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Enhanced performance by MoSI nanowires, and Raman and photocurrent mapping of P3HT PCBM solar cells

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One of the factors limiting the efficiency of organic bulk heterojunction solar cells is the narrow absorption range of most conjugated polymers. Here we present a study of the photovoltaic properties of P3HT: PCBM solar cells embedded with $Mo_6S_{9-x}I_x$ (MoSI) nanowires dispersed in the P3HT: PCBM matrix or deposited on the top of the active layer under the aluminum electrode. Since the MoSI nanowires form bundles with diameter from 3-100 nm, additional light scattering and broadening of the absorption spectrum can be expected, potentially improving the performance of the cell. We find that for the concentration of 0.5 wt% of MoSI nanowires dispersed within the P3HT: PCBM active layer, a relative increase in power conversion efficiency of ~15 % is observed compared with P3HT: PCBM reference cells. For the samples with MoSI nanowires on the top of the active layer a relative increase in power conversion efficiency of ~4 % is observed. The corresponding short circuit current increase matches with the broadening of the absorption and EQE spectra with the addition of MoSI nanowires.

Characterization of the active layer morphology is very important for the solar cell's performance improvement, in order to determine how it influences better dissociation and extraction of the charges. As alternative to atomic force microscopy (AFM), Raman mapping can give useful information on the composition and distribution of materials present on the sample's surface. Environmental degradation of the polymer solar cells is, behind the quite low efficiencies compared to the other types of solar cells, one of the major problems. Spatially resolved methods, such as the light-beam induced current (LBIC) are quite common for the photocurrent mapping and for identification characteristic spatial patterns of the degradation but it is also possible to compare LBIC data with information obtained from other complementary non-invasive analytical techniques and to get an information about solar cell degradation. Here we explore the correlation between the Raman mapping image and photocurrent mapping of the entire P3HT: PCBM solar cell area.

Keywords: light absorption; MoSI nanowires; light scattering; Raman mapping; LBIC