Optical, morphological and electrical characterization of poly (3-hexylthiophene) (P3HT) and phenyl-C61-butyric acid methyl ester (PCBM) used in Photovoltaic devices

Jamal Ghabboun[1], Marc Chaigneau[2], Mukhles Sowwan[3], Maryam faroun[3] and Zafer Hawash[3]

[1]Department of Physics, Bethlehem University, Bethlehem-Palestine.
[2]Laboratory of Physics of Interfaces and Thin Films, Ecole Polytechnique. Orsay- France.
[3]The Nanotechnology Research laboratory, Materials Engineering Department, Al-Quds University, East Jerusalem- Palestine.

Abstract

Organic photovoltaics currently lag behind their "inorganic" counterparts because of low solar energy conversion efficiencies. Several research groups are addressing conversion efficiency by employing a combination of nanomaterials and unique nanoscale architectures. Recently, new hybrid organic-inorganic photovoltaics are being studied and known as third generations' solar cells. These photovoltaics consist of light absorbing polymers in contact with semiconductor nanocrystals or nanostructured metals. The nanomaterials affect electro-optical properties of the conducting polymer, which include assisting in absorption of red and near-IR photons, a significant portion of the solar spectrum. To investigate thoroughly these new generation of solar cells containing potential efficient polymers, devices composed of PCBM (acceptor type fullerene C60), P3HT (donor conjugated polymer) and another low band gap material (LBG, undisclosed compound) have been prepared. High resolution AFM images have been carried out for surface characterization. Flat surface without any distinct structure was observed in the AFM images of the sample reference (1:1:0 / P3HT:PCBM:LGB) in contrast with a phase separated structure appeared with different domain size from 10 nm to 200 nm depending on the organic molecules concentration. The organic solar cell with low band gap (0.76:1:0.23 P3HT/P1/PCBM) ratios showed improvement in efficiency. In this case, the average domain sizes are estimated to be 11 nm, approaching the ideal domain of the exciton diffusion length. A finer phase separation observed confirms the intimate mixing of P3HT and PCBM at the nanoscale. One can clearly observe well-defined interfaces where the phase separation within the P3HT and PCBM can be seen as bright and dark regions, which are attributed to polymer rich domains and PCBM-rich domains, respectively. A relationship has been performed between the photovoltaic performance and morphology. Furthermore, Raman spectroscopy is used to clearly identify the chemical nature of the different domains. First measurements showed that the Raman signal of P3HT completely masked that of PCBM. Further work is in progress to optimize PV performance of these copolymers.