Summary of Doctoral Thesis

Title of Doctoral Thesis: Fabrication and characterization of large-area oriented floating films of semiconducting polymer

Name : HERIYANTO SYAFUTRA

Summary of Doctoral Thesis:

Semiconducting polymers (SCPs) are widely investigated for developing next-generation flexible electronic devices. Developing a new solution processable method to prepare a large-area oriented thin film of SCPs is required for high-performance performance electronic devices and circuits. Floating film transfer method (FTM) is a promising technique and can fulfill such requirements. Therefore, further investigation is required to reveal the mechanisms and other features of this method.

In this dissertation, the author presents a detailed investigation of the orientation mechanism and characteristics of a newly developed method for the fabrication of large-area oriented thin films of SCPs named Unidirectional FTM (UFTM). The UFTM films were investigated by polarized UV-vis-NIR absorption spectroscopy, atomic force microscopy, X-ray diffraction, and electrical parameters were analyzed by fabricating different kinds of organic thin-film transistors (OFETs).

In chapter 3, the author reports the characteristics of the large-area (~40 cm^2) highly oriented thin film of poly(3,3'''-dialkylquaterthiophene) (PQT) with dichroic ratio of >10 and its suitability for large-area flexible electronics. The film has a highly uniform orientation in the center region, covering > 70% of the entire film area. Furthermore, a very narrow standard deviation of 12.6% in OFET mobility of a single large-area floating film is found. In addition, Flexible OFETs with bottom-gated geometry show no significant change in mobility after the bending test. In chapter 4, the authors reveals that UFTM can provide the film having the unidirectional alignment of the π-conjugated polymer chains covering the entire thickness of the film and provide similar performance in OFETs with either a bottom- or top-gated geometry. In chapter 5, the discussion focuses on testing the versatility of UFTM in assisting the orientation of guest SCPs a well-oriented host SCPs, and orientation of the guest polymer increases. In contrast, the orientation of the host polymer decreases monotonically in the polymer blend.

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Summary of Thesis Examination Results:

Semiconducting polymers (SCPs) are widely investigated for developing next-generation flexible electronic devices. Developing a new solution processable method to prepare a large-area oriented thin film of SCPs is required for high-performance electronic devices and circuits. Therefore, the author investigated the orientation mechanism and characteristics of a newly developed solution-processable method to fabricate large-area oriented thin films of SCPs named a unidirectional floating film transfer method (UFTM) that can provide such requirements. These investigations are supported by different characterizations tools such as polarized UV-vis-NIR absorption spectroscopy, atomic force microscopy, X-ray diffraction. Organic field-effect transistors (OFETs) in different orientational geometries are also fabricated to characterize and analyze large-area oriented films.

The author demonstrated the characteristics of the large-area (~40 cm^2) highly-oriented thin film of poly(3,3'''-dialkylquaterthiophene) (PQT) with dichroic ratio of >10 and its suitability for large-area flexible electronic devices. The results showed that the film had a highly uniform orientation in the center region, covering > 70% of the area. A very narrow standard deviation of 12.6% in OFET mobility fabricated at a center region of a single large-area floating film supported characterization results of such large-area films. Flexible OFETs with bottom-gated geometry also showed no significant change in mobility after the bending test.

The author also demonstrated that UFTM films possess unidirectional alignment of the SCPs throughout the film thickness. The OFET performance and anisotropy were almost similar in bottom-gated or top-gated geometry. In addition, the author has also demonstrated the versatility of UFTM in assisting the orientation guest SCPs in well-oriented host SCPs by blending the polymers.

As described above, this thesis has revealed a detailed investigation of the orientation mechanism and characteristics of a newly developed method for fabricating large-area oriented SCP thin films. Since this knowledge is fundamentally essential for developing the next generation flexible electronic devices, the committee agreed that this thesis is worth a doctoral degree in engineering.