Analysis of compositional variation in $Mo_{1-x}W_xS_2$ single layer heterostructure using STM

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In recent years, monolayer transition metal dichalcogenides (TMDs), which recently turn out to be direct bandgap semiconductors, have attracted much attention due to many remarkable physical properties such as efficient photoluminescence, high optical absorption coefficient, and high charge carrier mobility. The quasiparticle band gap of monolayer TMDs can be tuned with a wide range of 1.0eV to 2.7eV, by changing a combination of transition metal atoms (W, Mo, and etc) and chalcogen atom (S, Se, Te). Alloying further provides a way to continuous control of energy band gap. In addition, several groups have recently fabricated in-plane lateral heterostructures by making sharp compositional variation within monolayers. Thus, compositional analysis of such heterostructures with high spatial resolution is indispensable to make future 2D devices with desired functionality.

Here, we performed structural and compositional analysis of monolayer $Mo_{1-x}W_xS_2$ by using STM. The sample were grown by the high-temperature CVD as a source of MoO_3 and WO_3 on the graphite substrate. Fig.1 shows the image of monolayer $Mo_{1-x}W_xS_2$ island. The triangular shaped bright inner part is Mo-rich region, W-rich region is formed on the outer side. Atomically sharp abrupt heterojunction was observed at their interface. In inner Mo-rich region, one dimensional structure consisting of pure Mo is formed in a linear shape with several nanometer width (Mo-line). As shown in Fig.2, the Mo line was found to extend toward the corner from the center of Mo-rich region. Such Mo line were considered to be formed during growth process due to higher diffusion coefficient of Mo atom than that of W atom. Namely Mo atoms are selectively adsorbed to reactive corner of triangular island, which resulted in the formation of Mo line. Thus shape of Mo-line reflects a growth history. Such growth mechanism can be utilized toward making in-plane quantum structures inside monolayer TMDs.

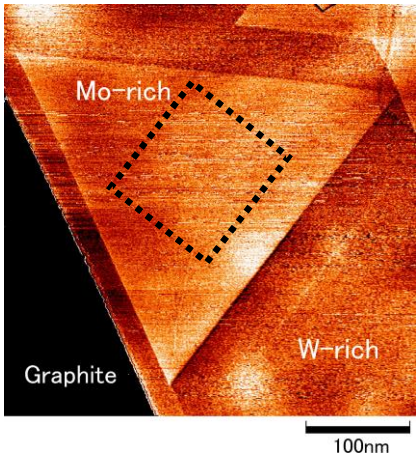

Fig.1 STM image of $Mo_{1-x}W_xS_2$ Island

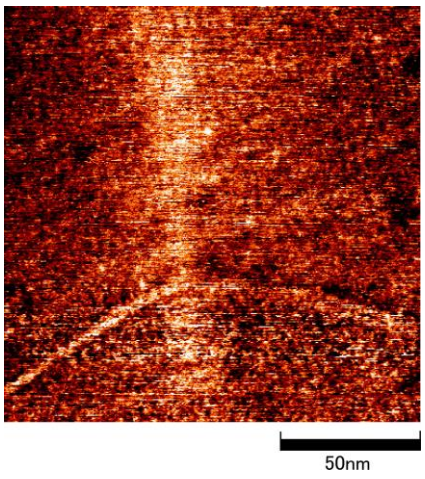

Fig.2 Mo-lines in central region of Mo-rich area (black square part of Fig.1)