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Low Contact Resistance of Source and Drain electrodes of OTFTs with PEDOT-PSS patterned by Ink-jet printing

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1. Introduction

Contact resistance caused by Schottky energy barrier between organic materials and S/D electrodes [1] drop the performances of organic devices. So many researches are being conducted such as self assembled mono-layers (SAM) treatment [2] or insertion of the buffer layer [3] between organic materials and S/D electrodes.

The most widely used Au as S/D electrodes has high conductivity and work function. But it is not suitable to organic devices. Because it is expensive and it has a high contact energy barrier [1]. PEDOT-PSS is the material researched to alternate Au because of low price and possibility of solution process and low contact resistance. But because of its poor conductivity, many researches are being conducted to enhance its conductivity [4].

We carried out an experiment on enhancing conductivity of PEDOT-PSS by adding glycerol and fabricated the outstanding pentacene OTFTs with modified PEDOT-PSS as S/D electrodes by using ink-jet printing method. And we extracted and compared the contact resistance of PEDOT:PSS and Au electrodes, confirming the much lower contact resistance of PEDOT:PSS than Au.

2. Experiments

The fabricated bottom contact OTFT is illustrated in Fig. 1. For gate electrodes, the 1000Å thickness Al was evaporated on the clean glass in a high vacuum chamber. The PVP layer was then spin-coated for 30sec at 1000rpm, and dried in 200℃ oven for 20min after 100℃ oven for 10min. The PEDOT-PSS layer was ink-jet printed on the 70℃ heated substrate with a resolution of 600dpi. The used PEDOT-PSS solution was modified by glycerol with weight ratio of 10:1. Finally, the 450Å thickness pentacene as active layer was evaporated in a high vacuum chamber. The deposition rates of the Al layer and pentacene layer were 3 and 0.3Å/sec, respectively. A channel width of fabricated devices is 2000㎛ and lengths are 80, 120, 160, 200㎛ for extracting the contact resistance of devices [5]. To compare the contact resistance values, we also fabricated the device with Au as S/D electrodes under the same process conditions. These samples were characterized in atmosphere using Keithley 4200 semiconductor analyzer.

3. Result and discussion

The sheet resistance of PEDOT-PSS is shown in Fig. 2 according to the each condition. In Fig. 2(a-c), the sheet resistance was the most stable under the conditions of glycerol weight 6g per PEDOT-PSS 10g, drying temperature 120℃ for 30min. And the PEDOT-PSS layer was not affected adversely against each solvent in Fig. 2(d). The Fig. 3 shows the PEDOT-PSS solution dropped by ink-jetting on the PVP layer. One drop size of PEDOT-PSS is 25.55㎛ in Fig. 3(a). The Fig. 3(b-d) shows that the PEDOT-PSS drops were lumped because of hydrophobic PVP surface and the drops viscosity although the resolution and substrate temperatures were changed. In order to reduce the viscosity glycerol density was decreased to 10:1 in weight without changing the conductivity as shown in Fig. 2(c). The patterned PEDOT-PSS pad is shown in Fig. 4, and its sheet resistance was 38Ω/□. Fig. 5 shows the transfer curve and output curve of OTFT with PEDOT-PSS as S/D electrodes. The graph inserted in Fig. 5(a) is the mobility characteristics versus gate voltages. The field effect mobility is 0.2 cm^2/V s, on/off current ratio is 10^5, threshold voltage is 4.1 V and sub threshold swing is 1.4 V/decade. The extracted contact resistance of PEDOT:PSS was about 200k Ω/□ at V_G=-5V, which was much smaller than that of Au, 1.4M Ω/□.

4. Conclusions

We enhanced the conductivity of PEDOT-PSS by mixing with glycerol and fabricated the low contact resistance of source and drain electrodes of OTFT with PEDOT-PSS by ink-jetting printing. The contact resistance was much smaller by seven times than Au with 200k Ω/□ at V_G=-5V. For the bottom contacted OTFTs the performance was comparable to OTFTs with Au electrodes with the field effect mobility of 0.2 cm^2/V s.

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References

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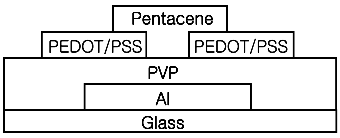

Fig. 1. The structure of bottom contact OTFT.

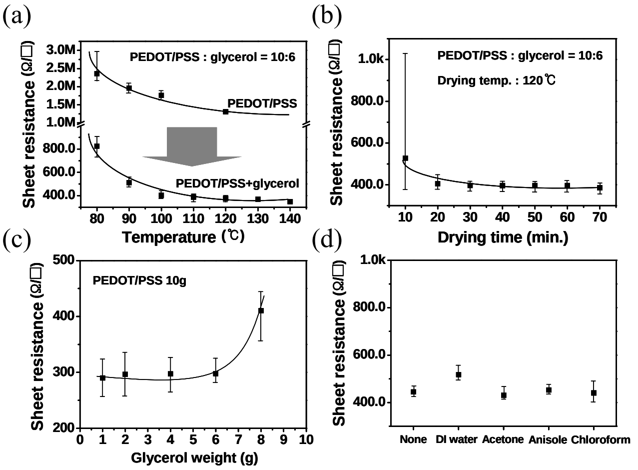

Fig. 2. The sheet resistance of PEDOT-PSS with glycerol electrodes according to (a) the curing temperature, (b) the curing time, (c) the glycerol density, and (d) the solvents.

