論 文 の 内 容 の 要 旨

論文題目　**Synthesis and structure characterization of one-dimensional van der Waals heterostructures**
（一次元ファンデルワールスヘテロ構造の合成と構造評価）

氏　　名　　鄭　永嘉

Low dimensional materials have been intensively studied recently. More and more researchers have been focusing on acquiring new properties by manipulation materials in nanoscale level. The term heterostructure usually refers to the combination of two or more materials along with interesting properties. Such structures play an important role in modern nanotechnologies, which requires advanced material growth techniques.

Compared to traditional heterostructures in which different materials are epitaxially grown, two-dimensional (2D) layered materials that weakly bonded by van der Waals (vdW) forces have attracted scientists' attention as they provide a new perspective to manipulate materials into heterostructures with no lattice matching. However, such vdW heterostructures are realized mostly in planar-based structure, while one-dimensional (1D) vdW heterostructures have not yet been deeply studied. In this dissertation, we will start with some of the most investigated 1D and 2D materials, such as metallic graphene, insulating hexagonal boron nitride (h-BN) and semiconducting MoS_2, followed by a discussion of vdW heterostructures with their combination. This will provide the foundation of the true 1D vdW heterostructures we proposed in this dissertation.

High quality of 1D vdW heterostructures were evaluated and confirmed by different method, such as absorbance, Raman spectrum, SEM, TEM, EELS, ED pattern, etc. Binary structure in SWCNT-BNNT and SWCNT-MoS2 order were characterized, and ternary structure in SWCNT-BNNT-MoS_2 was further

demonstrated. Formation mechanism of 1D vdW heterostructures was deeply discussed with the open-end-chiral growth, the effect of nucleation sites, and three kinds of growth models. The high quality of 1D heterostructure structures allows for further experimental exploration of properties. Some preliminary experiments for new phenomena were also given in terms of thermal, optical, and electronic characteristics. We believe there is a great prospect for these new structures as they extended the concept of vdW heterostructures to 1D materials.