Monolayer WSe_2-MoS_2 Lateral Heterojunction Light-Emitting Diodes

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Recent advances of heterostructure fabrications based on transition metal dichalcogenides (TMDCs) yield atomically regulated interfaces due to their intrinsically passivated surfaces, allowing us to explore unusual electrical and optical phenomena and to make outstanding improvements to device performance [1]. Although, numerous experimental demonstrations of vertically stacked heterostructures have been realized using scotch-tape approach, the investigation of physical properties of lateral heterojunctions, in which dissimilar TMDCs are artificially stitched together, has been still limited. In particular, lateral heterojunctions are easier to tune band offset for designing p-n junction because of their spatial separation. Moreover, compared with manual transfer of vertical heterostructures, lateral heterojunctions is ideally adopted for the scalable approach of chemical vapor deposition (CVD) for creating atomically sharp heterojunctions [2]. Here, we developed a scalable fabrication process for WSe_2-MoS_2 lateral heterojunction films and firstly realized its light-emitting device arrays.

WSe_2-MoS_2 lateral heterojunction films were synthesized by two-step CVD process. As shown in Fig. 1, W electrodes were firstly patterned for the subsequent location-selective growth of WSe_2 monolayers. And then, epitaxial growth of MoS_2 monolayers was performed to form heterojunctions. Finally, additional Mo pads were deposited, followed by spin-coating ion gel films for building light-emitting device [3-5]. As applying voltage, holes (electrons) are injected and accumulated in WSe_2 (MoS_2) mediated by electric double layers to form p-n junction (Fig.1). Figure 2 obviously indicates electroluminescence (EL) image generating along junction interface. Interestingly, the comparison between photoluminescence (PL) and EL spectra shown in Fig. 3 revealed inconsistent behavior. Although both contributions of WSe_2 and MoS_2 were observed in PL, EL only showed MoS_2 luminescence. This suggests band structure evolution at junction interface; thus we will discuss this physical picture based on recent scanning tunneling spectroscopy study. Importantly, we firstly realized lateral heterojunction light-emitting devices and achieved the improvements of their external quantum efficiency compared to reported homojunction devices, providing a new platform for high-performance optoelectronic device applications.

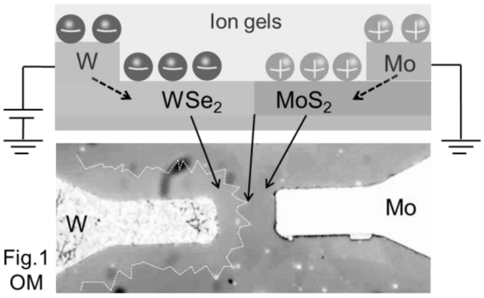

Fig.1 OM

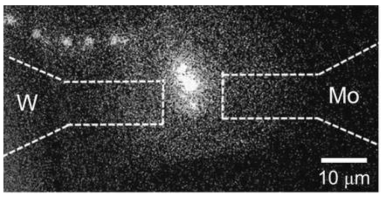

Fig.2 EL

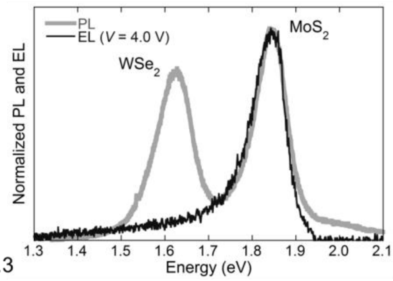

Fig.3

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[5] M.-Y. Li, J. Pu, *et al*. *Adv. Funct. Mater.* 1706860 (2018)