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Synergy in Two-dimensional $MoTe_2$/Pentacene Heterostructures: Charge Population and Extraction

Atomically-thin transition metal dichalcogenides (TMDs) have been recognized as a promising platform for the next generation photovoltaics on the basis of a tunable bandgap, large absorption coefficients, weak exciton-phonon coupling, and short distances for carrier extraction.[1-2] However, photovoltaic efficiencies which have been practically obtained to date from various TMD heterostructures remained below 5% and this raises the question of a new design of two-dimensional (2D) heterostructures in terms of composition or configuration.[1] Herein, we propose to construct a type II heterojunction between $MoTe_2$ and pentacene as n- and p- type materials, respectively. Two semiconductors in the heterostructure produced excitons under illumination ranging from visible (Vis) to near-infrared (NIR) light and the staggered band alignment facilitated the charge separation at the interface. The formation of carriers as well as the transfer between two layers was measured by transient absorption spectroscopy and it revealed a rapid decay or population at the peak position of ground state bleach (GSB) of pentacene and $MoTe_2$ as a function of time. This observation provides a clue to the fabrication of 2D photovoltaic devices to break the efficiency limit.

References

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[2] J. –H. Kim, M. R. Bergren, J. C. Park, S. Adhikari, M. Lorke, T. Fraunheim, D. –H. Choe, B. Kim, H. Choi, T. Gregorkiewicz, Y. H. Lee, arXiv:1801.01675 (2018).

Figures

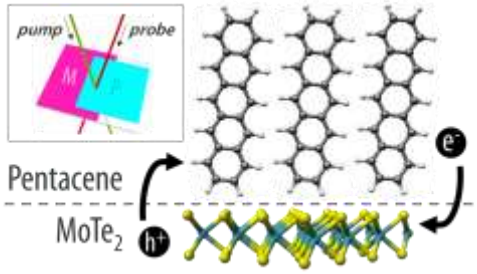

Figure 1: Schematic illustration of charge transfer at the interface between $MoTe_2$ and pentacene observed by transient absorption spectroscopy.