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Improvement of polymer solar cell performance via surfactant free surface engineered silicon nanocrystals with quantum confinement effects

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Research in organic polymer based solar cells has achieved significant advances in the efficiency, however due to polymer degradation the application under concentrated sunlight has remained a challenge. The use of luminescent inorganic nanocrystals represents a possibility to overcome some drawbacks related to the degradation by UV photons whereby nanocrystals would convert high energy photons to less harmfull red ones. In this context environmentally friendly silicon nanocrystals (Si-ncs), which exhibit quantum confinement effects, could be particularly useful. We argue that low-concentrated sunlight in combination with energy-transfer by the photoluminescent Si-ncs could represent a viable approach for further enhancement of the conversion efficiency of the polymer solar cells at low cost. In this contribution we demonstrate surface engineering of Si-ncs by an microplasma treatment without using surfactants allows achieving Si-ncs enhanced dispersion and carrier transport in water soluble poly-(3,4-ethylenedioxythiophene doped by poly(4-styrenesulfonate) (PEDOT-PSS) and polythieno[3,4-b]thiophenebenzodithiophene (PTB7). We present results on a nanocomposite formed by Si-ncs/PEDOT-PSS which has shown to be beneficial for PTB7/ [70]PCBM polymer solar cells under low-concentrated sunlight (<10 suns). We show how the presence of stabilized and highly luminescent Si-ncs at room temperature lead to an enhancement of the PTB7/[70]PCBM solar cells performance (7.58 % to 7.92 %) under concentrated irradiation. This is mainly due to the enhancement of the photocurrent generation resulting from the conversion of high energy photons (<450 nm) into red-emission (~680 nm) via pholuminescence occurring at the Si-ncs. Furthermore, the Si-ncs absorption prevents UV light from reaching the UV-sensitive PTB7 polymer and reduces solar cell performance degradation.

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