Basic Study on Organic Thin-Film Transistors with Various Kinds of Interfacial Layers

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[Introduction] Organic electron devices are now widely studied for organic light-emitting devices, organic thin-film transistors (OTFT), organic solar cells and organic sensing devices. In the OTFTs, much study have been carried out, for example, synthesis of new organic materials, fabrication conditions and methods of organic materials, concept of device operation, device structure and manufacturing process, and various kinds of application products. In order to realize higher performance of the OTFTs, fabrication process of the devices, especially in interfacial alignment condition of the OTFT is one of the key points. In this time, we have been studying comparison of device structures in OTFTs with various kinds of interfacial layer, such as, organic and inorganic insulating materials by comparison with common practice treatments of cleaning and/or self-assembled monolayer (SAM).

[Experiments] Device fabrication process is as follows: First, highly-doped n^+ silicon substrate oxidized with oxygen is cleaned using ultrasonic cleaning with alkaline solution and acetone. Where, thickness of SiO_2 is 1,000 Å. Then, an insulating interfacial layer (IIL) is coated on this substrate. The tested IIL are common practice treatments of SAM and organic insulating materials of polymethylmethacrylate (PMMA), CT4112 (Kyocera) and CYTOP (Asahi Kasei). Other kinds of sputtered IIL of Ta_2O_5,[1] HfO_2,[2] and $BaTiO_3$ are tested in order to evaluate interfacial effect of intermolecular force between the organic material and high-dielectric constant (high-k) inorganic material. Next, organic material is evaporated on the substrate. Organic materials are pentacene and another high mobility material system (NMS) to evaluate the effect of molecular interaction on the various kinds of insulating material. Typical substrate temperature is 70 and 100ºC, for pentacene and NMS, respectively. Finally, source/drain electrodes of gold are evaporated. Channel length and width is 0.5 and 2 mm, respectively.

[Results] Before inserting IIL, i.e., without additional insulating layer, a mobility of the OTFT using pentacene and NMS was 0.18 and 1.1 cm^2/Vs, respectively. Following is the typical evaluation example. By inserting the IIL, a threshold voltage of the OTFT were shifted, for example, by adding the polymer insulator, the threshold voltage was shifted to negative voltage. This tendency was similar to the pentacene and NMS OTFTs. This implies that there exist negative charge elsewhere, for example, insulator/insulator and/or insulator/ organic material interface. Crystal growth conditions are also interesting for these kinds of experiment. These experiments are now investigating.

[Conclusion] We have been studying basic experimental results of the OTFT with various kinds of interfacial layer. There are much combination, especially in high-k material system keep up interest.

[Reference] 1) T. Hyodo et al.: Jpn. J. Appl. Phys. **43**, 2323 (2004). 2) G. Masaki et al.: J. Photopolymer Sci. & Tech. **21(2)**, 189 (2008).