Domain shape evolutions of $MoSe_2$-WSe_2 monolayer lateral heterojunctions

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Monolayer lateral heterojunctions (HJs) consisting of two distinct transition metal dichalcogenides (TMDs) have formed a new class of atomically thin p-n junctions for applications in electronics and optoelectronics [1]. Here we report that monolayer $MoSe_2$-WSe_2 lateral HJs grown by chemical vaper deposition (CVD) can lead to very distinct domain shapes in the outer WSe_2 caused by different termination edges of the inner MoS_2 (Fig.1). Depending on the distances from the precursors, the domain shape of $MoSe_2$ evolves from truncated triangle at upstream to hexagonal and eventually returns to truncated triangle at the downstream, resulting in very distinct domain shapes in the outer WSe_2. Second harmonic generation microscopy reveals that the inner and the outer materials have the same crystal orientation. High-angle annular-dark-field scanning transmission electron microscopy (HAADF STEM) analysis indicates that the growth of outer WSe_2 is under W-rich condition, which leads to a faster outgrowth rate from the Se-zigzag (Se-zz) edges of the inner $MoSe_2$, leaving behind preferential W-zz termination edges in the outer WSe_2 [2]. A kinetics-driven growth model is proposed to explain the formation of forked shape edges and grain boundaries in the WSe_2 extended from the Se-zz edges of the inner $MoSe_2$ (Fig.2). Photoluminescence (PL) microscopy shows that the PL peak energy exhibits a non-uniform distribution, indicative of strain inhomogeneity in the outer WSe_2. The strain inhomogeneity induced by growth kinetics is discussed. This work elucidates the key growth parameters for controlling the domain shapes and grain boundaries in monolayer TMD lateral HJs.

References

[1] M.-Y. Li et al., Science, 349 (2015), 524
[2] S. Wang et al., Chem. Mater., *26*, (2014)**,** 6371

Figures

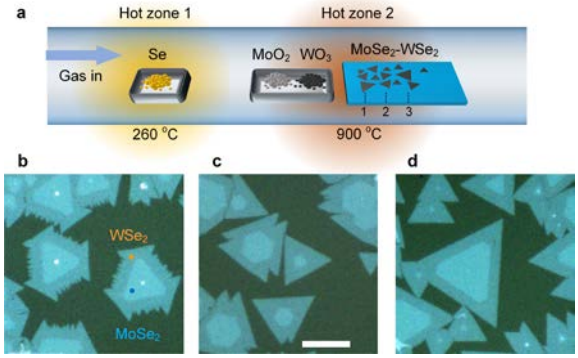

Figure 1: (a) Schematic illustration of the CVD system. (b-d) Domain shape evolutions of WSe_2 epitaxially grown at the edges of inner $MoSe_2$ from upstream (b) to downstream (d). The scale bar is 10 μm.

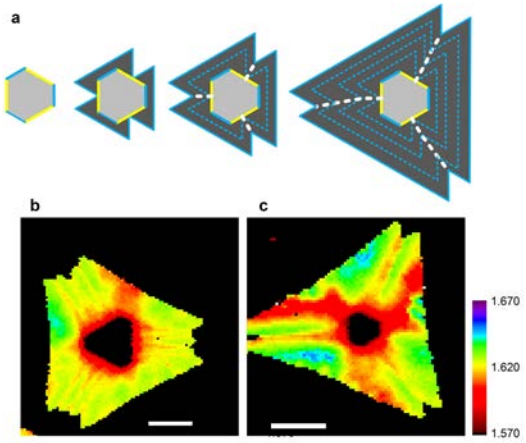

Figure 2: (a). Schematics of the proposed kinetics-driven growth model. (b,c) PL peak energy distribution in the outer WSe_2 for two different HJ flakes. The scale bar is 5 μm.