KAPI DİELEKTRİĞİ SiO_2 OLAN POLY(3HEXYLTHIOPHENE) ORGANİK ALAN ETKİLİ TRANSİSTÖR

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ÖZET

Bu çalışmada Organik İnce Film Transistör (OTFT) üretiminde kullanımı elverişli olan inorganik dielektrik katman olarak SiO_2 kullandık ve bu dielektrik katman üzerine döndürerek kaplama yöntemi ile Poly(3-Hexilthiophene) P3HT organik yarı iletken (OSC) molekülünü kapladık. Kapı, kaynak ve oluk kontaklar için yine termal buharlaştırma yöntemi ile Ag kapladık. P3HT OSC için μ_{FET}=0.103 cm^2/Vs alan etkili mobilite değerini, $I_{on}/I_{off}=10^1$ açma/kapama (I_{on}/I_{off}) akım oranını V_T=8V eşik voltajı değerini bulduk

Anahtar Kelimeler: *OTFT, P3HT, $SiO_{2,}$ mobility*

POLY(3-HEXYLTHIOPHENE) BASED FIELD-EFFECT TRANSISTORS WITH GATE SiO_2 DIELECTRIC

ABSTRACT

In this study we have used $SiO_{2,}$ which is actually a useful material as a inorganic dielectric layer for Organic Thin Film Transistor (OTFT) production, and then we have coated the Poly(3-Hexilthiophene) P3HT organic semiconductor (OSC). We coated the gate, source and drain contacts with Ag using thermal evaporation method. Our study has shown that on mobility value (μ_{FET}), treshold voltage (V_{Th}) and on/off current ratio (I_{on}/I_{off}). For P3HT OSC, we have reached the value as following; μ_{FET}=0.103 cm^2/Vs field effect mobility value, $I_{on}/I_{off}=10^1$ current ratio, V_T=8V threshold voltage.

Key Words: *OTFT, P3HT, $SiO_{2,}$ mobility*

1. INTRODUCTION

Organic field-effect transistors (OFET) are receiving significant attention because of their potential use in low-cost flexible electronic applications such as: smart pixels, radio frequency identification tags, drivers for electronic papers, and driving circuits for flat-panel displays [1]. Conjugated polymers such as poly(3-hexylthiophene) (P3HT) are becoming a valid alternative to amorphous silicon for the active layer in OFETs for large area and low cost applications [2]. Regi-regular P3HT (rr-P3HT) shows high field-effect mobility [3]. The most commonly used device geometry is bottom gate with top contact partly because of borrowing the concept of thin-film silicon transistor (TFT) using thermally grown SiO_2 oxide as gate dielectric. Due to advantage of being commercially available high quality Si/SiO_2 substrate, it has dominated the whole community. Transistor parameters such as mobility and threshold voltage are all deeply related to the chemical structure and the dielectric properties of the insulating materials [4].

2. EXPERİMENTAL SETUP

In this study, P3HT (Fig. 1.) based OFET was produced in which SiO_2 was used as a dielectric layer.

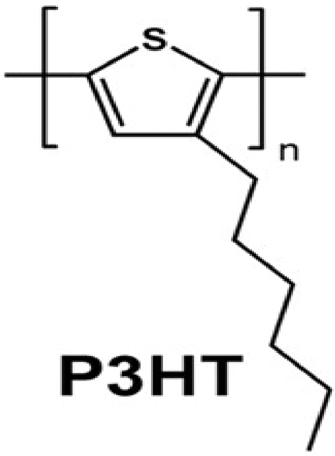


Figure. 1. *Structure of P3HT*

A bottom-gate with top contact device structure was shown in the Fig.2. At the first stage of the production, some SiO_2 was removed by hydrofluoric acid from one side of the silicon surface. Then, Si wafers were cleaned by acetone, methanol, ethanol and deionized water respectively. After cleaning processes, Ag was deposited by thermal evaporating under $5x10^{-6}$ mbar pressure on the silicon layer as gate contact. At the later stage, P3HT which was dissolved in chloroform solvent (10 mg/ml) was coated on SiO_2 layer by spin-coating (1800 rpm for 30s) and annealed 150 ^{o}C for 10 minutes. Finally, Ag source and drain contacts were deposited via thermal evaporating method. The current-voltage characteristics of our device were investigated by using a Keithley 4200 semiconductor characterization system (SCS).