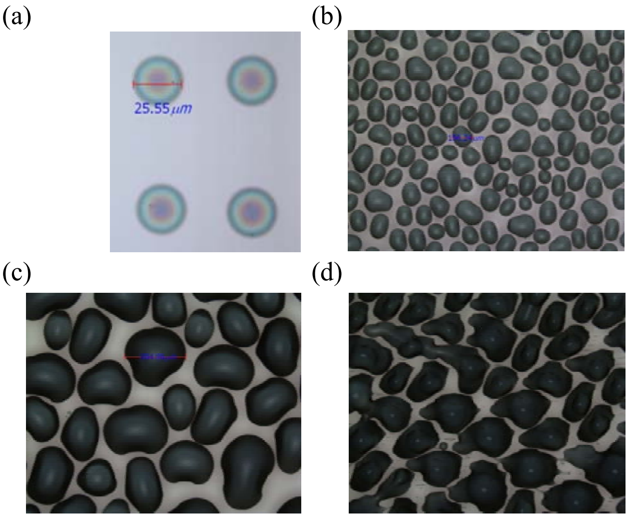

Fig. 3. The picture of PEDOT-PSS dropped on PVP layer by using a ink jet printing; (a) single drop, (b) drops of pad patterned by resolution of 400dpi, (c) resolution of 600dpi, (d) resolution of 600 dpi with substrate temperature of 70℃.

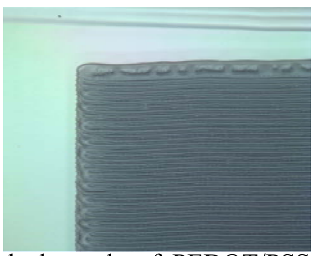

Fig. 4. The pad electrode of PEDOT/PSS on PVP layer optimized by PEDOT : glycerol = 10 : 1 and resolution of 600dpi and substrate temperature of 70℃.

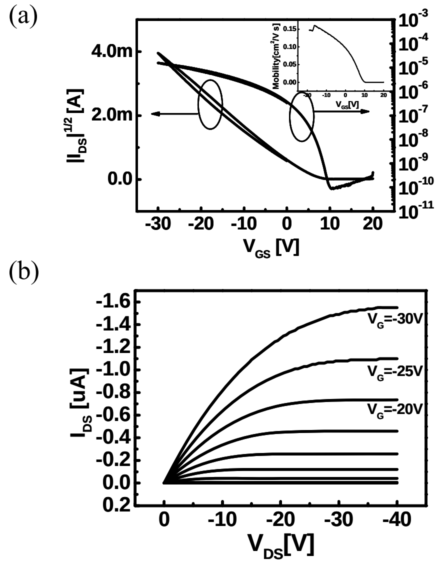

Fig. 5. The characteristics of OTFT with PEDOT-PSS S/D electrodes; (a) transfer characteristics with the inserted graph of the field effect mobility vs. gate voltages, (b) output characteristics; μ_{FET}=0.2 cm^2/V.s, on/off current ratio=10^5. V_{th}=4.1V, and SS=1.4V/dec.

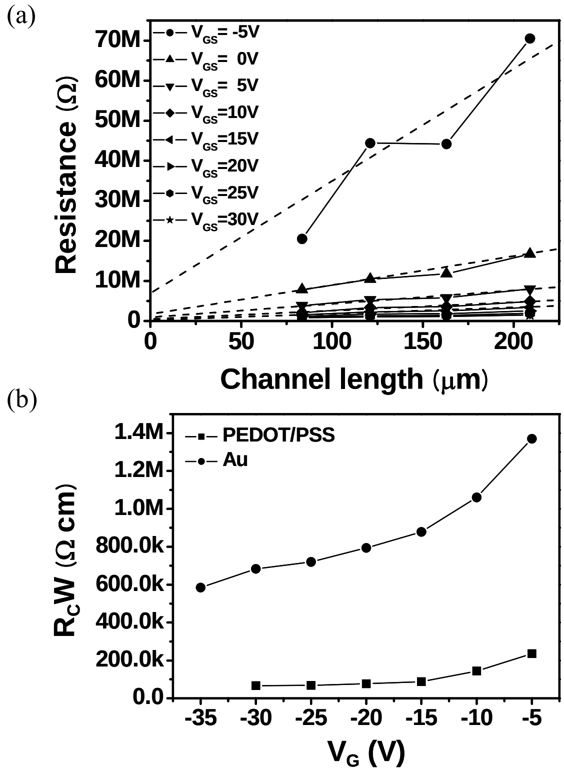

Fig. 6. (a) The total resistance of OTFT with PEDOT-PSS S/D electrodes according to the channel length, (b) the normalized contact resistance of PEDOT/PSS and Au electrodes vs. gate voltages.