High Performance Bottom Contact Organic Thin Film Transistor

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In organic thin film transistor (OTFT), top contact (TC) devices have demonstrated superior characteristic than bottom contact (BC) devices while BC devices have more commericial potential than TC devices. As photolithography has to be used when defining the contacts and pentacene is intolerant to the processing solvents, improving the property of BC is promising for industrial utility. In this work, TC and BC OTFTs were fabricated. Aluminum (80 nm) was deposited as a gate electrode and poly (methyl methacrylate) (PMMA) was then spin coated to a thickness of 180 nm. Pentacene was evaporated through a shadow mask at a rate of 0.3 Å/s to form a 70 nm thick active layer and also patterned with shadow mask. For TC structure, gold source/drain (S/D) electrodes (100 nm) were deposited after the pentacene layer. For BC structure, gold (30 nm) was deposited on the PMMA layer before pentacene layer. In BC structure, hexamethyldisilazane (HMDS) or poly (3,4-ethylenedioxythiophene): polystyrene sulfonate (PEDOT:PSS) was then coated after on S/D followed by pentacene evaporation. For all the devices, length and width of active channel was 100 μm and 1000 μm, respectively.

The transfer characteristic of each device type is shown in Fig. 1. The gate bias was swept from 10 V to -40 V under a drain bias of -20 V and the electrical properties are summarized in Table 1. The reason why BC has inferior property than TC is that, pentacene is nonpolar short molecule and repulsion from the substrate is good for its crystallization. However, gold is hydrophilic because of which pentacene tends to lay parallel to gold surface. Due to this, pentacene near gold electrode had small grain size resulting in very large contact resistance.

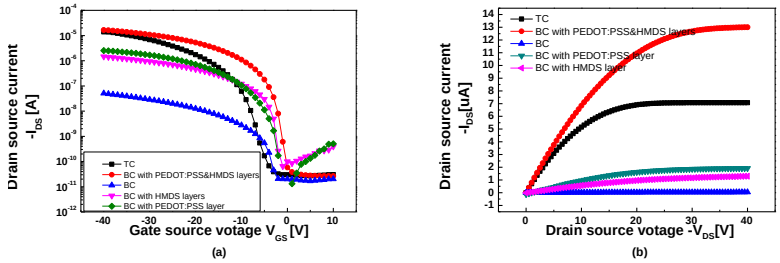

Fig. 1. (a) Transfer and (b) output characteristics for top contact and bottom contact with and without HMDS layer, PEDOT: PSS layer, and both

Table 1. Electrical properties of each condition

	TC	BC	BC with HMDS	BC with PEDOT:PSS	BC with both layers
V_{th} (V)	-9.3	-1.4	-0.5	-3.9	-1.8
μ ($cm^2V^{-1}s^{-1}$)	0.21	0.00056	0.017	0.043	0.23
On/off ratio	10^6	10^4	10^5	10^5	10^6

The water contact angle of gold and PMMA surface with and without HMDS and PEDOT:PSS was measured. The contact angle of bare gold and PMMA is 48.3 °and 67 °, respectively. After adding HMDS layer, gold and PMMA surface became less hydrophilic (54.1 °and 69.6 °) which resulted in larger pentacene grain size on them. PEDOT:PSS is a hole injection layer, as a result the contact resistance was reduced [1]. Benefited from the above advantages, HMDS and PEDOT:PSS coated BC devices showed better performance than TC devices and low threshold voltage which can be a potential candidate in industrial application.

References

1. Hong, K., Yang, S. Y., Yang, C., Kim, S. H., Choi, D., & Park, C. E. Organic Electronics, 9(5), 864-868. (2008).