MAR10-2009-004510

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Increased exciton harvesting in organic thin film solar cells

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The optimization of organic solar cells involves a fundamental tradeoff between optical absorption length, mobility, and exciton diffusion length (L_D). Organic semiconductors possess L_D that are at least one order of magnitude less than their respective absorption lengths, meaning that many excitons decay before reaching a dissociating interface. The bulk heterojunction concept, whereby one mixes donor and acceptor components into a single layer, is an effective way to avoid this bottleneck. However, because mixed layers tend to have lower mobilities compared with pure films, carrier transport in devices composed of mixed layers thick enough to absorb a significant amount of light is poor, producing an inefficient device. In this talk, we explore two promising approaches to solve these challenges. In one, we investigate the possibility of increasing L_D of a given material. By employing a properly chosen phosphorescent dopant, we are able to sensitize a population of long-lived triplet excitons in a normally fluorescent material, increasing the diffusion length by more than a factor of 2. In another approach, we look into the possibility of exploiting surface plasmon resonances of metal nanoparticles. These surface plasmon resonances lead to strongly enhanced near fields, increasing absorption of nearby chromophores. With this approach, therefore, the thickness of organic semiconductor layers containing metal nanoparticles could be reduced without compromising absorption. Here, we investigate exciton-plasmon interactions through photoluminescence and absorption measurements of thin-films consisting of organic semiconductors and metal nanoparticles, as a function of film thickness with and without the presence of spacer layers between the nanoparticles and absorbers. From this knowledge, we assess the prospect of using plasmonic effects in thin film organic solar cells.