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Evaluation of a WSe_2/MoS_2 Heterojunction in the Perspective of a Transparent Thin-film Solar Cell

Solar energy is one of the most powerful and reliable renewable energy sources, but its wide-use is often hampered by the limited installation space. As conventional c-Si solar cell is very bulky and heavy, it requires large extra space to be installed. As a means to overcome such limitation, a transparent and light-weighted thin-film solar cell, which can be installed at the exterior of the buildings, has been studied [1-3]. In order to achieve transparency and photon-electron conversion at the same time, special structure or material is needed. We are suggesting a p-n heterojunction of 2D semiconductors as a candidate material to realize a transparent thin-film solar cell. In that few layers of a 2D semiconductor is highly transparent due to its thinness, but still maintain its photovoltaic effect and show relatively high light-matter interaction, it can meet those two contradictory requirements of a transparent solar cell [4]. Here, we fabricated a transparent thin-film solar cell with a p-n heterojunction of WSe_2/MoS_2 and evaluated its performance. By utilizing a glass substrate, a 2D p-n heterojunction, ITO electrodes and a CYTOP encapsulation, we achieved a highly transparent (~80 %) and stable solar cell. Our WSe_2/MoS_2 heterojunction device showed clear current rectification under dark state, and photovoltaic effect with sizable open circuit voltage (Voc) and short circuit current (Isc) under illumination. 2D materials are usually vulnerable to the environmental factors and easily degraded under ambient condition. However, by simply spin coating CYTOP as an encapsulation layer, the device properties were maintained stable for ~2 months. Especially, the standard deviation of Voc values throughout the measurement was less than 3% of the initial Voc value, which indicates how stable the devices are. In order to evaluate the real performance of the 2D solar cell under sunlight, I-V characteristic of a WSe_2/MoS_2 heterojunction under AM1.5G illumination was conducted. It turned out to show power conversion efficiency of 0.84 % under solar spectrum. In addition, the photovoltaic characteristics under monochromatic light representing red, green and blue were measured. The Isc and Voc of our solar cell showed fast response to the light pulse repeating on and off with the interval of 1.5 and 3 seconds, respectively. Good dynamic performance with consistent current or voltage level at light 'on' stage during repetitive measurement indicates small interface trap density of our device. We believe that our result exhibits great potential of a 2D heterojunction to be utilized as a transparent thin-film solar cell.

References

[1] R. R. Lunt and V. Bulovic, Appl. Phys. Lett., 98 (2011), 113305.
[2] Y. Zhao and R. R. Lunt, Adv. Energy Mater., 3 (2013), 1143-1148.
[3] J. L. H. Chau, R. T. Chen, G. L. Hwang, P. Y. Tsai and C. C. Lin, Sol. Energy Mater. Sol. Cells, 94 (2010), 588–591.
[4] M. L. Tsai, M. Y. Li, J. R. D. Retamal, K. T. Lam, Y. C. Lin, K. Suenaga, L. J. Chen, G. Liang, L. J. Li, H. He Jr, Adv. Mater., 29 (2017), 1701168.

Figures

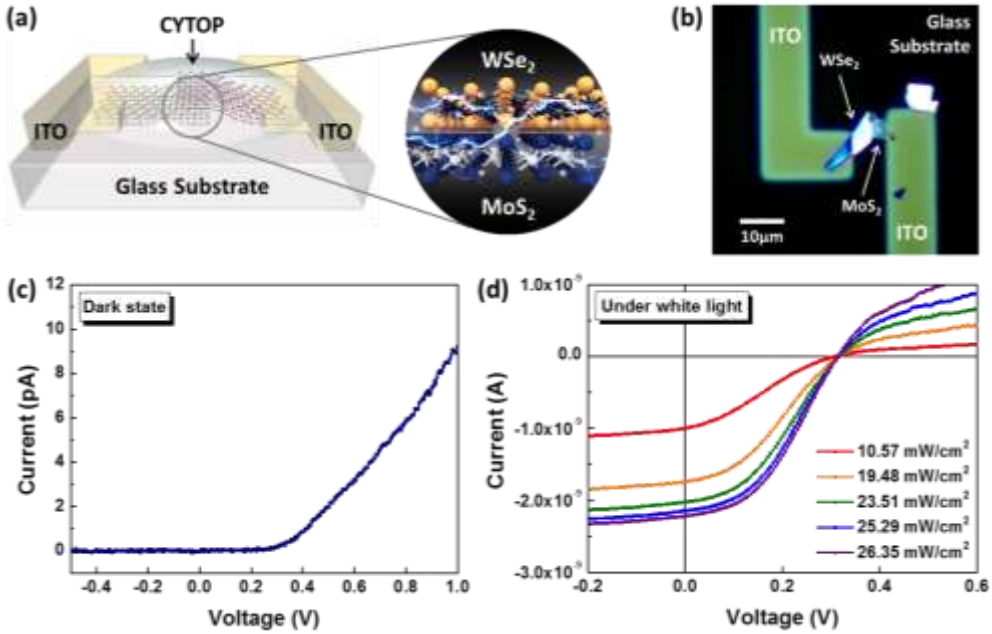

Figure 1: (a) A schematic and (b) an optical microscope image of a WSe_2/MoS_2 heterojunction device and its I-V characteristics under (c) dark state and (d) illumination (halogen lamp).

