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Analysis of the Current Transport Mechanism of Copper Phthalocyanine Organic thin film transistor

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Abstract. According to the test results of current-voltage characteristics, the current transport mechanism of Organic thin film transistor using copper phthalocyanine (CuPc) as active layer is investigated. The transport mechanism of small current region and especially medium-large current region are all analyzed. Depending on in-depth theory analysis of experiment data about current-voltage characteristics, the current-voltage characteristic of OSIT exhibits exponential relationship in small current region. However, the current-voltage characteristic in medium-large current region is governed by with exponential trap distribution.

Keywords: organic semiconductor; thin film transistor; space charge limited current

1 Introduction

Tsumura and his fellows manufactured Organic thin-film transistor (OTFT) using polythiophene as semiconductor materials in 1986.[1] After that, the study of transistor continues to develop. It had attracted much attention in the drive display application of liquid crystal display (LCD) and organic light-emitting diodes (OLED).[2] So far, organic thin-film transistors using pentacene as the active layer had showed the best performance.[3-4] Phthalocyanine as a series of organic semiconductor compound has become the main material of the molecular semiconductor research. These materials have a good chemical and thermal stability,[5] Phthalocyanine compounds exhibit the characteristics of the semi-conductive.[6] The electrical properties of the phthalocyanine have attracted much attention, phthalocyanine compounds is a promising molecular photoelectric device materials.

This article, by comparing the experimental data and theoretical fitting data, analyzed and discussed current-voltage (I-V) characteristics of organic static induction transistor (OSIT) using CuPc as active layer.

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2 Device Structure and Fabrication

The OSIT in this article consist of Au/ CuPc/ Al/ CuPc/ Au, as shown in Fig. 1. The Al for grid, Au for the source and drain. Al/ CuPc form Schottky barrier while Au / CuPc form an ohmic contact. Using organic semiconductor material CuPc as P-type material, it has good chemical stability and heat resistance.

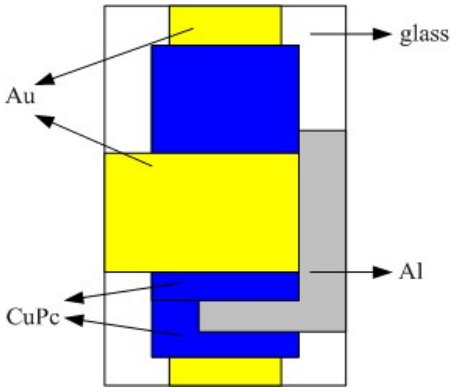

Fig. 1. The OSIT structure diagram

3 Results and Discussion

The test of OSIT sample's operating characteristic is conducting in the atmosphere and in room temperature. To avoid the influence of light, the sample is placed in a sealed metal box. Through aluminum gate and I-V characteristics test on both sides of gold electrodes, after the aluminum electrodes and both sides of CuPc evaporation film formed schottky contact, make the grid voltage V_{GS} with 0.2 V as stride length, varying from 0 V to 1.0 V, leakage voltage between the source and the drain changes from 0 V to 3 V V_{DS}, stride length is 0.2 V, test out the changes in relations of drain-source voltage V_{DS} and drain-source current I_{DS}. As shown in Fig. 2. Take logarithm in Fig. 2, we get the semi-logarithmic graph, as shown in Fig. 3, We can see from Fig. 3 that in small current range, I_{DS} and V_{DS} is linear relationship, in the high current range, it deviate from the linear relationship. Therefore, I-V characteristics of OSIT should be segmented for discussion.

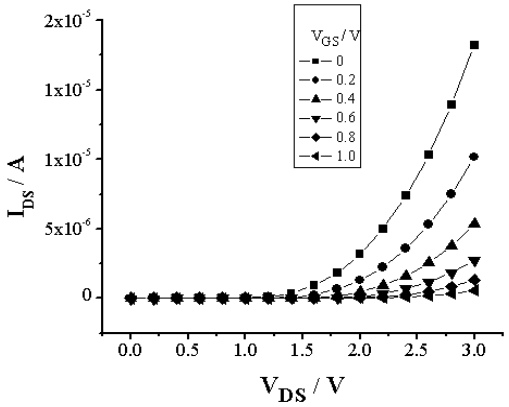

Fig. 2. The I-V characteristic curves of OSIT

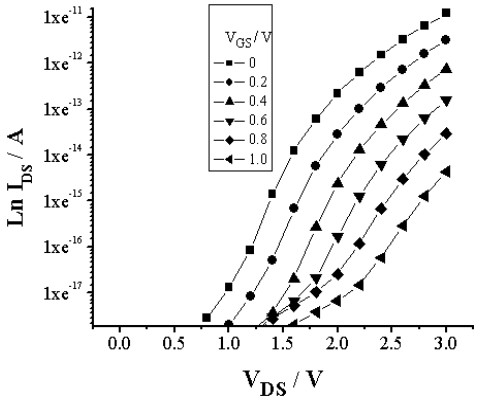

Fig. 3. The I-V characteristic curves of OSIT in semi-log coordinate

Analysis in small current range

In Fig. 2, take I-V characteristic curve when V_{GS}= 0, in the range of 0 V to 2.0 V, use the function Y= Aexp(BX) to fit measured data, then A= 4.57 x 10^{-9}, B= 3.28, it is the same as I-V linear relationship under semi-log coordinate system in small current range, as shown in Fig. 3.

From the consistency of fitting curve and the measured data,it can be getting that within the scope of the small current, the I-V characteristics of OSIT changes under the index relationship.

Analysis of large and middle current

In large or middle current, the I-V characteristic curves of OSIT is no longer the straight line under semi-log coordinate, it shows that the relationship between I-V characteristics deviates from index changes.

In 2.0 V to 3.0 V voltage range, using the function $Y= KX^m$ to fit the measured data when $V_{GS}= 0$ V, $K= 1.96\times10^{-7}$, m= 4.13 is got, the curve shows fitting results is match well.

4 Conclusion

Through the analysis and discussion of CuPc-OSIT I-V characteristics in small current range and high current range, no matter which mechanism it is, the I-V features are characterized by unsaturated features, should be seen as transistor characteristics. In addition, with the augmentation of the drain field, the carrier mobility may change，the I-V characteristics present different dependence. If drain field enhances, it will makes the carrier mobility of drift velocity tends to saturation.

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