OTFT materials Containing Fused Aromatics

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Abstract

Organic thin-film transistors (OTFTs) using organic semiconductors as an active layer are of interest for their use in low-cost, lightweight and flexible electronic products. Although the field-effect mobility of OTFTs is still lower than those of inorganic thin-film transistor, the advantages of easy manufacturing and processing make them suitable for selected applications. In this paper, we report the syntheses and characterization of new p-type OTFT materials.

1. Introduction

Organic semiconductors have been extensively investigated due to the potential application in a variety of electronic devices[1-2]. Organic thin film transistors (OTFTs) have attracted much attention as alternatives with low-cost, large-area, and simple device structure to conventional silicon-based one[3-9]. A number of p-type organic transistors have been reported so far, OTFT fabricated from a few materials show a comparable mobility to amorphous silicon based TFT. The most well-known OTFT materials is pentacene which has a mobility and on/off ratio of about 1 cm^2/V.sec and 10^7, respectively. However, Pentacene has several drawbacks such as, impossibility of solution process due to non-solubility in any organic solvent, and high cost etc. Especially, pentacene is very susceptible to some degradation in ambient conditions, presumably to form the endoperoxide or Diels-Alder adducts. Therefore, much attention has been focused on designing new organic semiconductor candidates with high stability. Another research trends on OTFT materials is related to the solubility in organic solvents. Soluble organic semiconductor could be fabricated into the device by solution process which cost is much lower than vacumn process. It is well known that desirable organic semiconductors are soluble amorphous one.

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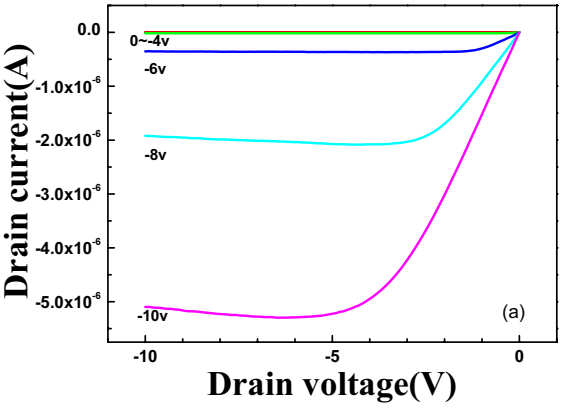
2. Results

Alkoxynaphthalene-end capped fused aromatic derivatives were fabricated into the OTFT device. The mobility calculated using the I_{DS} in the saturation regions is 0.64 cm^2/Vs, and the on/off ratio is 7.5 x 10^5, respectively.



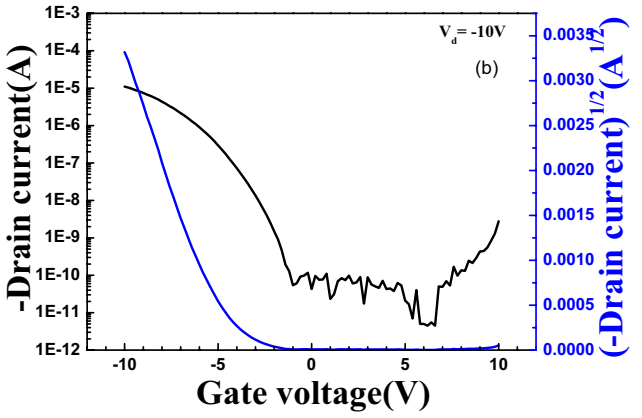


Figure 1. Plot of drain current (I_D) versus drain voltage (V_D) characteristics of Alkoxynaphthalene-end capped fused aromatic derivatives at different gate voltages (V_G); I_D versus V_G and $I_D^{1/2}$ versus V_G for TFT prepared using Alkoxynaphthalene-end capped fused aromatic derivatives as the semiconductor material

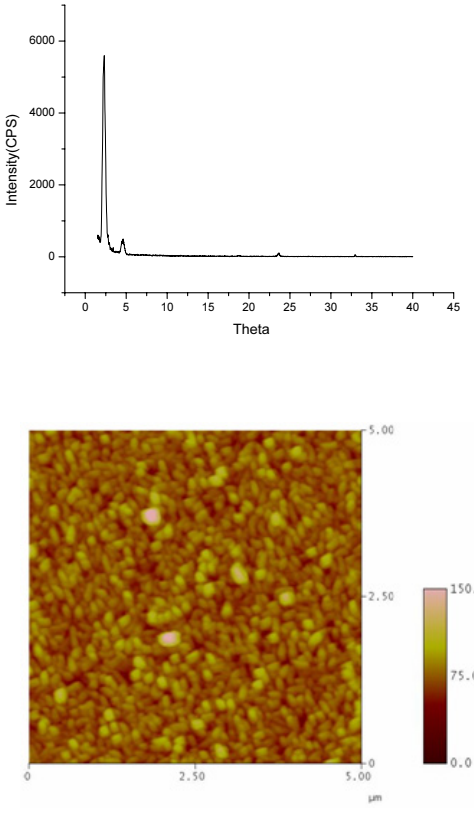


Figure 2. XRD patterns and AFM image of a 60 nm think Alkoxynaphthalene-end capped fused aromatic derivatives film on Si/SiO_2 deposited at a substrate temperature of 140 ^oC

Phenylacetylene containing anthracene derivative is prepared and fabricated into the devices, the mobility calculated using the I_{DS} in the saturation regions is 0.4 cm^2/Vs, standard deviation is 0.011, and the on/off ration is 8.9 x 10^6, respectively.

