Ionic Liquid-Gated Organic Field-Effect Transistors

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An ionic liquid-gated organic transistor can drive high output current at a low voltage compared with a general organic field effect transistor (OFET). It is necessary to elucidate the operation mechanism for improvement of the performance of ionic liquid-gated organic transistors. Two operation mechanisms of ionic liquid-gated organic transistors have been proposed. One is carrier generation due to electrochemical doping. The other is accumulation of a great number of carriers due to formation of an electric double layer, which functions as a very thin gate insulator. However, it is difficult to distinguish these mechanisms. In this study, the generation of carriers in a P3HT layer was in-situ observed using infrared absorption spectroscopy in the multiple internal reflection geometry (MIR-IRAS).

Figure 1 illustrates the structure of an ionic liquid-gated organic transistor. A gate insulator layer was replaced with ionic liquid. P3HT and [BMIM][PF_6] were used as an organic layer and ionic liquid, respectively. The thickness of a P3HT layer was 15 nm. Figure 2 shows the typical output characteristic of ionic liquid-gated organic transistors. The gate length and width were 2 μm and 1 mm, respectively. From Fig. 2, it can be seen that a large drain current of 0.7 mA flew when a gate voltage was 1.5 V and an ionic liquid-gated organic transistor can drive large current. Figure 3 shows infrared spectra or (a) a P3HT layer of the ionic liquid-gated organic transistor during operation and (b) a $FeCl_3$-doped P3HT film [1]. The P3HT layer was 3 μm in thickness. It was thick enough to observe penetration of PF_6^- to the P3HT layer because it was much thicker than the penetration depth of the evanescent field of infrared. From Fig. 3, we can see that intensities of infrared absorption peaks due to P3HT cation increased with an increase in the gate voltage. This indicates that PF_6^- penetrated into the P3HT layer to generate carriers, that is, electrochemical doping took place.

[1] Y. Furukawa, Synth. Met. **135-136** (2003) 341.

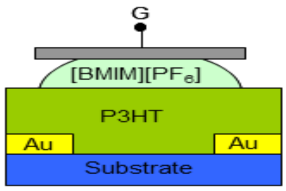

Fig 1 The structure of an ionic liquid-gated organic transistor.

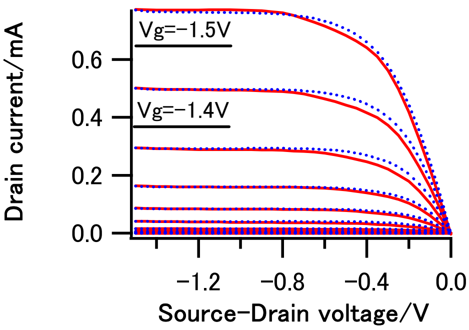

Fig 2 A typical output characteristic of ionic liquid-gated transistor.

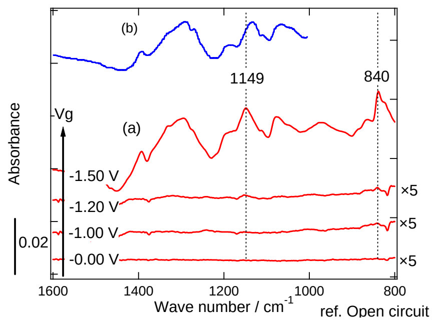

Fig 3 Infrared spectra for (a) a P3HT layer of the ionic liquid-gated organic transistor during operation and (b) a $FeCl_3$-doped P3HT film [1].