

Carbon Nanotubes and Their Applications, by Qing Zhang, Pan Stanford Publishing, Singapore, 2012.

Nanomaterials and nanotechnology are of increasing interest in a wide range of industries ranging from electronics and structural composites to pharmaceuticals and medical applications. Carbon nanotubes (CNTs) are an outstanding member (together with graphene) of the carbon family of nanomaterials. Their crystal structures are close to that of graphite and a single layer of graphene is formed by unfurling a single walled nanotube (SWCNT). CNTs have attracted not only extensive fundamental research but also interest in applications from both big and small businesses. A number of products, particularly in the area of polymer nanocomposites, have appeared in the market although many areas, such as those discussed in this book, though revolutionary still remain embryonic in terms of real world applications. For example, in the area of electronics, the difficulty of controlling the structural chirality of SWCNTs during synthesis necessitates the difficult task of separating conducting and semiconducting nanotubes, which poses a significant challenge to the development of electronic devices, such as nanotube-based transistors.

This edited book brings together 16 state-of-the-art chapters written by different groups covering most areas of CNT research and technology. It will be a valuable reference work and an important addition to the CNT literature, and will appeal to scientists and engineers involved with nanomaterials, nanodevices, and fabrication at the nanoscale level. Chapter 1 deals with the fundamental properties of carbon nanotubes. It discusses details about the bonding between the CNT carbon atoms, structure of single wall carbon nanotubes (SWCNTs), for example, the classification of SWCNTs, electronic structure of SWCNTs starting with that of graphene and advancing to that of CNTs, phonon modes of CNTs starting with the dispersion of modes in graphene to those in CNTs, and optical properties of CNTs involving discussion of selection rules and excitons. Chapter 2 deals in some detail with the synthesis, both laboratory scale and large scale using fluidized bed methods, of CNTs. Some readers, however, may have to consult a few of the comprehensive references given for more details. Chapters 3 and 4 deal with the assembly of nanotubes particularly in the form of polymer nanocomposites and the separation of metallic and semiconducting CNTs, respectively. Chapters 5

discusses electronic applications of SWCNTs—for example, field effect transistors (FETs) and logic circuits, Schottky-contact FETs, ohmic contact FETs, and the performance limit of CNT-based FETs. Other areas considered in Chapter 5 are single electron transistors and circuits, and memory and other electronic devices. Chapter 6 deals with high frequency applications of CNT electronics, Chapter 7 considers the status and trends in bulk and CNT tunneling FETs, and Chapter 8 provides details about transistors based on CNT networks. The latter chapter reviews methods of sorting CNTs by electrophoresis, polymer wrapping, DNA wrapping and selective functionalization, and the use of ultracentrifugation, debundling, and selective removal of metallic tubes to create SWCNT networks. Chapter 9 deals with CNT field emission technology for vacuum electronic device applications with the potential for rapid commercialization. Chapter 10 stands apart from the rest of the book in revisiting the controversial area involving magnetic and electrical properties suggesting ultrahigh temperature superconductivity in nickel particles embedded in multiwalled CNTs. Chapter 11 is focused on a review of work on CNT based biosensors which has sections on the electrochemical properties of CNTs and functionalization of CNTs. Chapter 12 is a review of work on the use of CNT FETs as gas sensors with a section on the methods that can be used to enhance the selectivity of these devices. Chapters 13–15 deal with viscoelastic applications, the fabrication of microscopic to macroscopic CNT fibers, and mechanical applications in resonators and actuators, respectively. The final chapter reviews work on the nonlinear properties of SWCNTs which stem from their estimated ultrahigh third order nonlinearity originating from interband transitions involving the π -electron system of the CNTs.

The book is a rich compilation of reviews on various aspects of CNT research and technology, and will benefit academics, students and scientists/engineers in government and industrial laboratories interested in nanomaterials and associated nanotechnologies. In this regard, a chapter on applications related to the extremely high thermal conductivity of the CNTs would have been useful, particularly to those who work in industry. The book would not be useful as a primary teaching tool but can be used as supplementary reading for graduate students, and portions can be selected by an instructor for an upper level undergraduate or graduate course on nanomaterials.