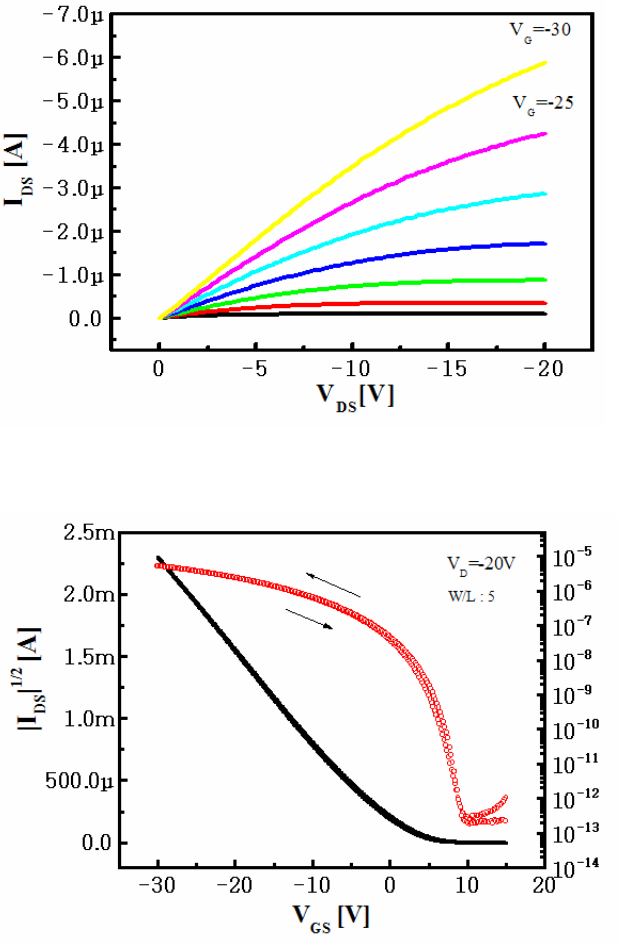
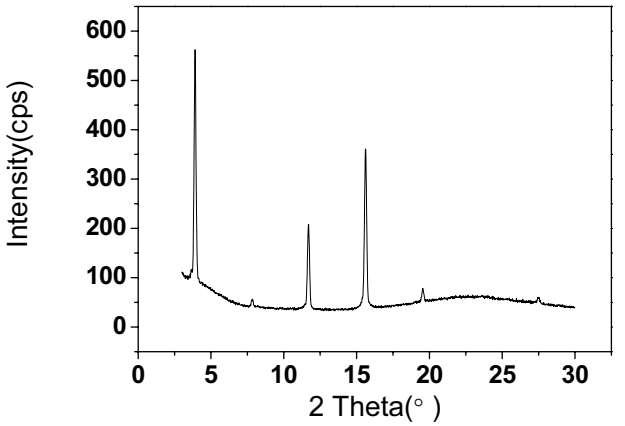


Figure 3. Plot of drain current (I_D) versus drain voltage (V_D) characteristics of Phenylacetylene containing anthracene derivative at different gate voltages (V_G); I_D versus V_G and $I_D^{1/2}$ versus V_G for TFT prepared using Phenylacetylene containing anthracene derivative as the semiconductor material



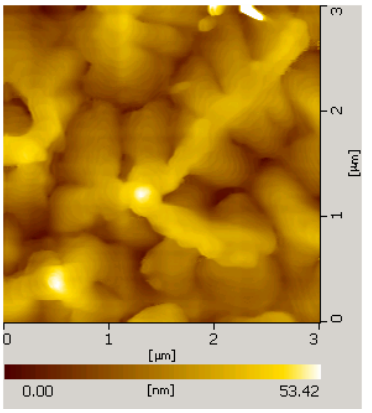
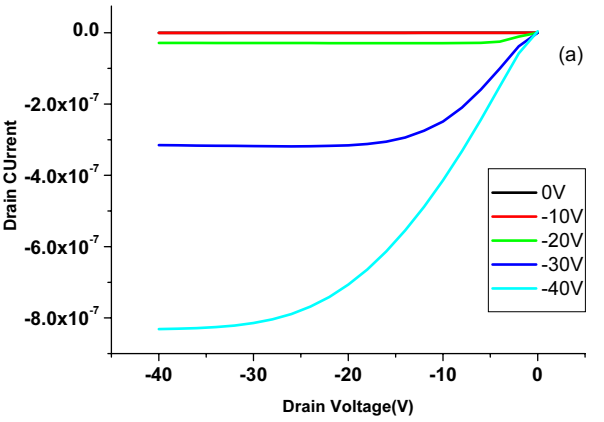


