Synthesis of Molybdenum Disulfide Ribbons by Chemical Vapor Deposition in Sulfur Enriched Condition

Nagoya Institute of Tech., °Rakesh Mahyavanshi, Golap Kalita, Masaki Tanemura

E-mail: rmahyavanshi@gmail.com

Monolayer transition metal dichalcogenides (TMDCs) are the emerging class of two dimensional direct band gap semiconductors for future nanoelectronic, optoelectronic and catalytic applications. The chemical vapor deposition (CVD) technique has been explored for synthesis of uniform and high quality molybdenum disulfide (MoS_2) and other TMDCs. TMDCs monolayer ribbons are also of significant interest owing to its unique properties, however the growth of ribbon is quite challenging than the other crystals [1]. Here, we demonstrate an approach to synthesize MoS_2 ribbons and their branched structures.

The MoS_2 ribbons were grown by a CVD method on SiO_2/Si substrate with optimized experimental parameters. The synthesis was executed in two individually controlled quartz tube furnaces using argon (97%) and hydrogen (3%) gas mixture at atmospheric pressure. The sulfur (1 gm) boat and MoO_3 (0.01 gm) boat were placed inside the CVD quartz tube. SiO_2/Si substrate was kept face down on the MoO_3 powder holding boat, where the substrate position significantly influence the morphology of the MoS_2 crystals.

Figure 1 shows scanning electron microscope (SEM) analysis of the MoS_2 ribbons, branches and edge structures. Interestingly, all the ribbons possess uneven edge structures, where the edges are formed with angles of 60° and 120°, indicating variation in molybdenum and sulfur edge terminations. The growth of ribbons can be explained by surface diffusion limited process with low concentration of MoO_3 and enriched sulfur concentration [2, 3]. In the CVD process, the directional growth of the MoS_2 ribbon is achieved in presence of very low concentration of molybdenum precursor on the SiO_2/Si substrate surface.

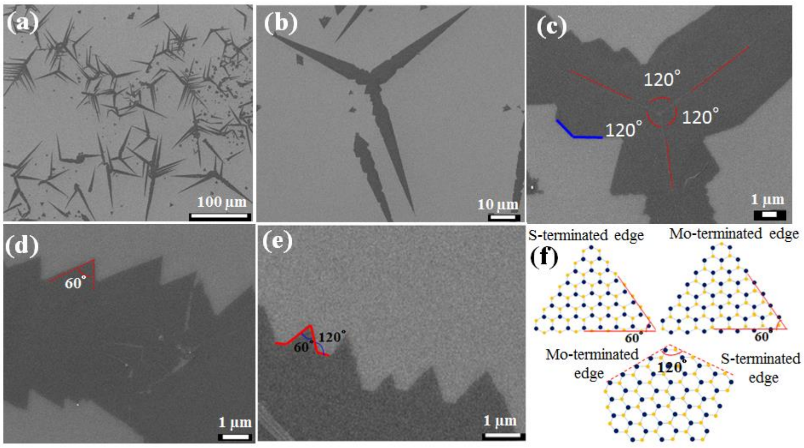

Figure 1. SEM analysis of the MoS_2 ribbons, branches and edge structures.

References:

[1] Y Li, et al. J. Am. Chem. Soc. 2008; 130: 16739-16744.

[2] J Lee, Nanoscale Res Lett. 2015; 10: 429.

[3] DH Jung, et al. Scientific Reports 2016; 6: 21136.