Formation of MoS_2 nanowire in $Mo_{1-x}W_xS_2$ alloy monolayer studied by STM

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In recent years, transition metal dichalcogenides (TMDC) family such as MoS_2 and WS_2 has attracted much attention due to their remarkable optoelectronic properties. These monolayers have direct bandgaps[1] in the visible light range (MoS_2 : 2.4eV, WS_2 : 2.7eV), which can be continuously tuned by forming alloy structures. For example, by introducing compositional variations within these monolayers, band engineering and fabrication of lateral heterostructures were realized to obtain desired optoelectronic characteristcs and device functions[2].

Here, we performed structural and compositional analyses of monolayer $Mo_{1-x}W_xS_2$ lateral heterostructure by STM. The sample was grown by the high-temperature CVD on a graphite substrate. MoO_3 and WO_3 were used as a source. Figure 1(a) shows the image of monolayer $Mo_{1-x}W_xS_2$ lateral heterostrucure. The bright triangular area corresponds to a Mo-rich region and the surrounding darker area does to a W-rich region. An atomically sharp heterojunction was clearly observed at their interfaces in a monolayer. By further exploring the Mo-rich region, almost pure MoS_2 nanowire lines were observed (Fig.2). As shown in Fig.1(b), the MoS_2 nanowires were found to extend from the center to each corner of the Mo-rich triangular area. Formation of MoS_2 nanowire was comprehensively explained by assuming that Mo atoms is preferentially segregated at every corner of triangular monolayer during growth process, which is considered to be caused by the difference in diffusion coefficient between Mo and W atoms. Such segregation mechanism may open a new route to fabricate one-dimensional nanostructure in various alloy TMDC monolayers.

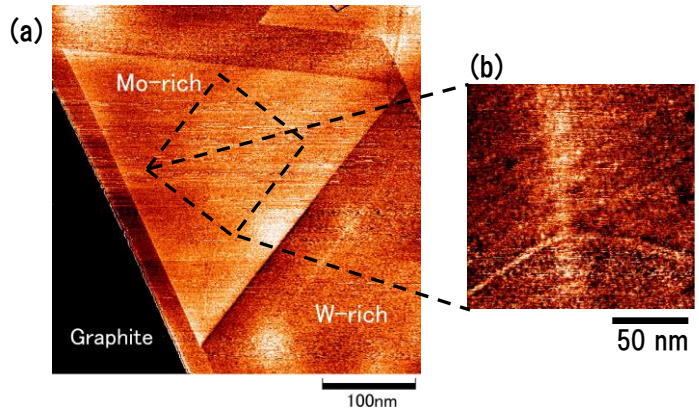

Fig.1 (a) Mo-rich area in $Mo_{1-x}W_xS_2$ monolayer (b) Magnification of the squared area in (a), showing the central region of the Mo-rich area

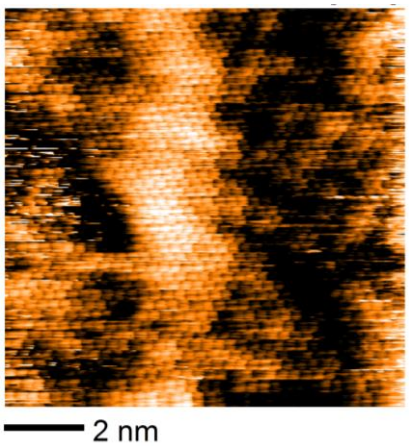

Fig.2 Atomically resolved image of a MoS_2 nanowire.

1. Gong, C. et al. *Appl. Phys. Lett.* **103,** (2013).
2. Y. Koyabashi et al., *Scientiic Reports*, 6, 31223 (2016). Yoshida et al., ibid., 5, 14808 (2015).