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# Low-Dimensional Heterointerface States in Monolayer Transition Metal Dichalcogenide

Featuring the exotic optoelectronics and spintronics from the spin-valley locking bands, monolayer transition metal dichalcogenides (TMDCs) $MX_2$ (*M*: Mo and W; *X*: S or Se) have drawn great attention in designs of advanced heterostructures, including both vertically stacked and laterally stitched heterojunctions. In addition to individual material properties, creation and modification of states at interfaces strengthen the functions of the heterostructures, and therefore, are worthy of detailed examinations. Using scanning tunneling microscopes (STM) at 4.5 K, we discovered in-gap states in monolayer $MoS_2$ on highly oriented pyrolytic graphite (HOPG) at the atomic scale.[1] Comparing the results with previous theoretical studies, we suggest that the states are charge re-distribution at the $MoS_2$-HOPG interface. The energy position and intensity of the in-gap states varied with the moiré periodicity and also the locations inside the moiré patterns (Figure 1 a), which sheds light on controls of TMDC conductive states in a few-nanometer range. In addition, we resolved the one dimensional heterointerface in a lateral $MoSe_2$-$WSe_2$ junction.[2] The narrow depletion width indicates high internal electric fields, which may benefits separation of excited carriers. Despite strong Mo atom diffusion into the $WSe_2$ region, the depletion region width was found nearly symmetric (Figure 1 b), showing that unavoidable diffusion defects are tolerable in the lateral *p-n* heterojunctions.

## References


[1] Chun-I Lu, Christopher J. Butler, Jing-Kai Huang, Yu-Hsun Chu, Hung-Hsiang Yang, Ching-Ming Wei, Lain-Jong Li, and Minn-Tsong Lin, npj 2D Materials and Applications, 1 (2017) 24.

[2] Yu-Hsun Chu, Li-Hong Wang, Shin-Ye Lee, Hou-Ju Chen, Po-Ya Yang, Christopher J. Butler, Li-Syuan Lu, Han Yeh, Wen-Hao Chang, and Minn-Tsong Lin, Appl. Phys. Lett. 113 (2018) 241601.


## Figures

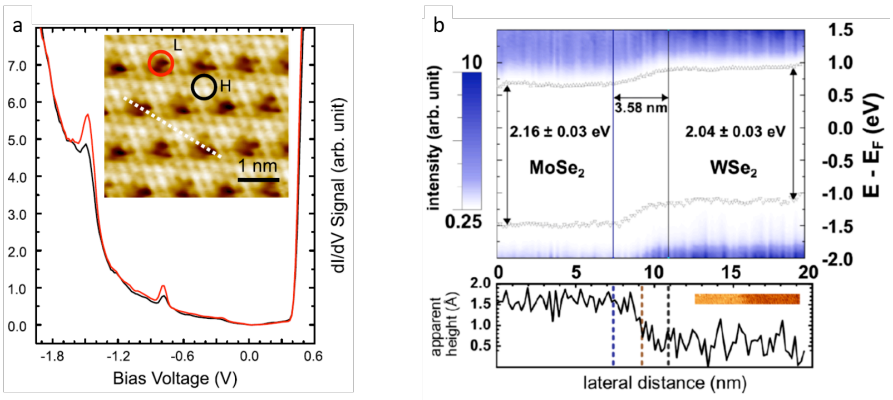


**Figure 1:** a: in-gap states depending on the location inside a moiré pattern on $MoS_2$. b: a band plot of the $MoSe_2$-$WSe_2$ lateral heterojunction.