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Fabrication of a stable lying sexithiophene ultrathin film on a SiO_2 substrate

Genki YOSHIKAWA*[1], Yuki TSURUMA[2], Ryo ONOKI[3], Shiro ENTANI[2], Susumu IKEDA[2], Keiji UENO[3], and Koichiro SAIKI[2]
[1]Institute for Materials Research, Tohoku University, Katahira 2-1-1, Aoba-ku, Sendai 980-8577, Japan
[2]The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8561, Japan
[3]Department of Chemistry, Saitama University, Shimo-Okubo 255, Saitama, 338-8570, Japan

Introduction

Sexithiophene (6T) has been attracted much attention because of its high field effect carrier mobility. It has been reported that the built-in high-resistive region at the contact between a channel and electrodes in the top contact FET structure reduces drain current significantly [1]. In this study, we succeeded in fabricating a lying 6T ultrathin film by depositing 6T molecules on a SiO_2 substrate maintained at 100 K. With this lying molecular orientation, thiophene rings of 6T molecules can face top electrodes, so that this film has a potential to make a better contact between the electrodes. Furthermore, we annealed this 6T ultrathin film, measuring *in situ* NEXAFS, and found that this film is quite stable up to 470 K without changing the lying molecular orientation, while 6T deposited on a SiO_2 substrate maintained at room temperature exhibits standing orientation.

Experiment

Two types of SiO_2 substrates were used; one prepared by oxidation of a Si wafer with Shiraki method, and a commercially obtained Si wafer with natively oxidized amorphous SiO_2 layer. 6T molecules were evaporated from a Knudsen cell in a custom-designed all-in-vacuum system with a base pressure of 10^{-8} Pa and deposited on the SiO_2 substrates maintained at 100 K. The sample was annealed up to 470 K, measuring *in situ* S K-edge NEXAFS without exposing the specimens to the atmosphere.

Results and Discussion

Figure 1 shows the NEXAFS spectra of 6T thin film deposited on the SiO_2 substrate prepared by Shiraki-method. The substrate was maintained at 100 K during the deposition. 6T films deposited on a natively oxidized amorphous SiO_2 substrate also exhibits practically the same NEXAFS spectra. Clear polarization dependence is observed in an as-deposited 6T film at 100 K, that is, σ*-peak is most enhanced at normal X-ray incidence (90°), while π*-peak is enhanced at grazing incidence (15°). This polarization indicates that 6T molecules grow with lying-mode. This ultrathin film with lying orientation is quite stable and the lying orientation maintains up to 470 K without any dissociation, which can be confirmed by the absence of atomic S peak in the pre-edge region. The change of inclination angles of each orbital by annealing is also shown in Fig. 1. In the lower temperature region than

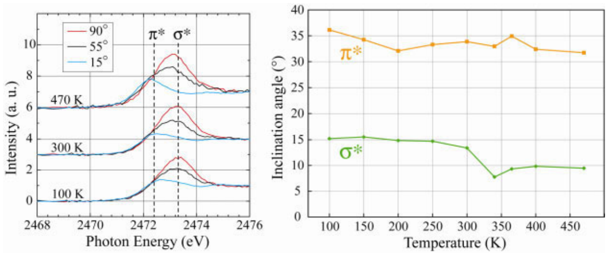

Figure 1: (Left) S K-edge NEXAFS spectra of 6T films deposited on SiO_2 maintained at 100 K. Annealing temperature is indicated at each spectrum. (Right) Change of the inclination angles of π*- and σ*-orbitals.

300 K, σ*-orbital exhibits slightly higher inclination angle, indicating a slightly random structure within the film due to the lack of diffusion on the surface during deposition. As temperature exceeds 300 K, 6T exhibits more lying orientation presumably due to the rearrangement or recrystallization of the molecules within the film. As for the inclination angle of π*-orbital, it exhibits almost the same value all through the annealing process. It would be attributed to the herringbone structure in the surface normal direction, while we could not eliminate the possibility of having completely random orientation of 6T molecules in the direction around the molecular long axes because the obtained inclination angle is close to the so-called "magic angle", where any anisotropy can not be determined by NEXAFS. The growth mechanism of the lying 6T film can be understood by the thermodynamic behavior of growing molecules [2,3]. This lying orientation also maintains even after exposing it to the atmosphere. The robustness of the lying 6T ultrathin film is also important for achieving higher FET performance as reported in our recent publication [4]. The present success in fabricating a stable lying 6T ultrathin film on a SiO_2 substrate will open a door to further improvement of the FET performance, especially in the case of top contact FET.

References

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*yoshik-0@imr.tohoku.ac.jp