Preparation and investigation of intrinsic electronic and optical properties of individual structure-identified nanostructures: double-wall carbon nanotubes and two-dimensionale atomic layers

Abstract

Ever since the exciting discoveries of Buckyballs (C_{60} fullerene) and carbon nanotubes (CNTs) in the 1980s and 1990s, the study of nanomaterials and nanoscience has been attracting considerable research interest in the field of material science. In 2004, researchers at the University of Manchester successfully isolated the first one-atom-thick two-dimensional (2D) material, graphene, which opened new avenues of extensive research on the properties of 2D materials.

In this dissertation, I will provide a very general introduction to nanomaterials by presenting some representative examples while emphasizing on the intriguing and unique properties of those materials that are qualitatively distinct from conventional three-dimensional (3D) materials. The nanomaterials that will be discussed in this dissertation include one-dimensional (1D) CNTs, 2D graphene, and 2D layered transition metal dichalcogenides (TMDCs). The properties of nanomaterials are sensitive to the specific physical structures and environments. Consequently, to investigate the intrinsic physical and chemical properties, it is essential to prepare discrete nanomaterials with well-defined structures while simultaneously controlling the environment.

In order to understand the properties of nanomaterials more thoroughly, I have been working on the preparation of individual nanostructures (*e.g.*, CNTs, TMDCs) and probing the fundamental relationship between structure and function. The elucidation of one-to-one structure–property correlations enables us to more clearly understand the fundamental underlying

mechanisms that lead to the unique properties. Here, I will present the details of my primary research results from the past several years in the following chapters: Probing the effect of van der Waals interaction on the electronic structures in individually suspended double-wall carbon nanotubes, direct growth on hexagonal boron nitride (hBN), optical identification and transport properties of 2D layered metallic TMDCs (NbS_2). Finally, an introduction and progress report of my ongoing research project will be briefly described.