High Performance Organic Field Effect Transistor by using Main Chain Conduction

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1. Introduction

In this study, main chain conduction was employed to obtain high carrier mobility in organic field effect transistors (OFETs). Diacetylene derivatives are well-known organic semiconductors having main chain conduction that can be fabricated by irradiating UV-light and/or heating of diacetylene monomers. In a theoretical study, the possibility of high carrier mobility more than 10000 cm^2/Vs has been anticipated[1)]. Indeed, the high performance OFETs using 10,12-pentacosadiynoic acid (PCDA) have been demonstrated[2)].

In this study, we controlled the morphology of polymerized PCDA (PDA) films under irradiation of UV-light to enhance the carrier mobility.

2. Experimental

The PDCA was deposited in a vacuum at a pressure less than 10^{-3} Pa on a n^{++}-Si wafer having a 300nm-thick SiO_2 layer, which was pre-cleaned by conc-sulfuric acid, heated at 403K for 30 min. in a grove box, and transferred to a deposition chamber without exposing to air.

After polymerizing PCDA deposited films, Au was deposited in a vacuum as the source and drain electrodes with the length and width of 42 μm and 200 μm, respectively.

The wavelength and the energy density of the UV-light were 254 nm and 30 $\mu W/cm^2$, respectively, and the irradiation was performed in the air. Further, the polymerization of PCDA by electron beam (EB) was performed at 10 KV acceleration voltage with the magnification power of 300 with ULTRA55 (Carl Zeiss Inc.). The thin film X-ray diffraction was measured before and after the polymerization of PCDA at 173K to avoid polymerization by X-ray irradiation.

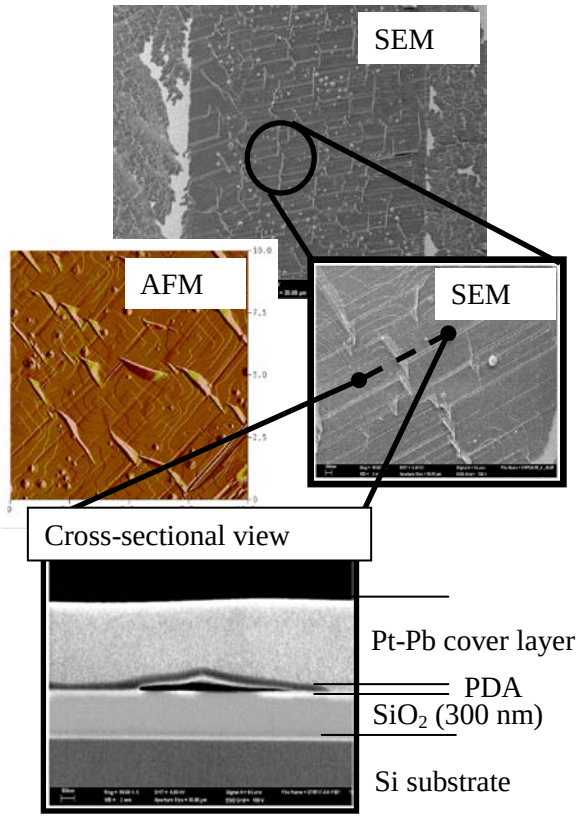

Fig. 1. SEM and AFM images for surface and cross-sectional view of a PDA film.

3. Result and Discussion

Figure 1 shows the SEM and AFM images of the surfaces of PDA films polymerized by UV-light. Those clearly show the crack and upheaval formation in the surface of PDA films, exfoliated from the substrate.

Although it is assumed that the position of the PCDA molecular center is immobile through the polymerization, a very small displacement of the unit cells occurred during the polymerization as shown in the X-ray diffraction (Fig. 2).

We found that the occurrence of upheaval region can be well restrained by polymerizing PCDA with EB as shown in Fig. 3. In the case of polymerization by UV-lamp in the air, absorption of UV light and O_2 radical formed by UV-light can start polymerization for PDA. Thus, the polymerization rate of a PDA surface is faster than that of a bottom region. On the other hand, in the case of polymerization by EB, polymerization can occur uniformly.

As shown in Fig. 4, the carrier mobility of a PDA film polymerized by EB demonstrated a very high mobility of 3.8 cm^2/Vs.

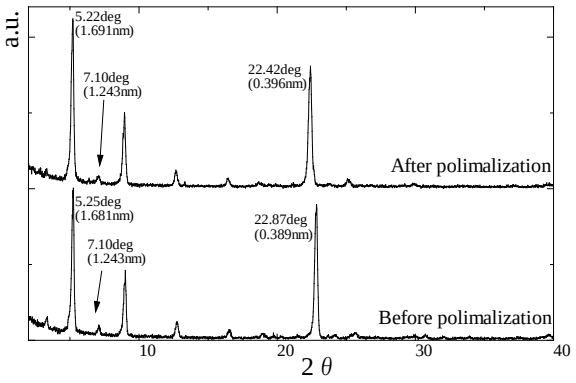

Fig. 2. XRD results for PDA and PCDA films

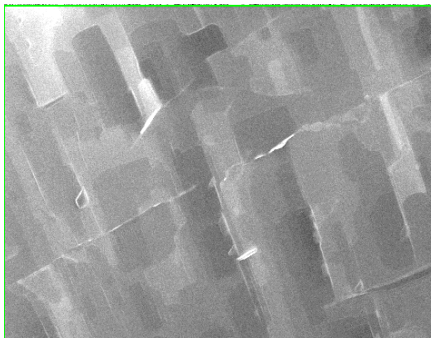

Fig. 3. SEM image for PDA polymerized by electron beam.

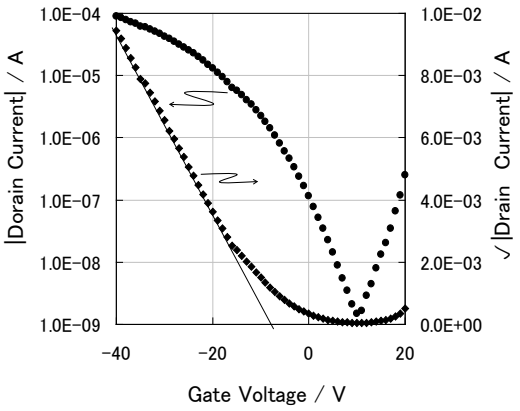

Fig. 4. Transfer characteristics for a PDA film polymerized by electron beam.

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4. References

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4. Acknowledgement

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