Bandgap modulation in one-dimensional interface of MoS_2/WS_2-based semiconductor heterojunction

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Interface of semiconductor heterojunctions has been one of the central topics in modern solid state physics and applications in electronics and optoelectronics. Recently, atomic layers of semiconducting transition metal dichalcogenides (TMDCs) are expected to realize novel one-dimensional state at their heterojunction interface [1-5]. However, the realization of conducting interface state still remains as an unsolved issue. Here, we report the observation of conductivity enhancement and unique bandgap modulation of the one-dimensional heterojunction interface based on bilayer TMDCs. The heterojunction is composed of bilayer WS_2 and vertically-stacked MoS_2/WS_2 heterostructure (Fig.1a), which can be grown on graphite by chemical vapor deposition as reported in our previous work [6]. This conductivity enhancement has never seen for the heterojunctions of monolayer MoS_2-WS_2, and monolayer-bilayer WS_2. Furthermore, STM/STS measurements reveal the upshift of both valence and conduction band edges and band-gap narrowing around the heterointerface (Fig.1b). This bandgap modulation could be explained by stacking mismatch due to lattice strain around the heterointerface. The present findings indicate that highly tunable electronic properties of TMDC systems provide an ideal system to realize 1D confined electronic system in the heterointerface.

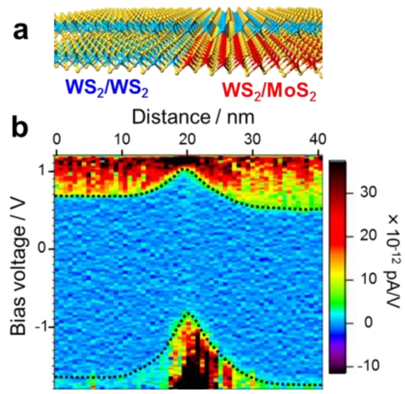

Fig.1 (a) Structure model of the present bilayer heterojunction. (b) Map of color scale d*I*/d*V* curves calculated from the spatially-resolved STS spectra.

[1] Y. Gong, *et al.* ***Nat. Mater.*** 13, 1135 (2014)., [2] X. Duan, *et al.* ***Nat. Nanotechnol***, 9, 1024 (2014).,
[3] C. Huang, *et al*. ***Nat. Mater.*** 13, 1096 (2014). [4] Y. Kobayashi *et al*., ***Nano Res.***, 8, 3261 (2015).
[5] S. Yoshida, *et al*. ***Sci. Rep.***, 5, 14808 (2015). [6] Y. Kobayashi *et al.*, ***ACS Nano,*** 9, 4056 (2015).
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