Gate-bias and temperature dependent characteristics in organic thin-film transistors with MoO_3/Au electrode structure

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【Introduction】 Recently, metal oxide have been used in organic thin-film transistor (OTFTs) and organic light-emitting diode (OLED) as a buffer layer for carrier injection to improve OTFT performance. Our research group has been investigated temperature dependence of pentacene-based TFTs by inserting metal oxide between gold source/ drain and pentacene, such as, molybdenum oxide (MoO_3)[1], germanium oxide (GeO)[2], tungsten oxide (WO_3)[3], and titanium oxide (TiO_2)[4] without applying gate voltage condition. In this study, we have investigated gate-bias and temperature dependence in pentacene-based OTFTs by inserting MoO_3 between pentacene and Au electrodes. For evaluation of activation energy, drain current (I_D) vs drain voltage (V_D) characteristics under different temperature with various gate voltage (V_G) was measured.

【Experimental】 The device were fabricated on n-type silicon substrate with 100 nm SiO_2 layer, using 50 nm pentacene as the active layer in a top-contact structure. Finally, 20 nm MoO_3 and 50 nm Au were deposited as source and drain electrodes. The channel length (L) and channel width (W) were 0.5 mm and 1.5 mm, respectively. Electrical properties of the device were measured using a semiconductor parameter analyzer (HP 4155B). To investigate the charge transport mechanism, the device was cooled down using a cryostat. The I_D-V_D characteristic was measured in the temperature range between 133 K and 293 K by flowing liquid nitrogen into the vacuum chamber.

【Results and discussions】 Figure 1 shows I_D-V_D characteristics with different V_G in the temperature range between 133 K to 293 K. From these results, I_D was decreased with decreasing temperature. By inserting MoO_3, activation energy E_A was 0.31 eV at V_G = -5 V obtained from the slope of the plot in Figure 2. And, the activation energy decreases as negative gate voltage increases. These results indicate that change of carrier transport occur either charge injection at a source/drain or in organic materials while transport across grain boundaries/barrier height due to the Fermi level shift and/ or change of free carrier concentration.

【Conclusion】 We have studied the temperature dependence characteristics in organic thin-film transistor with MoO_3/Au electrodes at various gate voltages.

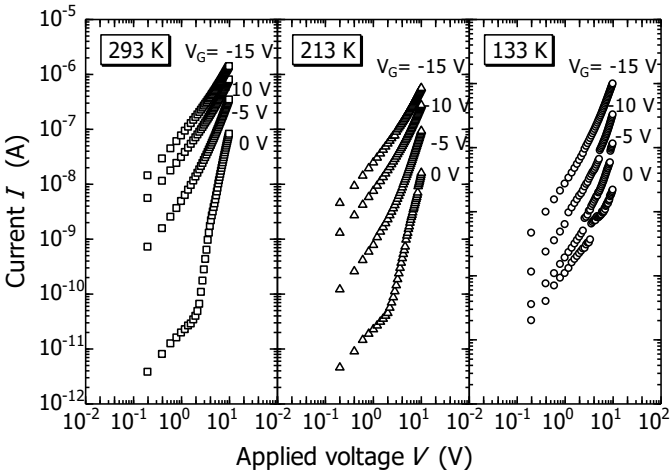

Fig. 1

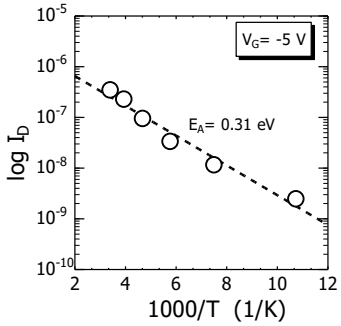

Fig.2

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