High-density carrier doping and insulator—metal transition in two-dimensional semiconductor C_{10}–DNTT

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Ionic liquid-based electric double layer transistors (EDLT) have been investigated as a method to study the physical properties of high carrier density states, where high capacitance in the electric double layer enables high-density carrier to be induced into organic semiconductors [1]. In our group, we have realized a two-dimensional insulator-metal transition by high-density carrier induction of *abt.* 10^{14} cm^{-2} (0.25 charge per molecule) in an EDLT using a single crystal of the small molecule semiconductor C_8–DNBDT–NW [2]. In this molecule, insulating linear octyl groups are bonded to both ends of the pi-conjugated framework, so that electrons are confined two-dimensionally in the conjugated framework, and the linear octyl layer spatially isolates the carrier conduction layer and ionic liquid, thus it can suppress potential disorder from the ionic liquid and achieve high carrier state while keeping high mobility.

C_{10}–DNTT has slightly different band structure with narrower band width and less anisotropy between in-plane effective masses as compared with C_8–DNBDT. In this study, band-filling control was performed using EDLT on single crystals of C_{10}–DNTT with heteroacene framework to verify the generality of the two-dimensional insulator-metal phase transition in organic semiconductors. After high-density carrier induction, the magnetotransport properties were evaluated from room temperature to low temperatures, and resistance values smaller than the quantization resistance h/e^2 and a positive resistance temperature coefficient dR/dT, which could be realized by metallization, were successfully observed.

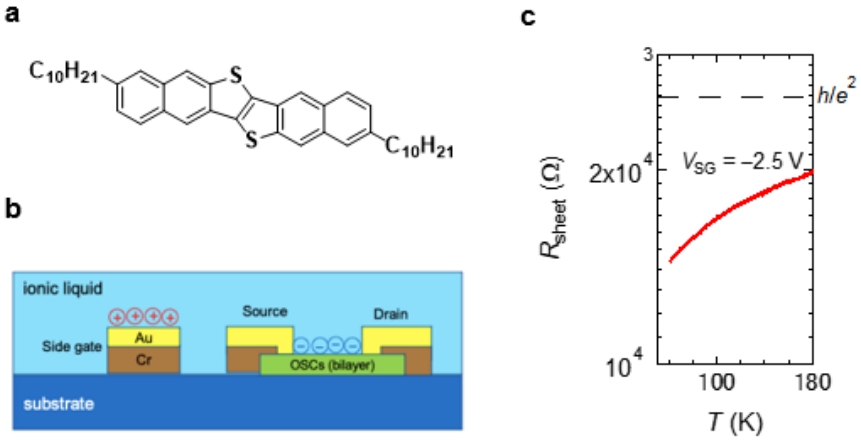

Fig. 1. a) The chemical structure of C_{10}–DNTT. b) The general scheme of EDLT. c) The temperature dependence of sheet resistance R_{sheet}.

References

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