$F_{16}CuPc$를 활성층으로 사용한 유기전계효과트랜지스터의 바이폴라 특성연구

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Bipolar Characteristics of Organic Field-effect Transistor Using F16CuPc with Active Layer

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Abstract : We fabricated organic field-effect transistors (OFETs) based a fluorinated copper phthalocyanine ($F_{16}CuPc$) as an active layer. And we observed the surface morphology of the $F_{16}CuPc$ thin film. The $F_{16}CuPc$ thin film thickness was 40nm, and the channel length was 50㎛, channel width was 3mm. We observed the typical current-voltage (I-V) characteristics and capacitance-voltage (C-V) in $F_{16}CuPc$ FET and we calculated the effective mobility.

Key Words : *Fluorinated copper phthalocyanine($F_{16}CuPc$), Organic Field-effect transistor(OFET), Effective mobility*

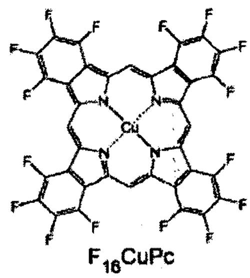
1. Introduction

Organic field effect transistors (OFETs) are very attractive for low-cost and low performance applications devices, such as Organic light-emitting diode (OLED) and integrated circuit for organic circuits [1]. It has been known phthalocyanine derivate materials with high thermal and chemical stability represent one of the most promoting candidates for modern optical electronic devices such as optical recording, gas sensors, thin film transistors and solar cells [2, 3]. The $F_{16}CuPc$ materialhas a similar molecular shape and a similar crystal structure, with a hole mobility of about 0.04 cm^2/Vs. The highly ordered polycrystalline thin film of the $F_{16}CuPc$ can be deposited on amorphous SiO_2/Si substrates under similar optimized growth conditions. Fig. 1 show the related energy levels of the highest occupied molecular orbital (HOMO) is 5.9 eV and the lowest occupied molecular orbital (LUMO) is 4.6 eV of the $F_{16}CuPc$ and the line was indicated the Fermi-level [2, 5].

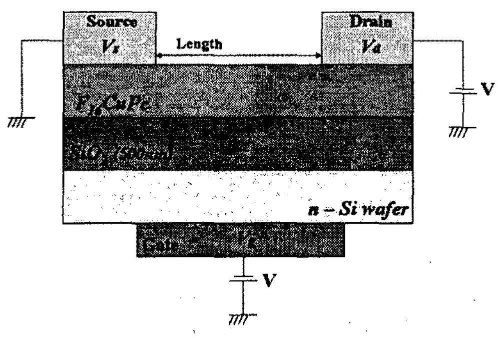
In this paper, we fabricated the single layer $F_{16}CuPc$ (40nm) FET and we measured the drain current-drain voltage (I_D-V_D), capacitance-gate voltage (C-V_G) characteristics with various applied frequency and observed the AFM images of the $F_{16}CuPc$ thin film surface. The single and double layer FET device have the channel length and width was 50㎛and 3mm, respectively. The I-V and C-V characteristics were carried out in an ambient condition by using a source-meter (Keithley type-2400) and LCR meter (Hioki type-3522-50) [4, 6, 7].

2. Experimentals

Figure 1 shows a molecular structure and the device structure of the single layer $F_{16}CuPc$ FET. The $F_{16}CuPc$ FET was fabricated using the silicon substrate and the UV/ozone treatment for 30 min with oxygen gas before deposition of the active materials. The $F_{16}CuPc$ were deposited on to the substrate by thermal evaporation method with a deposition rate of 0.5 [Å/s] at 10^{-7} torr. The channel length (L) and width (W) were 50 *mm* and 3 mm, respectively.



(a) Molecular structure

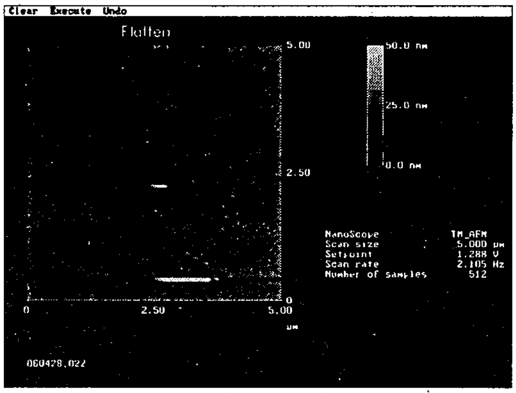


(b) Device structure (single layer)

