Solution Processed Organic Thin-Film Transistors and Solar Cells

Dawen Li

Department of Electrical and Computer Engineering, Center for Materials for Information Technology, University of Alabama, Tuscaloosa, AL 35487

The seminar presentation focuses on two organic devices: thin-film transistors with TIPs-pentacene as active layer and heterojunction solar cells based on P3HT/PCBM material system.

Organic thin-film transistors (OTFTs) based on 6,13-bis(triisopropyl-silylethynyl)-pentacene (TIPS-pentacene) polycrystalline films are promising for low-cost flexible electronics due to their relatively high mobility, air stable, and the ability to be solution-processed at room temperature. However, TIPS-pentacene thin films severely suffer from crystal growth anisotropy, which consequently results in poor consistency of device performances. To solve this problem, silicon dioxide nanoparticles (SiO_2 NPs) (~20 *nm*) were mixed with TIPS pentacene in solution, and subsequent drop-casting of the blend solution yielded uniform film morphology with enhanced average mobility and significantly reduced performance variation. In addition, pure TIPS-pentacene thin film with uniform crystal orientation was also obtained by spray deposition. Sharp peak in X-ray diffraction indicates great crystallization of sprayed TIPS-pentacene.

In the heterojunction solar cell project, PS-b-P3HT diblock copolymer was added into P3HT/PCBM blend system to improve the crystallization and morphology. Compared with energy-conversion efficiency of 3.25% from the pure P3HT/PCBM blending system, the maximum efficiency of 4.11% has been achieved with addition of P3HT-b-PS diblock copolymer at weight ratio of 5% in P3HT/PCBM blends. The effect of adding PS-b-P3HT diblock copolymer on the morphology and phase separation of P3HT/PCBM blend was systematically studied through AFM. Uniform morphology with interpenetrating nanoscale domains of P3HT and PCBM network has been obtained at 5% concentration of diblock copolymer. This favorable interpenetrating nanoscale P3HT/PCBM network morphology increases the donor/acceptor interface areas and facilitates exciton separation. The crystallization of P3HT/PCBM thin film also plays a significant role for charge carrier transport and collection in bulk heterojunction solar cells. The x-ray diffraction patterns show a sharp peak at concentration of 5% diblock polymer, indicating better crystallization of active layer. In general, our results show block copolymer approach represents a promising way to enhance the power-conversion efficiency of bulk heterojunction solar cells.

Key words: organic thin-film transistors, TIPS-pentacene, SiO_2 nanoparticles, heterojunction solar cells, diblock copolymer, mobility, power-conversion efficiency