Thin Film Formation and Photovoltaic Application of Transition Metal Dichalcogenides By Liquid Exfoliation

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Abstract: We studied on a liquid exfoliation technique for the robust production of transition metal dichalcogenides (TMDC) thin films, because this technique has advantages for residue-free, large-scale, and low-cost fabrication. During the process of liquid exfoliation, a mixture of DI water and ethanol was used to obtain higher concentrations of TMDC flakes in the solution compared to that in water-based solution. The film thicknesses were controlled by a two-step centrifuge process to analyze the influence on the photovoltaic properties with gold/TMDC/silicon geometry. Based on ultraviolet photoelectron spectroscopy measurement results, the energy band diagram of the devices using MoS_2 and WS_2 films were constructed. The external quantum efficiency (EQE) and power conversion efficiency (PCE) were measured as a function of film thickness. The maximum EQE values of MoS_2 and WS_2 devices are 63.7 and 58.5%, respectively, which are higher than the maximum EQE values of 23% from the Au/Si/In device. PCE of 126-nm-thick MoS_2 and 132-nm-thick WS_2 film devices appeared 3.55 and 2.98%, respectively, under 100 mW cm^{-2} solar illumination. These photovoltaic properties could be further improved by enhancing the film coverage and reducing the amount of surface oxidation and impurities. This work shows the potential of using MoS_2 and WS_2 films in highly efficient photovoltaic devices and other applications due to the various advantages of the liquid exfoliation method.

Keywords: Transition metal dichalcogenides; liquid exfoliation; photovoltaic application