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Epitaxial Growth, Chemical Doping and Electronic Applications of Two-Dimensional Transition Metal Dichalcogenides

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論　文　内　容　の　要　旨

Thesis Summary

Graphene is a single layer of carbon sheet and has attracted a great attention due to its unique and interesting physical properties. Having atomically thin two-dimensional structure, graphene is mechanically flexible and transparent. Also, graphene has very high electrical conductivity and good thermal conductivity. However, because of the zero-gap nature of graphene, there is a limitation in applications of graphene so that researchers started to look for new semiconducting two-dimensional materials. Thus, transition metal dichalcogenides, which are called TMDs, have attracted a great interest. Similar to graphene, TMDs also have an atomically thin two-dimensional structure where a single layer of transition metal (W, Mo) sheet is sandwiched by single layers of chalcogen (S, Se) sheets. Having sizable and direct band gaps when in single layer (< 1 nm in thickness), TMDs show interesting optical and electrical properties, and their promising applications in various field such as for energy harvesting, sensing and logic circuits have already been proved by active research.

In this thesis, chemical vapor deposition (CVD) growth of TMDs and their electronic applications are investigated. By changing and investing the influence of CVD growth parameters, the growth mechanism of TMD crystals by CVD method is studied. In addition, by using chemical doping method, the electrical transport properties of CVD-grown TMDs are selectively controlled and their electronic applications are demonstrated.

This thesis covers six chapters. In Chapters 1 and 2, introduction and background of physical properties and preparation methods of TMDs are explained. In Chapter 3, use of H_2 carrier gas for CVD growth of WS_2 is introduced and the resultant epitaxial growth and improved crystal quality are discussed. In Chapter 4, investigation of the influence of c-plane sapphire on growth of WS_2 is presented. In Chapter 5, chemical control of electrical property of CVD-grown TMDs is presented. By using two different chemical dopants, electrical transport polarity of WSe_2 is selectively controlled to p- and n-type, and their applications to complementary metal-oxide-semiconductor inverter as well as p-n junction are demonstrated. In Chapter 6, the thesis is closed with conclusions and the future outlook of the research of 2D materials is presented.