Stevens Institute of Technology

Nanotechnology Graduate Program

Kelvin Probe Force Microscopy for in situ Electrical Characterization of Organic Solar Cells

Wednesday October 19, 2011, Babbio 122, 11am

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The most efficient organic solar cell today is made from blending conjugated polymers (donors) and fullerene molecules (acceptors) together to form bulk nanoscale heterojunctions. The nanomorphology of the disordered bulk heterojunctions, largely affected by material properties and processing conditions, plays a critical in determining the overall device performance. However, our understanding on organic bulk heterojunctions is still limited because of lacking characterization tools in differentiating donors and acceptors in bulk heterojunction organic solar cells. Most microscopic characterization on organic solar cells using AFM are limited to the characterization of nanoscale roughness of the active layer without providing the phase separation map. In order to map the phase separated regions and correlate the nanomorphology to device performance, a high resolution microscopy characterization tool, which can differentiate the donor and acceptor regions, is needed. Kelvin Probe Force Microscopy (KPFM), combining AFM and Kelvin probe technology, has the ability to quantitatively map the work function of semiconductors at nanometer scales and hence promising potential to identify phase separated nanostructures in organic solar cells. The traditional dual-pass lift-up scan mode KPFM is not appropriate for characterization of organic solar cells because its spatial resolution is not high enough to differentiate the phase separation domains. The single-pass scan mode KPFM offers better spatial resolution but has cross-talk between topography and surface potential images. By setting the electrical driving frequency away from the mechanical resonant frequency, we have decoupled the cross-talk in single-pass scan mode KPFM and have successfully examined the electrical properties of single-walled carbon nanotubes when they are blended with the conjugated polymer poly-3-hexylthiophene (P3HT) and phenyl-C61-butyric acid methylester (PCBM). From this study, we have discovered the electrical role of single-walled carbon nanotubes in improving organic solar cell performance.

Guangyong Li is currently an Assistant Professor in the Department of Electrical and Computer Engineering at the University of Pittsburgh, Pittsburgh, PA. He received the B.S. degree in Mechanical Engineering from Nanjing University of Aeronautics and Astronautics, Nanjing, China, in 1992, the M.S. degree in Control Theory and Applications from Beijing Institute of Control Engineering, China Academy of Space Technology, Beijing, China, in 1999, and the Ph.D. degree in Electrical Engineering from Michigan State University, East Lansing, in 2006. His current research interests include Micro/Nano Robotic Systems; Scanning Probe Microscopy; Modeling, Simulation, and Characterization of Organic Solar Cells. Dr. Li has published more than 20 papers in Journals and 60 papers in conference proceedings. Dr. Li and his co-authors received the 2006 IEEE Transactions on Automation Science and Engineering Best Paper Award.

Co-sponsored by the Department of Mechanical Engineering

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