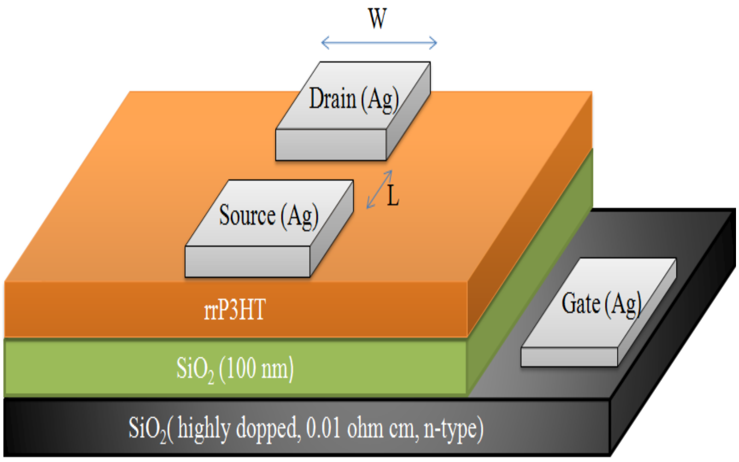


Figure. 2. *Scheme of common top contact geometry for P3HT-OFET*

3. DISCUSSION

The thickness of the oxygen layer of SiO_2 is 100 nm and this layer's capacitance value is 96.8 nF/cm^2. W/L ratio is 1000µm/17µm. The device exhibits saturation characteristics at -40 V operation voltage. Field-effect mobility (μ_{FET}=0.103 cm^2/Vs), thershold voltage (V_T=8V) and current on/off ratio ($I_{on}/I_{off}=10^1$) were obtained from output (Fig. 3.) and transfer characteristics (Fig. 4 (a).).

Finally, as shown in Fig. 4(b), the field effect mobility μ_{FET} can be determined from the slope of a plot between $|I_{DS}|^{0.5}$ versus V_{GS} output curves derived Eg.1. The extrapolated x-intercept of this plot yields the value of the threshold voltage.

$$I_{DS} = \mu_{FET} \frac{WC_i}{2L} (V_{GS} - V_T)^2 \qquad (1)$$

We have calculated the mobility value of the SiO_2/Pentacene based OTFT in its saturation zone from the slope (α) of the best fitted curve applying the formula shown in Eq. 2.

$$\alpha = \left(\frac{WC_i}{2L}\right)^{1/2} \qquad (2)$$

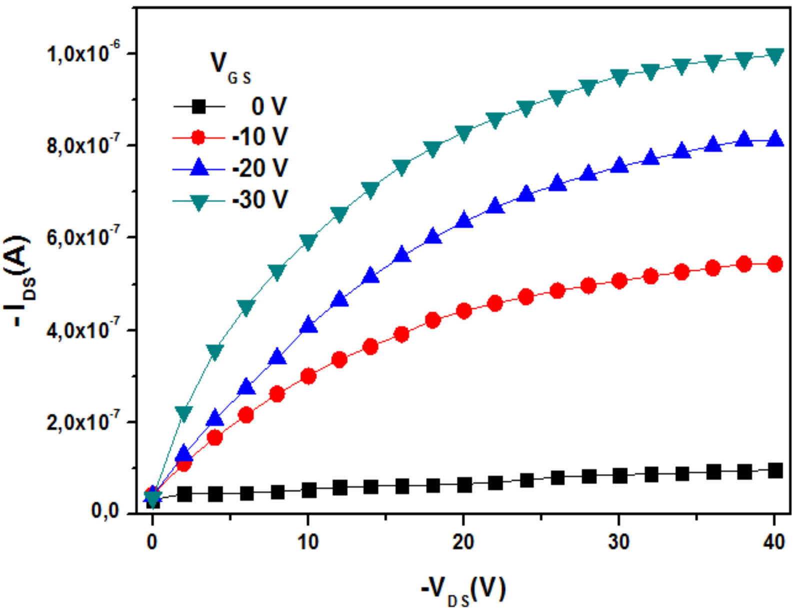
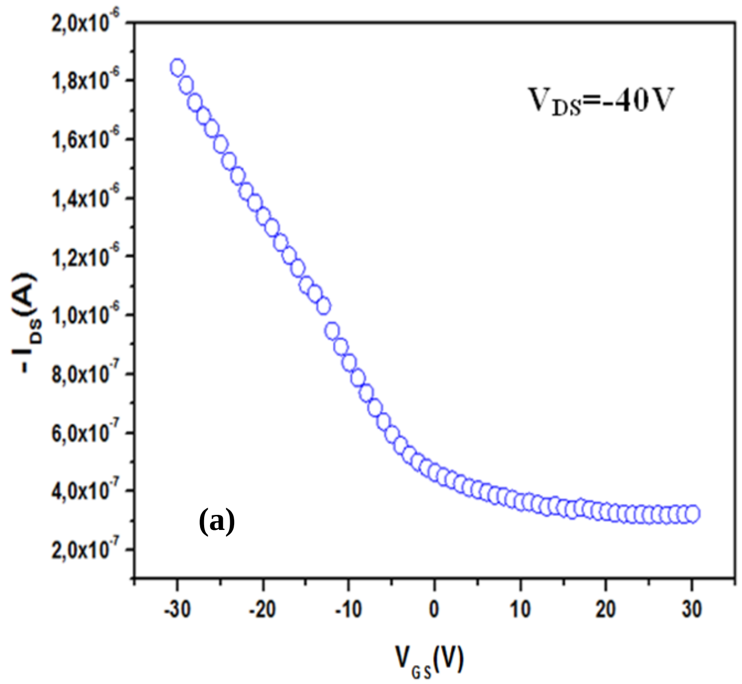


