



Title	Growth of MoS ₂ Nanowires by Catalytic Chemical Vapor Deposition [an abstract of dissertation and a summary of dissertation review]
Author(s)	WENG, Mengting
Degree Grantor	北海道大学
Degree Name	博士(総合化学)
Dissertation Number	甲第13226号
Issue Date	2018-03-22
Doc URL	https://hdl.handle.net/2115/69946
Rights(URL)	https://creativecommons.org/licenses/by-nc-sa/4.0/
Type	doctoral thesis
File Information	Mengting_Weng_abstract.pdf, 論文内容の要旨



学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称 博士（総合化学） 氏名 WENG Mengting

学 位 論 文 題 名

Growth of MoS₂ Nanowires by Catalytic Chemical Vapor Deposition
(触媒を用いた化学気相成長法による MoS₂ ナノワイヤの成長)

Molybdenum disulfide (MoS₂) is receiving more and more attention due to its potential for a wide application in electronics, energy and catalysis field. Continuous efforts have been made to synthesize its monolayer, while little attention has been paid on its 1D nanostructures. Thus, in this thesis, I studied the synthesize MoS₂ nanowires. I found that it is possible by using catalytic CVD with FeO nanoparticles and established the methods to control the aspect ratio and growth density of the nanowires. Chapter 1 is the general introduction of the thesis and background of this study.

In Chapter 2, it was found that FeO nanoparticles could be the catalyst for the growth of MoS₂ nanowires in the iron and iron oxides group. The MoS₂ nanowires synthesized with the commercial FeO nanoparticles had the length of 9.6 μ m and the diameter of ≥ 150 nm. The catalytic activities of other transitional metal oxides nanoparticles (MnO, CuO, NiO and Cu₂O) were also searched. NiO and Cu₂O particles could promote the growth of MoS₂ nanowires but MnO and CuO could not. Among the catalyst particles examined, FeO had the best catalytic activity in the growth of MoS₂ nanowires by comparing the CVD results of these particles. The mechanism was discussed based on the existence of transition metal-Mo-S compounds with layered structure.

In Chapter 3, 30 nm six-horned FeO nanoparticles were successfully synthesized and used as the catalyst for the growth of MoS₂ nanowires. It was found that the MoS₂ nanowires synthesized with the 30 nm FeO nanoparticles had the length of 10 μ m and the diameter of 40 - 80 nm. The structure, chirality and growth mechanism of the nanowires were studied. The nanowires were multilayered and had a hollow structure. The cross section was in rectangular shape and the end was closed. By the analysis of the TEM diffraction, the direction of S-S (or Mo-Mo) nearest neighbor was parallel to the direction of the nanowires, indicating that the structure of the nanowires was armchair structure. The growth mechanism of the nanowires was proved to be vapor-solid (VS) growth based on the structure analysis of the nanowires and some extra experiment results. The nucleation sites of the nanowires were formed by the deposition of MoS_x on the surface of the catalyst nanoparticles and the MoS₂ nanowires would be further grown by the continued supply of the precursor materials.

In Chapter 4, size and shape control of the FeO nanoparticles and their effect on the morphology and composition of the CVD products were studied. Firstly, it was found that the size and shape of the nanoparticles could be controlled by regulating the decomposition conditions, such as the composition of the mixture, the decomposition temperature and time, and the stirring. Then, by controlling the shape of the catalyst nanoparticles, a switching between SiO_x nanowires and MoS₂ nanowires was observed. In the presence of spherical FeO catalyst nanoparticles, SiO_x nanowires were obtained, while in the presence of six-horned octahedral catalyst nanoparticles, MoS₂ nanowires were formed. It was proved that SiO_x nanowires grew in vapor-liquid-solid (VLS) growth mechanism, attributed to the formation of FeO-FeS system. The eutectic point of the FeO-FeS system is 944 °C (lower when the particle size smaller), lower than the growth temperature (1000 °C) of MoS₂ nanowires. When the size of the nanoparticles increased, it is difficult to form the FeO-FeS system due to the decrease in surface to volume ratio. When the shape turned from spherical to six-horned octahedra, the acute angles and the sharp edges of the nanoparticles promoted the deposition of MoO₃, leading to the growth of MoS₂ nanowires in VS growth mechanism. Finally, the size effect

of the nanoparticles was studied. By controlling the size of the FeO catalyst nanoparticles, the composition and structure of the nanowires were not changed with the increased size in catalyst nanoparticles while the aspect ratio and the growth density became lower when the size of the nanoparticles increased.

In Chapter 5, other factors to control the growth of MoS₂ nanowires were studied, such as the substrate surface, the growth temperature and time. The substrate surface was treated in order to improve the growth density of MoS₂ nanowires with various methods. The plasma etching and the porous carbon coating methods could promote the desorption of FeO catalyst nanoparticles, while the Al₂O₃ deposition and chemical etching of the substrates did not facilitate the catalyst particle desorption, but even hinder the growth of MoS₂ nanowires. By setting the growth temperature and time, it was found that the aspect ratio of the MoS₂ nanowires could be controlled.

Chapter 6 is the general conclusions of this thesis.