Nanoscale Mapping of Charge Transport Properties of Conjugated Polymer Films by Conducting Atomic Force Microscopy

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Thin films of conjugated polymers have recently emerged as promising material candidates for organic electronics such as light-emitting diodes, field-effect transistors, and solar cells [1]. In all instances, their device performance critically depends on the charge (holes and/or electrons) transport efficiency within the film, which is influenced by the crystallization, aggregation, and phase separation of the constituent polymers. Therefore, high-resolution techniques for characterizing electrical properties of the nanostructures in the films are of prime importance for further material and device improvement. Conductive atomic force microscopy (C-AFM) is a useful method for directly observing the charge-transport characteristics of conjugated polymer films with a high resolution on the order of nanometers [2-6].

Here, we investigated the local hole conductivity of poly(3-hexylthiophene) (P3HT) by C-AFM. The C-AFM hole current images visualized spatially inhomogeneous hole transport in the film on a nanometer scale, with relatively low conductive regions and high conductive domains with a typical size of approximately 200 nm [2,3]. The increase in the macroscopic hole conductivity of the P3HT film was explained from the increase in current flow processed mostly in the relatively high conductive domains. We further investigated the local electron conductivity of a naphthalene diimide based copolymer, P(NDI2OD-T2), and visualized the growth of high conductive ribbon-like features with length ranging from several hundred nanometers to a few micrometers [4]. Moreover, we observed both hole and electron transport networks formed in the blend film of P3HT/N2200 for solar cells application. Our results demonstrate that electrical characterization of conjugated polymers by C-AFM is critical for visualizing the charge-transport nanostructures that govern their device performance [4].

References

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