STM observation to double hetero junction of TMDC monolayer made by MOCVD

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Transition metal dichalcogenides (TMDCs) have been attracting considerable attention because of their desirable physical properties for semiconductor devices. pn junctions and quantum wells, which are essential building blocks for electronic and optoelectronic devices, have been realized by growth of lateral and vertical heterostructure based on a wide variety of TMDC such as MoS2, WS2, MoSe2, WSe2. Recently, Metal organic chemical vapor deposition (MOCVD) techniques has been developed for the growth of various TMDCs materials. Compared to the conventional powder precursor based CVD techniques, MOCVD is a highly controllable and reproducible process, and is suitable for large-area deposition [1]. In addition, we succeeded in making WS2/MoS2/WS2 double hetero junction by switching gas resources in MOCVD process, and this structure is expected to contribute to making electronic devices. However, atomic scale characterization related to point defects and impurities, which is essential for the growth of high quality films, has not yet been carried out for MOCVD grown TMDC.

In this study, we performed STM/STS measurements on WS2/MoS2 grown on graphite substrates by MOCVD. Fig. 1 shows large area STM image of WS2/MoS2 monolayer which contains double hetero junction. Fig. 2 shows a magnified view of monolayer region in Figure.1. The monolayer has two grain boundaries. Outer-boundary forms clean straight line, but inner-boundary has patterned indented surface due to alloy effects. We think we can control alloy effect by altering MOCVD process time. Further details will be discussed in the presentation. Further details will be discussed in the presentation.

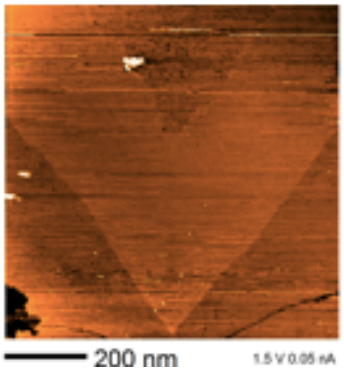

Fig .1; Large area STM image of WS2/MoS_2/WS2 monolayer

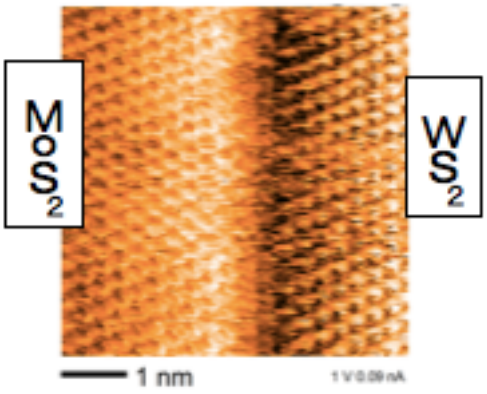

Fig .2; STM image on hetero junction.

[1] X. Liu and I. Balla, *J. Phys. Chem.,* **120**, 20798(2016).