Figure. 3. *I_{DS}-V_{DS} output characteristic of P3HT-OFET with SiO_2 as gate dielectric layer.*



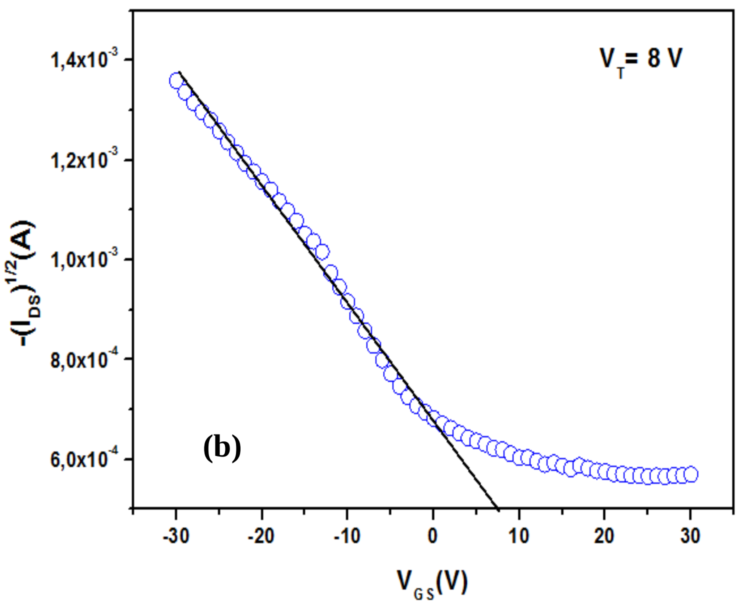


Figure. 4. (a) *I_{DS}-V_{GS} transfer characteristic and (b) $(I_{DS})^{0.5}$-V_{GS} characteristic of P3HT-OFET with SiO_2 as gate dielectric layer*

4. RESULT

We calculated the values of field effect mobility and on/off current ratio of fabricated OFET in the experimental section. The values we obtained are smaller compared to those found in the literature. In literature, the reason that rr-P3HT is found higher by using same materials is due to some interface improvements [5]. The reason why the SiO_2 dielectric layer did not show good interface characteristics with rr-P3HT thin layer in our OTFT devices is related to the organic/inorganic incompatibility of the interface. On the other hand, the mobility of our devices and their performances is improved and it is considerably high compared to the polymeric based transistors since dielectric layer was inorganic.

5. REFERENCES

[1] S.P. Tiwari, W. J. Potscavege, T. Sajoto, S. Barlow, S. R. Marder, B. Kippelan, Organic Electronics 11 (2010) 860-863

[2] G. Scavia, W. Porzio, S. Destri, L.Barba, G. Arrighetti, S. Milita, L. Fumagalli, D. Natali, M. Sampietro, Surface Science 602 (2008) 3106-3115

[3] H. Yang, T.J. Shin, L. Yang, C.Y. Ryu, Z. Bao, Adv. Funct. Mater. 2005, 15, No.4, April

[4] A.Wang, I. Kymissis, V. Bulović and A.I. Akinwande, Appl. Phys. Lett. 89 (2006) 112109-112109.

[5] Vibha Saxena, A.K. Chauhan, N. Padma, D.K. Aswal, S.P. Koiry, Shashwati Sen, R.B. Tokas, S.K. Gupta, C. Sürgers, J.V. Yakhmi, Thin Solid Films, 517, 6124, 2009