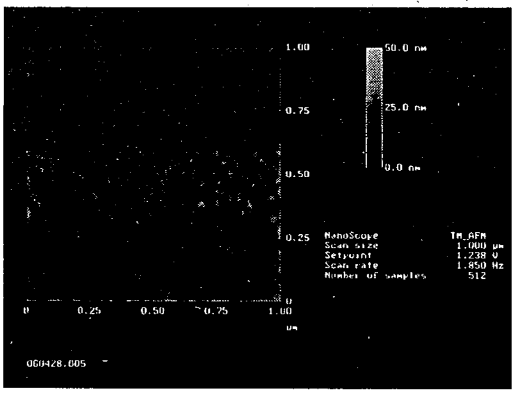
Fig. 1. Device and molecular structures of the $F_{16}CuPc$ FET device.

3. Results and Discussion

Figure 2 shows the AFM images of the bulk $F_{16}CuPc$ thin film surface at room temperature and the $F_{16}CuPc$ thin film thickness was 40 nm. From the large area (Fig 2. (a)) AFM images we could observe the very smoothly surface characteristics of the $F_{16}CuPc$ organic thin film. Also we could guess that the $F_{16}CuPc$ materials were layered to parallel with the substratefrom the small area (Fig. 2(b)) AFM image.



(a) $F_{16}CuPc$ surface morphology (5×5 μm^2)

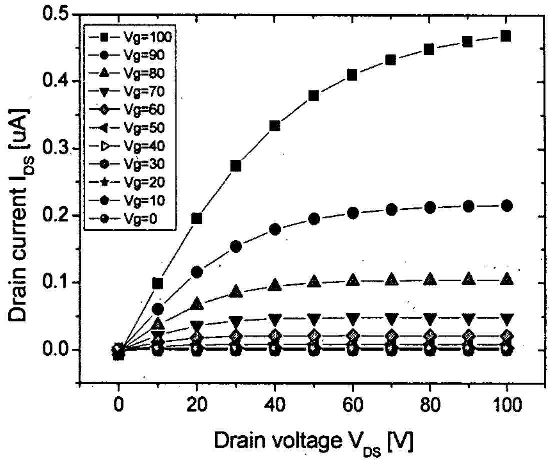


(b) $F_{16}CuPc$ surface morphology (1×1 μm^2)

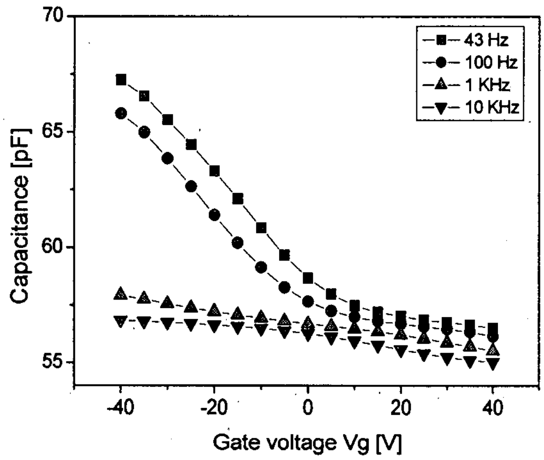
Fig. 2. AFM images of the bulk $F_{16}CuPc$ thin film surface at 40 nm.

Fig. 3 shows the I-V and C-V characteristics of the $F_{16}CuPc$ single FET. The Fig. 3(a) shows the typical FET characteristics as the n-type characteristics and we were calculated the field-effect mobility of 1.5×10^{-4} cm^2/Vs.

Also we measured the C-V characteristics of the $F_{16}CuPc$ FET with various applied frequency in Fig. 3(b). We applied the varying frequency 43, 100, 1K, and 10K [Hz] to the $F_{16}CuPc$ FET for the capacitance measurement. The applied gate voltage was increase the capacitance was also increased in the between dielectric layer and $F_{16}CuPc$ layer in range of the 40V to -40V.



(a) Typical I-V characteristics (n-type)



(b) C-V characteristics with various applied frequency

Fig. 3. I-V and C-V characteristics of the $F_{16}CuPc$ single layer FET.

4. Summary

We fabricated the top-contact $F_{16}CuPc$ FET and we were measured the C-V characteristics of the $F_{16}CuPc$ single FET.

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