Solvent-vapor Induced Crystallization in Organic Semiconducting Materials

Chia-Hsin Wang (王嘉興)[1], Yung-Chiuan Cheng (鄭詠全)[2], Jing-Wun Su (蘇敬文)[2], Liang-Jen Fan (范良任)[1], Ming-Chou Chen (陳銘洲)[3], and Yaw-Wen Yang (楊耀文)[1,2]

[1]National Synchrotron Radiation Research Center, Hsinchu, Taiwan
[2]Department of Chemistry, National Tsing Hua University, Hsinchu, Taiwan
[3]Department of Chemistry, National Central University, Chungli, Taiwan

Organic thin film transistors offer a viable route of producing low-cost, large-scale plastic electronics by taking advantage of solvent-processibility. Solvents are also known to be capable of inducing a larger grain growth once the organic materials are exposed to solvent vapor. As "annealed" organic materials often result in a better electrical performance in terms of higher mobility and higher on/off switching ratio. Unfortunately, the solvent annealing is no panacea for improving electrical performance. The issue of interaction between solvents and organic materials cannot be overlooked. We thus set up to investigate this solvent-vapor induced crystallization effect using multiple techniques including AFM, UPS, XPS, NEXAFS, and XRD. TESADT thin films were grown on two different substrates: one with thermal-grown oxide and the other with 4-PBTS terminated. We use the simple sample name for the former as **I,** and the latter as **II**, respectively. Afterward, these two samples were annealed by dichloromethane vapor. The sample names were represented by **III**, and **IV**. AFM image of sample **IV** revealed the growth of continuous thin film with reduced roughness, as compared to mound-like structure with large roughness for sample **I**-**III**. Carbon *K*-edge NEXAFS results indicate that anthradithiophene ring of TESADT spin-coated onto two substrates remains nearly the same at 70° from the substrate surface, implying the maximum overlap of π electron clouds along the in-plane direction in Fig. 1. UPS data show that the HOMO's of TESADT on both substrates move toward the Fermi level by ~0.2 eV after solvent annealing, thereby reducing the hole injection barrier. To assess the electronic characteristics of the samples, top-contact thin film transistors with thermally evaporated gold electrodes were fabricated. The devices fabricated from sample **IV** yields a high field effect mobility of 1.20 $cm^2V^{-1}s^{-1}$, and its output curve and transfer curve were shown in Fig. 2.

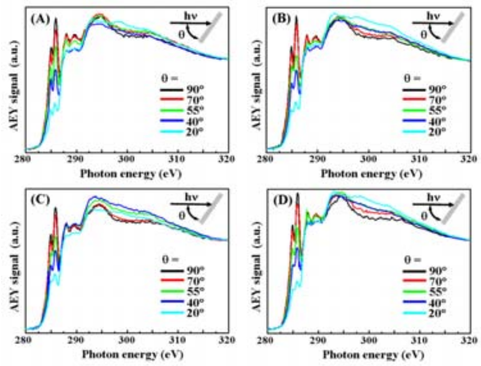

Fig. 1: Polarization dependent carbon *K*-edge NEXAFS spectra for (A) sample **I**, (B) sample **II,** (C) sample **III**, and (D) sample **IV.**

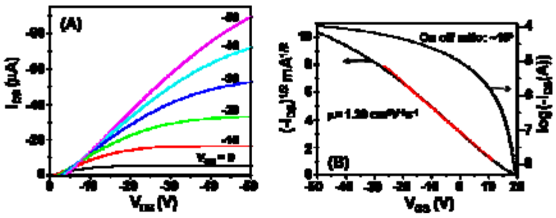

Fig. 2: (A) Output characteristics of the OFET fabricated from the sample **IV**. (B) The saturated transfer characteristics. ($I_{DS}^{1/2}$vs.V_{GS}) of the OFET in (A) at V_{DS} = –50.