High-mobility field effect transistor based on vacuum deposited 2,7-dioctyl[1]benzothieno[3,2-b]benzothiophene (C_8-BTBT) thin film

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1. Introduction

Organic field-effect transistors (OFETs) have been widely investigated for their use in various electronic applications in organic light emitting diodes (OLEDs), smart cards and radio frequency identification (RFID) tags. In these devices, high mobility transistors are inevitable for high performance device operation. One of the promising OFET materials is benzothienobenzothiophene (BTBT) derivatives. Excellent performance of these derivatives has been reported using various fabrication techniques such as vacuum deposition[1], spin-coating[2] and solution casting[3]. In this study, we achieved the very high mobility over 10 $cm^2V^{-1}s^{-1}$ in OFETs using a vacuum deposited 2,7-dioctyl[1]benzothieno[3,2-b]benzothiophene (C_8-BTBT) film.

2. Result and discussion

We selected a bottom gate/top contact (BG/TC) structure aimed for high mobility. N type silicon wafer with a thermally grown SiO_2 dielectric (300 nm) was used as a substrate. The surface of the SiO_2 dielectric layer was treated with hexamethyldisilazane (HMDS) after solvent cleaning and UV/O_3 treatment. A thin film of C_8-BTBT was fabricated using vacuum deposition. Au source and drain electrodes were deposited in vacuum onto the semiconductor film through a metal shadow mask. The channel length and width were 200 μm and 2.5 mm, respectively.

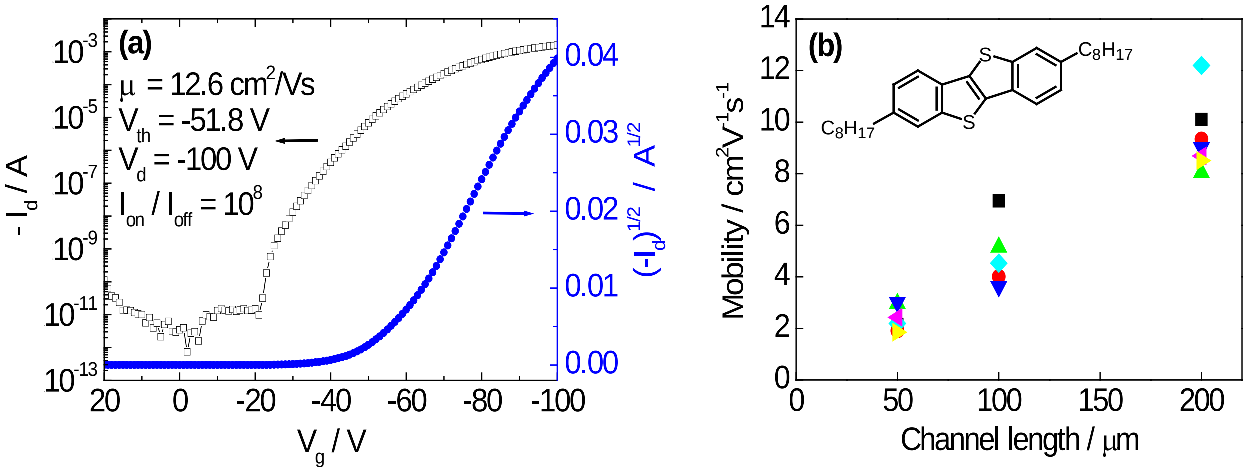

Fig. 1. (a) Transfer characteristics (b) distribution of mobility values in C_8-BTBT based FETs. Inset is chemical structure of C_8-BTBT.

Figure 1 (a) shows the transfer characteristics of a C_8-BTBT based FET. The highest mobility reached μ_h = 12.6 $cm^2V^{-1}s^{-1}$ and threshold voltage was -51.8 V. Figure 1 (b) shows the distribution of the mobility values with the different channel length, suggesting the presence of large contact resistance. Since C_8-BTBT has deep highest occupied molecular orbital (HOMO) level, it increases the injection barrier height and contact resistance. This effect has been generally attributed to the increased weight of the contact resistance at small channel length devices. Therefore, the C_8-BTBT based FET shows high mobility in the large channel length devices.

3. References

[1] T. Izawa, E. Miyazaki and K. Takimiya, *Adv. Mater.*, 2008, **20**, 3388

[2] H. Ebata, T. Izawa, E. Miyazaki, K. Takimiya, M. Ikeda, H. Kuwabara and T. Yui, *J. Am. Chem. Soc.*, 2007, **129**, 15732

[3] T. Uemura, Y. Hirose, M. Uno, K. Takimiya and J. Takeya, *Appl. Phys. Exp.*, 2009, **2** ,111501

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