamp printed on the substrate. Electrical characteristics of the device were measured using Keithley 4200-SCS semiconductor characterization system.

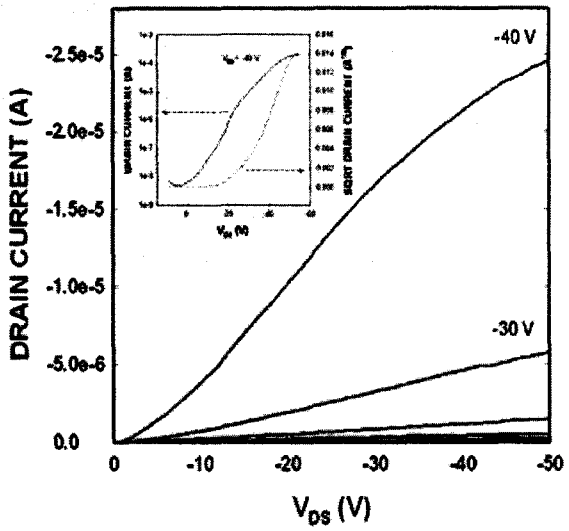
3. 결과 및 고찰

OTFT array was fabricated with P3HT as the active channel layer. The P3HT solution was spin coated over the fabricated device. Figure 1 (a) shows the transfer characteristics of the OTFT device with drain voltage (V_{DS}) of -40 V, and the inset shows the drain current (IS) versus drain voltage (V_{DS}) at various gate voltages (VS). The OTFT device had bottom contact TFT geometry and the gate length (L) and the width (W) were 25 ㎛ and 500 ㎛, respectively.

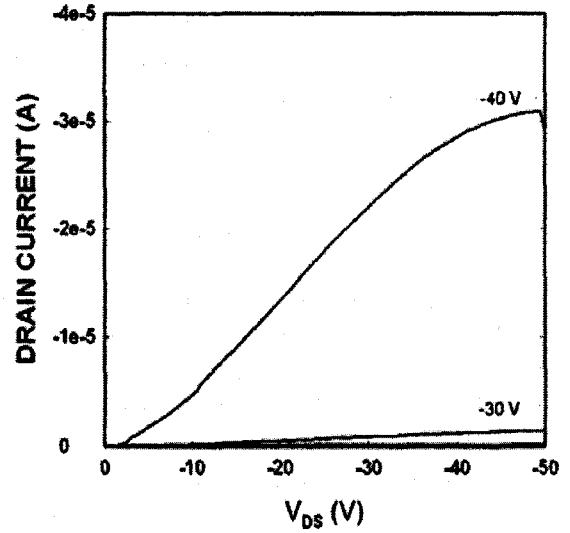
The field effect mobility calculated in the saturation regime was 0.05 cm^2/V·s where the threshold voltage (VT) was -11.9 V. The current modulation which is the ratio of the current in accumulation mode over the current in the depletion mode was more than 10^4. These results of OTFT on paper substrate are compatible to the results in conventional OTFT on glass/polymer substrates.

In addition to the spin coating method, the transistor was

also fabricated by using a rubber stamp printing process with pre-patterned stamps [3]. Figure 1 (b) shows the output characteristic of an OTFT device fabricated by using the rubber stamp printing method. The device was fabricated on a parylene coated paper substrate with an additional polymer resin coating to improve the surface properties. Here, the calculated field-effect mobility was 0.081 $cm^2/V{\cdot}s$, showing similar result compared to the spin coated devices.



(a)



(b)

Fig. 1. I-V characteristics of polymer thin-film transistors using IZO electrode (a) spin-coated, (b) rubber-stamp-printed.

4. 결 론

We fabricated high performance organic transistors using oxide electrode with the field effect mobility up to 0.086 $cm^2/V{\cdot}s$ and on/off ratio of 10^4. In order to carry out the wet chemical process, the photo-resistor process with negative photo resistor. The fabrication of organic devices using oxide electrode may be important for realizing future applications in flexible and disposable electronics.

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