Spatial Mapping of Excitons and Trions in 2D MoS_2

Heesuk Rho[1]

Hanul Kim[1], Young-Gui Yoon[2], Hayoung Ko[3], Soo Min Kim[3]

[1]*Department of Physics, Chonbuk National University, Jeonju 54896, Korea*

[2]*Department of Physics, Chung-Ang University, Seoul 06974, Korea*

[3]*Institute of Advanced Composite Materials, Korea Institute of Science and Technology (KIST), Wanju-Gun 55324, Korea*

rho@chonbuk.ac.kr

We report spatially resolved photoluminescence (PL) mapping results of CVD-grown layered MoS_2 in which a monolayer/bilayer (1L/2L) lateral interface is present [1]. Simultaneous analysis of atomic force microscope and Raman mapping results identified a skewed triangular-shaped 1L/2L lateral interface. Interestingly, spatially resolved PL intensity mapping over the 1L and 2L MoS_2 layers revealed that the neutral exciton emission was inhomogeneously enhanced in the 1L region near the 1L/2L boundary, whereas the negative trion emission remained unchanged (figures 1(a) and (b)). We used density functional theory (DFT) to calculate work functions of 1L and 2L MoS_2 surfaces on a SiO_2 substrate. The work function of 1L MoS_2 was smaller than that of 2L MoS_2. Therefore, transfer of electrons from the 1L to 2L MoS_2 should take place across the 1L/2L lateral interface to equilibrate the Fermi energies. Furthermore, DFT calculations showed that the work functions were strongly modulated by the terminal atoms of the MoS_2 edge (figures 2(a) and (b)). Therefore, the oscillatory behavior of the exciton PL intensity enhancement in the 1L MoS_2 region near the 1L/2L boundary was attributed to a non-uniform electrical potential distribution at the 1L/2L lateral interface.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (Grant No. 2019R1A2C1003366).

References

[1] H. Kim, Y.-G. Kim, H. Ko, S. M. Kim, H. Rho, 2D Materials, 6 (2019) 025004.

Figures

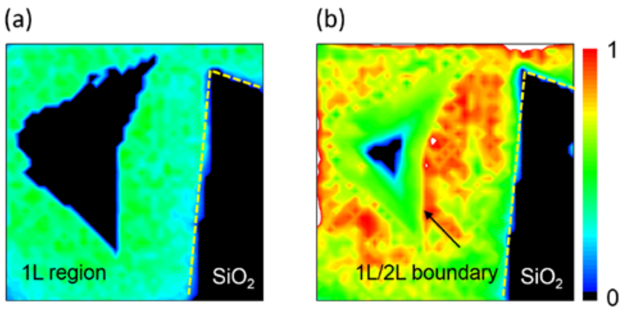

Figure 1: (a) Integrated PL intensity maps of (a) the negative trion and (b) the neutral exciton peaks of CVD-grown layered MoS_2 on the SiO_2 substrate. The thickness of the center region is ~50 nm. The trion emission was only observed in the 1L region. The dashed line denotes the boundary between 1L MoS_2 and SiO_2. The arrow denotes the 1L/2L boundary.

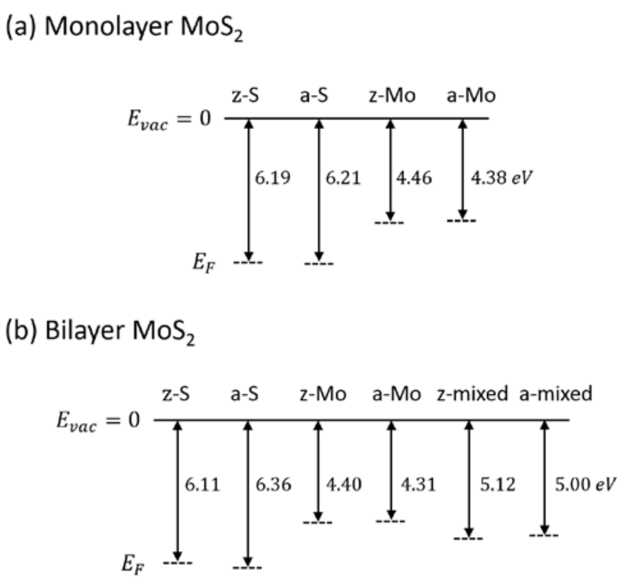

Figure 2: Calculated work functions of the zigzag and antenna edges with the S- and Mo-terminations for (a) 1L and (b) 2L MoS_2. Mixed terminations, whose outer edge atoms are both S and Mo, are additionally considered in the case of 2L MoS_2.