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Emerging 2D/0D Heterostructures: Spectroscopic Studies and Device Applications

Two-dimensional (2D) transition metal dichalcogenides (TMDs) have emerged as promising candidates for next-generation electronics and optoelectronics. [1] Beyond this, heterojunctions of 2D layered TMDs with zero dimensional (0D) quantum dots and organic semiconductors have attracted significant research attention. [2,3] However, advance material processing knowledge and detail spectroscopic insights are required to exploit these materials in real-world applications. This talk will cover the exploration of various haterojunctions of layered TMDs using spectroscopic techniques and their device applications. A fully solution processable method called *semiconductive Polymer assisted chemical exfoliation (SPACE)* of synthesizing polymer-MoS_2 (PG-MoS_2) nanoheterostructures will be presented. Efficient dissociation of excitons in PG-MoS_2 heterostructures will be demonstrated and explained on the lights of electron and hole transfers mechanism. Generation of photocarriers via exciton dissociation at the interface of polymer and MoS_2 is reflected from the strong photovoltaic activity with high open circuit voltage (~0.60 V) of PG-MoS_2. Moreover, these heterojunctions show a bipolar resistive switching effect with very high ON/OFF ratio (~10^4) in a sandwiched device. The temperature dependent Raman spectroscopic investigation has been undertaken to know about the electron-phonon (e-p) interaction and thermal properties of organic/TMD heterojunctions. Furthermore, quasi type II semiconductor like band alignment of 0D/2D (CdSe QD/MoS_2 nanosheet) heterojunction facilitates exciton breaking via hole transfer from QD to MoS_2. We demonstrate extraction of two holes through biexciton breaking at the 0D/2D interface. Our observations provide a new concept of exploiting Multiple Exciton Generation in quantum dot sensitized solar cells.

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References

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[2] D. Jariwala, T. J. Marks and Mark C. Hersam, Nat. Mater., 16 (2017) 170-181
[3] X. Liu, J. Gu, K. Ding, D. Fan, X. Hu, Y-W. Tseng, Y-H. Lee, V. Menon and S. R. Forrest, Nano. Lett., 17 (2017) 3176-3181.

Figures

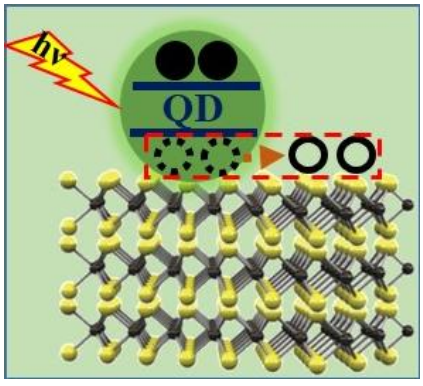

Figure 1: Dissociation of biexciton at the 0D/2D interface.