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Highly sensitive photoinduced current characteristics of π-conjugated dendrimer based organic thin film transistor

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ABSTRACT

We fabricated organic thin film transistors (OTFTs) using soluble π-conjugated dendrimer such as 4(HP3T)-benzene and investigated current-voltage characteristics the OTFT devices with the condition of low light intensity. We observed the increase of the source-drain current under irradiation of light and the variation of the source-drain current with varying the energy of incident light. Using the current-voltage characteristics with light, we obtained photo-responsivity of devices. The photo-responsivity of our devices was relatively higher than that in previous reports.

1. INTRODUCTION

Electronic and optoelectronic devices based on π-conjugated organic materials have recently been studied, because of advantages such as the ease processing at low-temperature and the fabrication of flexible devices [1-2]. The TFT devices have been used for an electrical driver for flat panel displays. Organic thin film transistors (OTFTs) can be fabricated through spin coating of soluble organic materials, and their photoinduced characteristics are applied to the photoswitching. We report on the increase of the source-drain current incident light with low intensity for π-conjugated dendrimer based OTFT.

2. EXPERIMENT

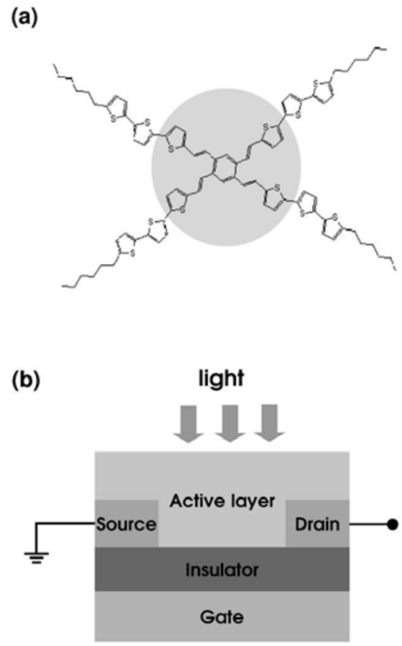

Fig. 1 (a) Chemical structure of 4(HP3T)-benzene (b) Schematic diagram of 4(HP3T)-benzene based OTFT devices

We fabricated OTFTs using 4(HP3T)-benzene as an active layer. The 4(HP3T)-benzene has core part of two-dimensions of planar structure as shown in Fig. 1(a). The 4(HP3T)-benzene was dissolve in chlorobenzene and spin coated onto the photolithographic pattern to form active layer. The highly *p*-type doped Si and thermally grown SiO_2 layer were used for a gate electrode and dielectric layer, respectively. As source and drain electrodes, the gold (Au) was thermally deposited followed by thin Ti layer for better adhesion. The channel length, defined as the distance between the two Au electrodes, was varied from 5 μm to 20 μm. The channel width, defined as the length of the Au electrodes perpendicular to channel length, was 1.5 mm. The schematic diagram of the OTFT is shown in Fig. 1(b). The light source was a 500 W Mercury-Xenon lamp, and light was incident on the top side of the device. All measurements were performed at room temperature.

3. RESULT AND DISCUSSION

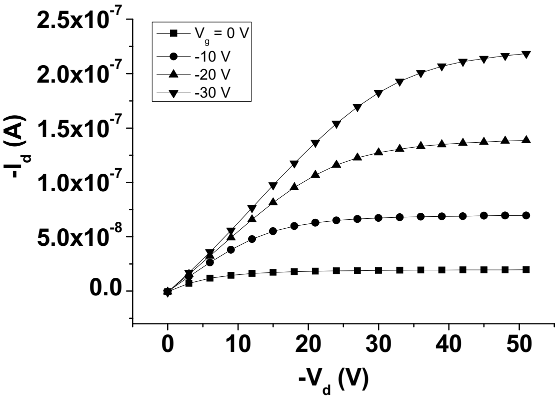

Fig.2 Output characteristics curves of OTFT in dark condition

The 4(HP3T)-benzene based OTFT in dark has p-type characteristic. As the gate voltage (V_g) negatively increased, the source-drain current (I_d) increased shown in Fig. 2. The OTFT devices using 4(HP3T)-benzene were showed good performance such as field effect mobility and on-off ratio comparatively in OTFT using soluble active material, due to a planar structure of core part. Under light irradiation, the source-drain current of OTFTs largely increased, as shown in Fig. 3. The localized charges were excited through the absorption of light, thus leading to the increase of I_d.

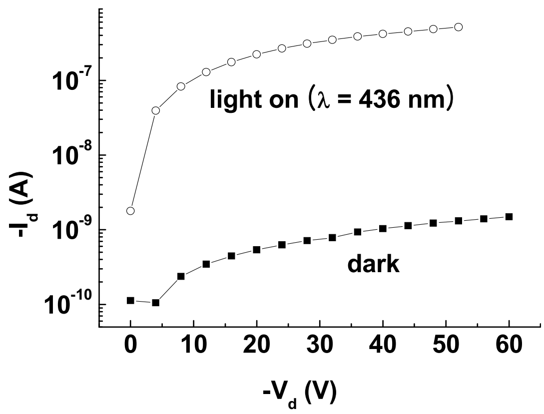

Fig.3 Source-drain current in dark and in light (~ 200 μW/cm^2) at V_g = 0 V

Figure 4 shows the photoinduced current responsivity of OTFTs as a function of incident light wavelength at various intensities of light. The responsivity can be described by Eq. (1) :

$$responsivity = \frac{\Delta I_d}{P_{inc}} \qquad (1),$$

	18 μW/cm^2	28 μW/cm^2	100 μW/cm^2
436 nm	96 A/W	95 A/W	23 A/W
546 nm	122 A/W	141 A/W	26 A/W
577 nm	115 A/W	109 A/W	21 A/W

Fig.4 Responsivity of OTFTs as various incident light wavelength and power

where ΔI_d is the based variation of I_d on dark and light condition and P_{inc} is the incident intensity of light [3]. The responsivity was enhanced up to ~140 A/W. The results shown here are highly sensitive to the light with low intensity. This reponsivities are much higher than those of soluble polymer based devices (1 A/W) [4].

4. CONCLUSION

The OTFTs using 4(HP3T)-benzene as an active layer were fabricated by spin coating. Electrical characteristics of OTFTs were shown p-type enhancement mode characteristics. We investigated current-voltage characteristics the OTFT devices according to various intensities and energy of incident light. We observed the 4(HP3T)-benzene based OTFTs responded with low light intensity sensitively.

5. REFERENCES

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