Magnetophotocurrent of Field Effect Transistors Based on Ternary Device of Tetracene/Pentacene/Fullerene

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The singlet fission (SF) process is the exciton multiplication process in which a singlet exciton is converted into two spin-triplet excitons. The SF reduces the thermalization losses in the solar cell devices and improves their overall power conversion efficiency [1, 2]. However, triplet-triplet annihilation (TTA) which is the reverse process of SF always occurs parallel and competes with SF. We provide a method to reduce the TTA.

In this work, we inserted a thin layer of Pentacene (PEN) interlayer (~2 nm in thickness) between Tetracene and Fullerene (C_{60}), as shown in figure 1, to dissociate the triplet exciton and minimize the TTA process. Without PEN layer, the negative magnetophotocurrent (MPC) in TET/C_{60} device was observed, as shown in figure 2, indicating that triplet exciton produced by SF in TET cannot be dissociated into electrons and holes. Reichert et al. mentioned this decrease of current is caused by the scatter of triplet excitons with the charge carriers [3]. When the magnetic field is smaller than 30mT, the photocurrent of TET/C_{60} device decreased, because the SF rate increases at low applied magnetic field. At the higher magnetic field, the photocurrent of the device is increased compared to the low field condition, because TTA process becomes dominant.

The MPC was turned to positive when a thin layer of PEN was sandwiched between TET and C_{60} layer. The MPC curve is changed from unique “W shape” to non-Lorentzian shape, as shown in figure 2. This phenomenon can be explained by the transfer of triplet excitons form TET to PEN layer. These excitons are dissociated at the PEN/C_{60} interface and contribute to the photocurrent. In other words, the PEN interlayer can improve the SF effect of the device.

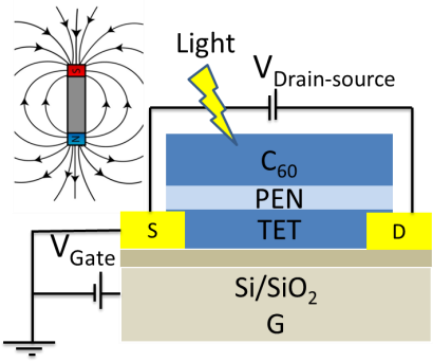

Figure 1: Illustration of the device structure.

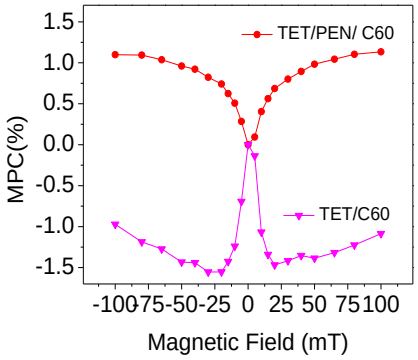

Figure 2: Magnetophotocurrent of field effect transistors based on TET/C_{60} and TET/PEN/C_{60}.

References:

[1] Paul M. Zimmerman, J. Am. Chem. Soc, 133 (49), pp 19944–19952 (2011).
[2] J. Lee, P. Jadhav, and M. A. Baldo, Appl. Phys. Lett. 95, 033301 (2009).
[3] Tobat P. I. Saragi, and T. Reichert, Appl. Phys. Lett. 100, 073304 (2012).