The effect of Interfacial Layer on performance of Organic Thin-Film Transistors using V-shaped material

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[Introduction] Recent rapid development of organic electron devices has been a gateway for wide range of applications, such as, organic thin-film transistors (OTFT), organic solar cells and organic sensing devices. In the OTFTs, many studies have been focusing on improving the performance of the device, especially, synthesis of new organic materials, controlling the crystal growth of devices and interfacing alignment between the organic semiconductor and the dielectric substrate. In order to increase performance of OTFTs, we have investigated and fabricated OTFTs with various interfacial layers (IIL), such as, second-polymer materials, self-assembled monolayers (SAMs) and high-k materials. The various IIL have been used in order to evaluate the effect on the electrical properties and also crystalline structure of the device. In this study, a V-shaped organic semiconductor dinaphtho[2,3-b:2',3'-d]thiophene (C6-DNT)[1] is used as an active material to be optimized in our fabrication. The V-shaped materials promises higher mobility compared with previous materials: pentacene in our previous report[2].

[Experiments] A schematic diagram of OTFTs is shown in Fig.1.A heavily doped n-type Si-wafer with a thickness of SiO_2 of 100 nm was used. Silicon was cleaned with acetone, alkaline solution and DI water. Then, the IIL was coated on the substrate. Dielectric surface layer is treated with SAM; polymethylmethacrylate (PMMA), CT4112 (Kyocera Chemical), CYTOP (Asahi Glass) and organic insulating layer; octadecyltrichlorosilane (OTS) and hexamethyldisilazane (HMDS). For high-k materials which are HfO_2[3], Ta_2O_5[4] and Si_3N_4 layer were deposited by sputtering on Si/SiO_2. After the formation of IIL, the contact angle was measured. Then, the C6-DNT was evaporated to a thickness of 50 nm with substrates temperature to 90 ºC. Finally, source and drain were deposited on the top layer. Channel length and width is 500 μm and 1.5 mm, respectively.

[Results] The OTFT without interfacial layer has the field-effect mobility of 0.70 cm^2/Vs, threshold voltage of 1.2 V and on/off ratio of 10^6. By inserting the IIL, particularly by using SAM and organic insulating layer, the threshold voltage of the OTFT were shifted to negative voltage. Among various interfacial layer, SiO_2 with CT4112 was significantly improved the mobility from 0.70 cm^2/Vs to 1.2 cm^2/Vs and threshold voltage shifting from positive voltage to negative voltage, which are shown in Fig. 2. These results also show that device characteristics are influenced by the various IILs, due to the presence intermolecular interaction on the charge transports occur via a conduction mechanism at grain boundaries of organic semiconductor and dielectric materials/organic semiconductor interfaces.

[Conclusion] We had studied OTFTs using C6-DNT and thoroughly compared against mobility and threshold voltage performances with various interfacial layers. This study will continue with further investigations on structural properties of C6-DNT by using AFM observation and XRD to identify and describe the charge transport mechanism between organic semiconductor and dielectric layer.

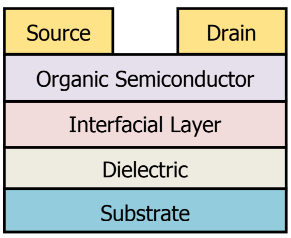

Fig. 1 Structure of OTFT

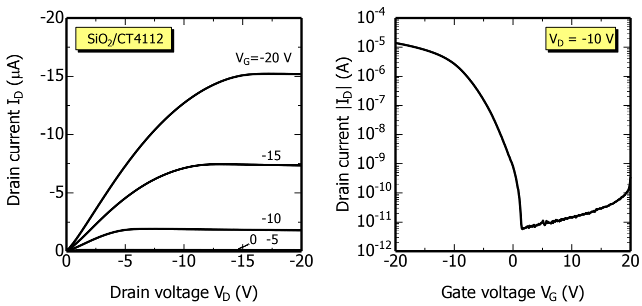

Fig. 2 Drain current vs drain voltage characteristics of OTFT

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