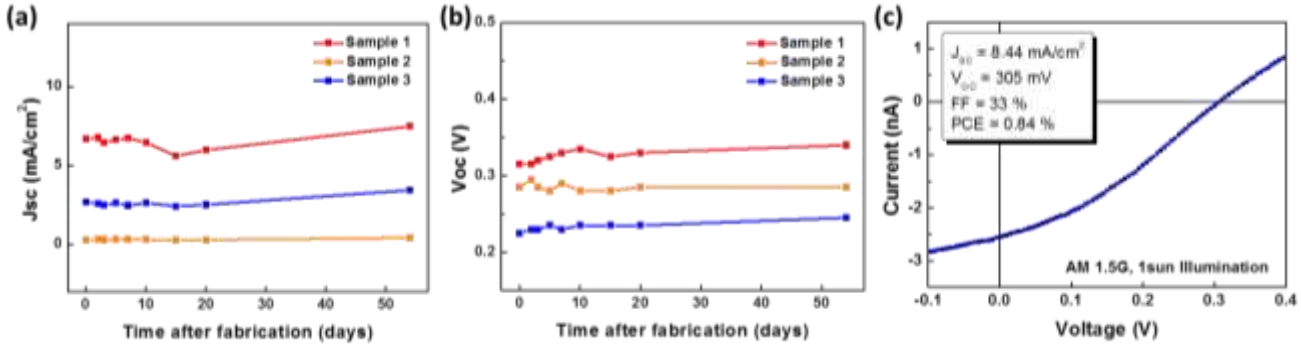

Figure 2: Variation of (a) Jsc and (b) Voc values as time goes on after fabrication. (c) I-V characteristic of the 2D solar cell under AM 1.5G illumination (1sun) and related parameters.

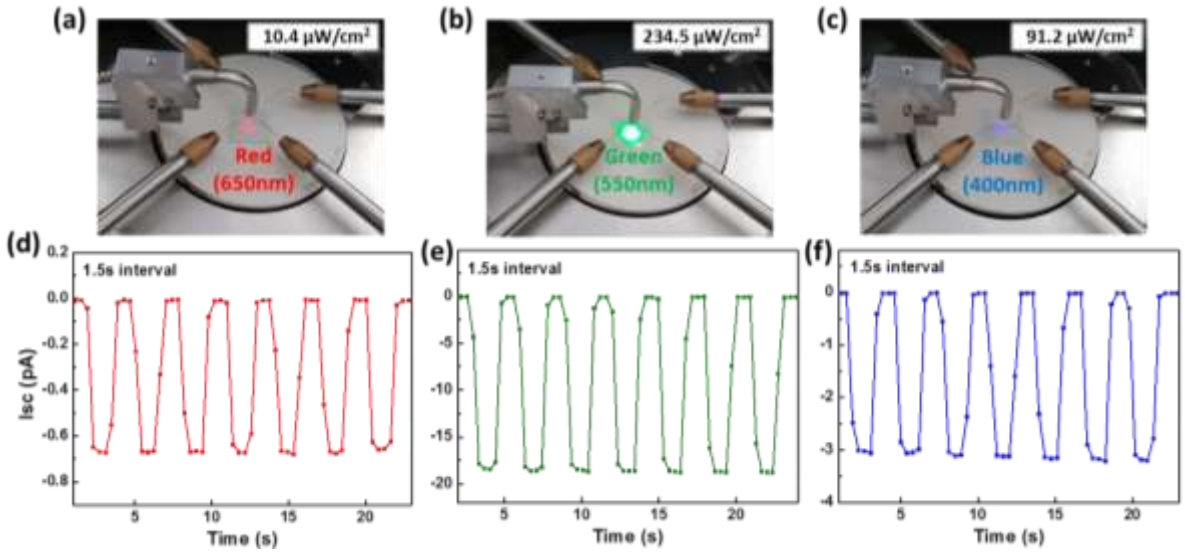

Figure 3: Photograph of measurement setup for (a) red, (b) green and (c) blue light response. Isc-time plot of our device, measured under (d) red, (e) green and (f) blue light pulse repeating on and off for 1.5 seconds.