Heterogeneous defect domains in h-WS_2

Youngjo Jin
Hye Yun Jeong, Seok Joon Yun, Jiong Zhao, Jaeyoon Baik, Dong Hoon Keum, Hyun Seok Lee*, and Young Hee Lee*

Center for Integrated Nanostructure Physics (CINAP), Institute for Basic Science (IBS), Department of Energy Science, Sungkyunkwan University, 16419, Suwon, Republic of Korea

hs.lee@skku.edu; leeyoung@skku.edu

Although intricate defects are inevitably generated during the synthesis of transition metal dichalcogenides by chemical vapor deposition (CVD), the related discussions are mostly limited to chalcogen vacancies.[1-3] Here, we report the prevailing role of metal vacancies determining macroscopic material properties using a single-crystalline monolayer 2H-WS_2 grown by CVD. The hexagonal shape of the WS2 flake is segmented into alternating triangular domains without forming explicit defective grain boundaries: sulfur-vacancy (SV)-rich and tungsten-vacancy (WV)-rich domains. The WV-rich domain with deep-trap states[4-6] revealed an electron-dedoping effect, and its electron mobility and photoluminescence were lower by one order of magnitude than those of the SV-rich domain with shallow-donor states.[7] The vacancy-induced strain and doping effects in such domains were investigated by analyzing spectral changes via Raman spectroscopy and the core-level shift via scanning photoelectron microscopy. Our work sheds light on tailoring macroscopic physical properties of two-dimensional materials via native defect engineering.

References

[1] I. S. Kim, et al., ACS Nano, 8 (2014) 10511
[2] H. V. Han, et al., ACS Nano, 10 (2016) 1454
[3] H. Li, et al., Nat. Mater., 15 (2016) 48
[4] H. P. Komsa, et al., Phys. Rev. B, 91 (2015) 125304
[5] S. Haldar, et al., Phys. Rev. B, 92 (2015) 235408
[6] J. Kunstmann, at al., arXiv:1606.00347
[7] W. Zhou, et al., Nano Lett., 13 (2013) 2615

Figures

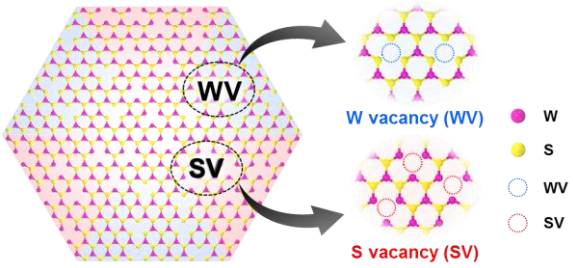

Figure 1: Schematic of heterogeneous defect domains in h-WS_2

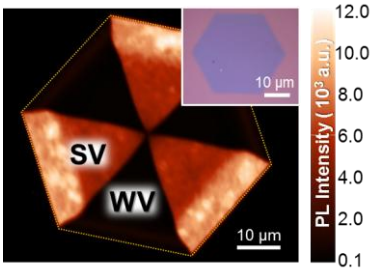

Figure 2: Photoluminescence intensity mapping image of h-WS_2. Inset shows its optical image.