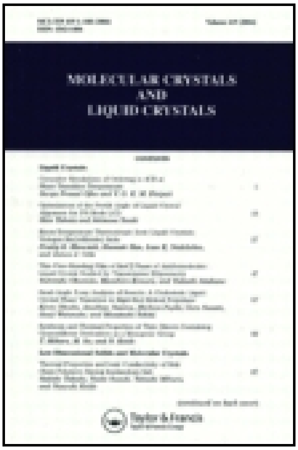

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Pentacene Thin Film Transistor Using Organic Material as a Gate Insulator

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Pentacene Thin Film Transistor Using Organic Material as a Gate Insulator

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Organic thin film transistors were fabricated using pentacene and organic gate insulator on the glass substrates. Polyimide and photo-acryl were used as a gate insulator respectively. We investigated transfer and output characteristics of the thin film transistors(TFT's) having active layer of pentacene. We calculated field effect mobility and on/off ratio from transfer characteristics of pentacene TFT's, and measured IR absorption spectrum of polyimide used as gate insulator.

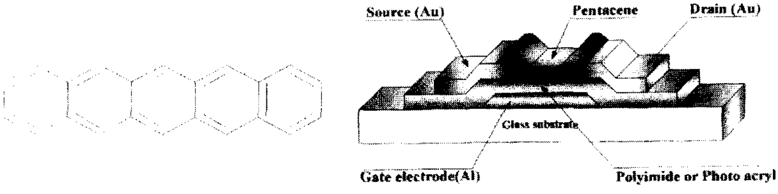
Keywords: organic thin film transistor; pentacene; transfer characteristic; output characteristics; organic gate insulator

INTRODUCTION

Organic thin film transitors(TFT's) are of interest for use in broad area electronic applications. For example, in active matrix liquid crystal displays(AMLCD's), organic TFT's would allow the use of inexpensive, lightweight, flexible, and mechanically rugged plastic substrates as an alternative to the glass substrates needed for commonly used hydrogenated amorphous silicon(a-Si:H)[1]. Recently pentacene TFTs with carrier field effect mobility as large as 2 cm^2/Vs have been reported for TFTs fabricated on silicon substrates, and it is higher than that of a-Si:H[2]. But these TFTs are fabricated on silicon wafer and SiO_2 was used as a gate insulator. SiO_2 deposition process requires a high temperature. We fabricated TFTs at lower temperature by using organic material as a gate insulator.

EXPERIMENTS

We have fabricated pentacene TFTs on glass substrates. Figure 1 (a) shows the molecular structure of pentacene. Pentacene is a π-electron-rich molecule and their conduction mechanism involves charge transport across π-π stracks of molecules. Pentacene that exhibit high mobility has been found to adopt a highly ordered and preferred orientation of molecules essentially normal to the substrate to maximize the flow of charges from source to drain electrodes[3].

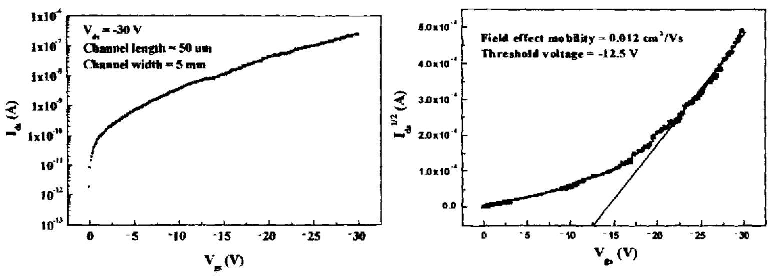


(a) Molecular structure of pentacene (b) device structure of pentacene TFTs
FIGURE 1 Molecular structure of pentacene and device structure of TFTs

Figure 1 (b) shows the device structure of TFTs fabricated in this study. Aluminum was used for the gate electrodes, and patterned using photolithography. Gate insulator, polyimide and photo acryl (PC-403 from JSR Co.), was spin-coated on gate electrode and cured at 220 °C for an hour. PC-403 is used as a photoresist in general, but in this study, used as a gate dielectric layer. Gold was evaporated through shadow mask, which is used as source and drain contact. The large work function of gold forms an ohmic contact with pentacene and improves carrier injection into the active layer. To form the active layer, the pentacene was thermally evaporated, where vacuum pressure is near 5×10^{-6} Torr, and deposition rate is 0.2 – 0.3 Å/s.

RESULTS AND DISCUSSION

Figure 2 shows transfer characteristics of pentacene TFTs using polyimide as a gate insulator. Because pentacene is a p-type semiconductor, and pentacene TFTs is operated in accumulation mode, negative voltage is biased at drain-source and gate-source electrode.



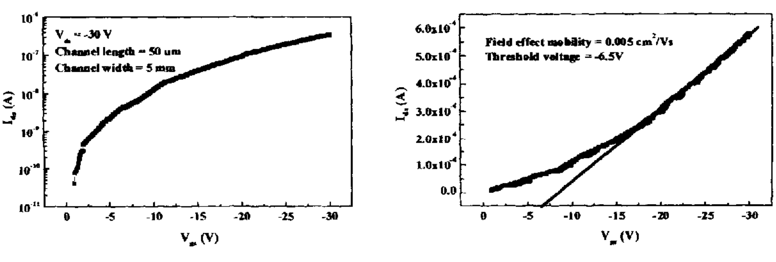
(a) I_{ds} versus $\log_{10}V_{gs}$ plot (b) $I_{ds}^{1/2}$ versus V_{gs} plot

FIGURE 2 Transfer characteristics of pentacene TFTs using polyimide as a gate insulator

Channel length and width was 3 mm, and 50 μm, respectively. On/off ratio was 10^5. Field effect mobility can be calculated from figure 2 (b) by using function shown below. The calculated mobility was 0.012 cm^2/Vs.

$$I_{DS} = \frac{W}{L}\frac{C_i}{2}\mu(V_G - V_{th})^2$$

Figure 3 shows transfer characteristics of pentacene TFTs using PC-403 as a gate insulator. Field effect mobility was 0.005 cm^2/Vs, and on/off ratio was 10^4.



(a) I_{ds} versus $\log_{10}V_{gs}$ plot (b) $I_{ds}^{1/2}$ versus V_{gs} plot

FIGURE 3 Transfer characteristics of pentacene TFTs using photoacryl as a gate insulator

Figure 4 shows output characteristics of TFTs using polyimide gate insulator. According to increasing gate bias, drain current increased and maximum drain current was 7.0×10^{-8} A. When drain voltage was increased, drain current was saturated.

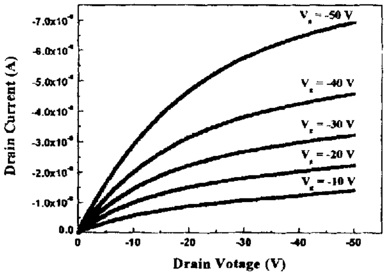


FIGURE 4 Output characteristics of pentacene TFTs using polyimide as a gate insulator

CONCLUSIONS

We fabricated pentacene TFTs by using organic gate insulator, which may be a simple method for TFT process. From this study, it was found that using the PC-403 as a gate insulator, threshold voltage decreased from –12.5 V to –6.5 V, but field effect mobility decreased from 0.12 cm^2/Vs to 0.005 cm^2/Vs. It seems that TFTs using polyimide gate insulator is apt to form channel than TFTs using photoacryl gate insulator. Further study of interface between organic gate insulator and pentacene are needed.

Acknowledgments
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