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Transient Current Characteristics of Organic Field Effect Transistors with Polymer and Inorganic Gate Insulators

Kouji Suemori[1], Sei Uemura[1] , Manabu Yoshida[1], Satoshi Hoshino[1],
Takahito Kodzasa[1], Toshiide Kamata[1]

[1]National Institute of Advanced Industrial Science and Technology,
Photonics research institute
Central 5, 1-1-1, Higashi, Tsukuba, Ibaraki 305-8565, Japan
Phone: +81-29-861-4516 E-mail: kouji-suemori@aist.go.jp

1. Introduction

A lot of kinds of polymer or inorganic insulators have been used for organic field effect transistors (OFETs). Good transistor performance was reported in the both of when polymer or inorganic insulator was used. Each type of insulator films can be fabricated on flexible substrate by printing processes [1]. Thus, polymer and inorganic insulators are important candidates as insulator for OFETs. On the other hand, polymer insulators have specific characteristics such as structural relaxation which is not observed in inorganic insulators. Thus, transistor characteristics of polymer-insulator-OFETs would be different from that of inorganic-insulator-OFETs. To design an insulator for high performance OFETs, it is necessary to clarify the difference between the transistor characteristics of OFETs with polymer and inorganic insulators.

In this presentation, we report the transient current characteristics of OFETs with polymer and inorganic insulators. The difference between polymer and inorganic insulator was observed in transient characteristics.

2. Experimental

Top contact pentacene-OFETs (Fig. 1) were fabricated on SiO_2 and polyvinylchrolide (PVC) substrates. Channel length and channel width were 20 and 1000 μm, respectively. PVC films were formed by spin coating from 1 wt% solution of the PVC in tetrahydrofuran. Pentacene and gold souce-drain electrode were fabricated by vacuum evaporation in 3 x 10^{-4} Pa with the deposition rate of 0.03 and 0.05 nm/s, respectively. The device fabrication and measurement were carried out in a glove box to avoid the influence of air on transistor characteristics.

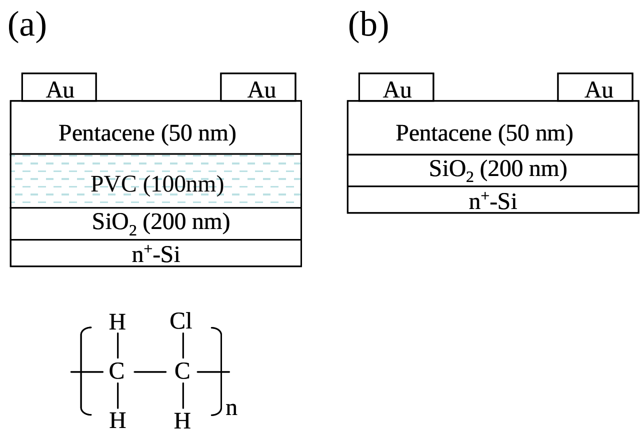

Figure 1 Device structures of PVC (a) and non-PVC (b) cells. Chemical structure of PVC is also shown.

3. Result and Discussion

Figure 2 shows the transient source-drain current of OFETs under the bias of the -20V of source-drain voltage (Vsd) and -60 V of source-gate voltage (Vg). In the case of non-PVC devices, fast response was observed. The time reaching to the saturation current was approximately 50 μs. On the other hand, in the case of PVC devices, the response speed became different order of magnitude slower than non-PVC devices. The time reaching to the saturation current was several milliseconds.

Figure 3 shows the dependence of applying voltage frequency on capacitance of ITO / PVC (1.2 μm) / Au capacitor. In the region of more than 70 Hz, capacitance was decreased with increase of frequency.

PVC shows the dielectric loss due to dipole relaxation with a peak frequency of several kilohertz [2]. This dielectric loss occurs in wide frequency range of several orders of magnitude. The frequency to which dielectric loss due to dipole relaxation and capacitance decrease (Fig. 3) occur is almost same. Thus, the capacitance decrease in high frequency (Fig. 3) can attribute to delay of orientational polarization of C-Cl bonds in high frequency.

In the case of PVC devices, delay of orientational polarization occurs immediately after the applying gate bias. It is well known that gate capacitance strongly affects to hole concentration at pentacene / insulator interfaces [3]. Thus, delay of orientational polarization induces the delay of accumulation of hole at PVC / pentacene interface. This would be a main reason for slow saturation of transient source-drain current in PVC devices observed in Fig. 2(b).

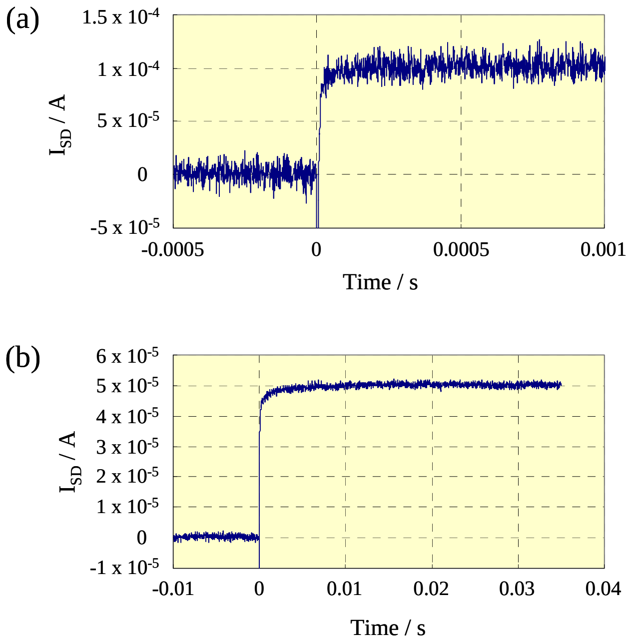

Figure 2 Transient source-drain current responses of non-PVC (a) and PVC (b) cells. The zero points of horizontal axes correspond to gate-on time. Voltage are Vsd = -20 V and Vg = -60 V, respectively.

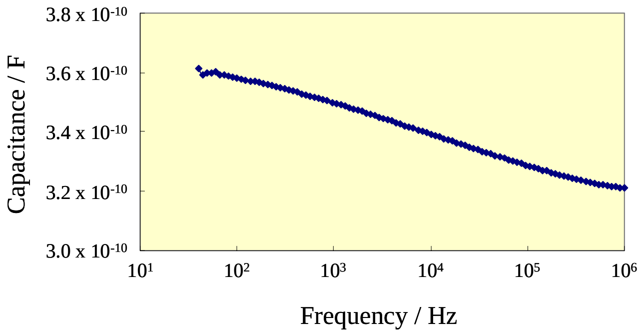

Figure 3 Dependence of frequency on capacitance of ITO / PVC / Au cell. Oscillation voltage is ±1V.

4. Conclusion

OFETs with PVC insulator showed slow response with respect to gate voltage due to the delay of orientational polarization of C-Cl bonds. For application to switching device of display, fast source-drain current response of less than several tens microseconds with respect to gate bias are needed. These results suggest that insulator materials with small dielectric loss are necessary for fabrication of fast response transistors.

References

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