Figure 4. XRD patterns and AFM image of a 50 nm think Phenylacetylene containing anthracene derivative film on Glass /PVP deposited at a substrate temperature of 80 °C



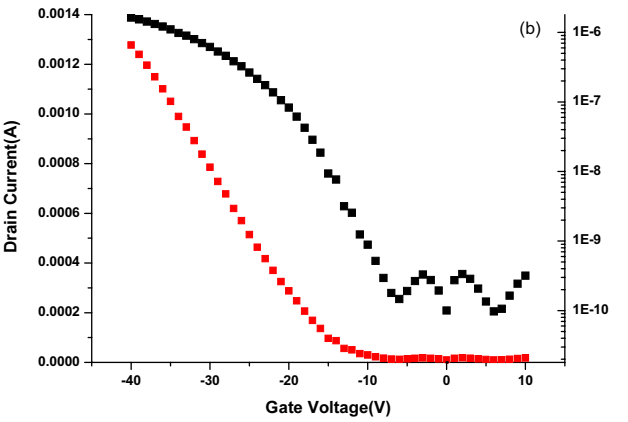


Figure 5. Plot of drain current (I_D) versus drain voltage (V_D) characteristics of TIPSAN-NA at different gate voltages (V_G); I_D versus V_G and $I_D^{1/2}$ versus V_G for TFT prepared using TIPSAN-NA as the semiconductor material

2,6-Di-naphthalen-2-yl-9,10-bis-[(triisopro-pylsilanyl)-ethynyl]-anthracene (TIPSAN-NA) and its analogues were prepared as air stable and soluble organic semiconductors, the mobility calculated using the I_{DS} in the saturation regions reach to 0.1 cm^2/Vs, and the on/off ration is 1.1 x 10^4, respectively

Naphthalene containing polymeric organic semiconductors was synthesized. The resulting polymer was found out to be highly crystalline and to have interdigitation structure from XRD. The OTFT spin cast from the polymeric semiconductor exhibits the mobility of 1.7 x 10^{-2} cm^2/Vs, and the on/off ratio of 4.8 x 10^4, respectively.

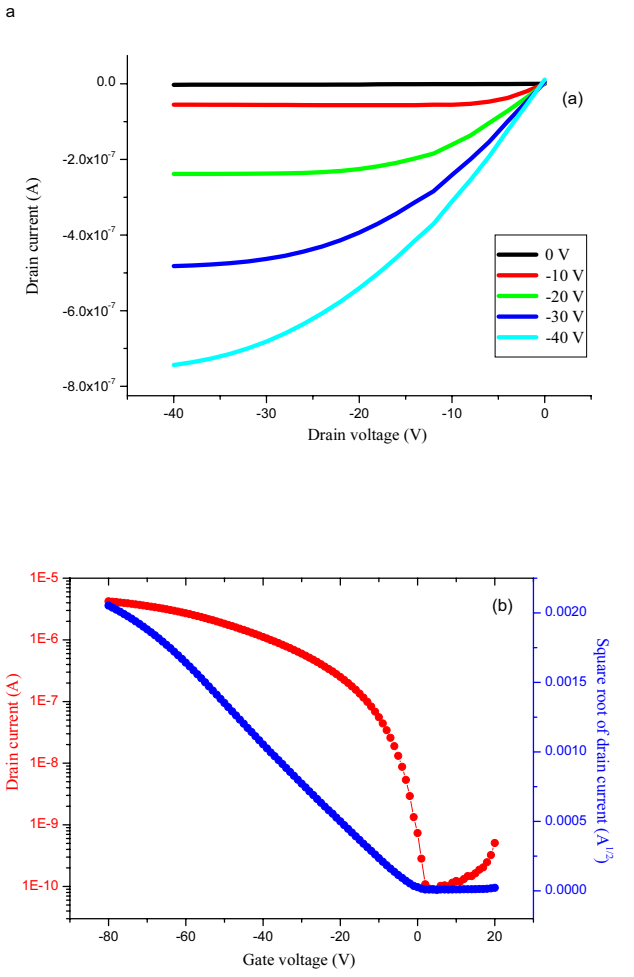


Figure 6. Plot of drain current (I_D) versus drain voltage (V_D) characteristics of Naphthalene containing polymeric organic semiconductors at different gate voltages (V_G); I_D versus V_G and $I_D^{1/2}$ versus V_G for TFT prepared using Naphthalene containing polymeric organic semiconductors as the semiconductor material

3. Conclusion

We have fabricated organic field-effect transfers based on fused aromatic units (anthracene and naphthalene) which act as organic semiconductors for organic electronics. A high mobility of up to $6.4x10^{-1}$ cm^2V^{-1} s^{-1} and an on/off ratio of about $7.5x10^5$ for Alkoxynaphthalene-end capped fused aromatic derivatives have been obtained in vacuum deposition. The electronic and optical properties measured by Atomic Force Microscope, and X-ray diffraction measurements.

4. Acknowledgements

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