Optical and transport studies of polymer/fullerene based solar cells structures and devices

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The discovery of photo-induced electron transfer from conducting polymer onto C_{60} has already been reported a decade ago [1] and the dynamics of the charge separation process (between the photo-induced electron and polaron) have extensively been studied today [1,2]. Here we present results of the reverse charge recombination processes on several polymer/fullerene structures by using transient absorption spectroscopy (TAS) and time of flights (TOF) measurements. We note that the competition between recombination processes and charge collection from device electrodes is crucial factor for the solar cell device performance. As an example we have already performed room temperature (RT) TAS spectroscopy in a composite of poly[2-methaxy-5-(3'.7'-dimethyloctyloxy)-1-4-phenylene vinylene], (MDMO-PPV) (PCBM) solar cell structures as a function of laser excitation density. Our results indicate that the decay dynamics of the MDMO-PPV polarons is dependent upon the laser excitation density employed. The slower, power law, decay phase (100 ns- 10 ms) is attributed to recombination dynamics of localised polarons, while the fast decay component (< 20 ns) is attributed to recombination of mobile polarons observed when you exceed the density of photo-generated polarons above the density of localised states (~ 10^{17} cm^{-3}) [3]. The recombination dynamics in (MDMO-PPV) (PCBM) solar-cell devices is expected to be dominated by the slower decay phase. Continuous illumination at ~1/4 solar irradiation results in the steady state occupancy of ~10^{16} cm^{-3} which is less than the density of localised states (~ 10^{17} cm^{-3}) [4]. The above measurements were performed on solar cell structures in the absence of collecting electrodes. In order to clarify the competition between recombination processes and charge collection from device electrodes we will perform TAS and TOF measurements in the corresponding solar cell devices. At solar lights intensities and RT, most polarons are trapped and therefore the released of polarons from the traps could be the key process determining recombination times in solar cell devices [5]. TOF measurements will be a useful tool in order to gain more information about the mobility's of polarons in these structures In this presentation we shall discuss our results in terms of the different polymer/C_{60} systems studied and show how improved solar cell devices may be engineered.

[1] N. S. Sariciftci et. al, Science **258**, 1474 (1992), [2] B. Kraabel, et al, J. Chem. Phys. **104**, 4267 (1996), [3] I. Montanari et. al, Appl. Phys Lett., in press, [4] A. F. Nogueira et al, Journal of Phys. Chem. B, submitted, [5] J.Nelson, Phys. Rev. B, submitted (2002).

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