【156】

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論文の内容の要旨

The discovery of carbon nanotubes (CNTs) in 1991 stimulated intense interest to such structures due to their unique nanoscale hollow channels and novel properties. Boron Nitride nanotubes (BNNTs) - one of the most interesting non-carbon nanotubes - have revealed many excellent properties which in many respects are superior to those of CNTs. In fact, the Young's modulus and thermal conductivities of BNNTs and CNTs are compatible, but BNNTs have a distinguishing wide bandgap of ca. 5.8 eV, basically independent of the tube geometry/morphology. In addition, the oxidation and thermal resistances of BNNTs are much higher than for of CNTs. Such unique characters make BNNTs promising in a wide range of potential applications. In spite of the bright future of BNNTs, the progress in their research has been rather modest to date, especially being compared with CNTs. Such situation is primarily a result of the significant difficulties involved in the preparation of BNNTs at high quantity and quality, e.g. pure BNNTs with ultrathin diameters. 0n the other hand, as BNNTs possess high chemical stability at ambient conditions, the surface functionalization of BNNTs is not that easy. Such functionalization is a very important step in tailoring the properties of BNNTs and their real utilization in the Nanotechnology. The dissertation entitled "Synthesis, Functionalization and Properties of Boron Nitride Micro/Nanotubes" has taken into account all the pre-existing restrictions/limitations of the BNNT researches and focused on the development of the tube diameter-controllable synthesis and novel surface functionalization of BNNTs, with the aim of exploiting their superior properties towards prospective applications. The whole dissertation includes five Chapters as follows: Chapter 1. Introduction; Chapter 2. Ultrafine Boron Nitride Nanotubes: Large-Scale Preparation and Property studies; Chapter 3. Thin-walled BN/BCN Microtubes; Chapter 4. Surface Functionalization of Boron Nitride Nanotubes and Properties of Functionalized Tubes; Chapter 5. Conclusions.

Chapter l describes the research background and motivation of this study. It starts with the introduction of the latest achievements in BNNT structure analysis, synthesis, and property evaluations: Then the current research status and challenges in the BNNT field are discussed. Finally, the purpose and significance of this study are presented.

Chapter 2 develops a novel precursor for the synthesis of bulk amounts of pure and thin BNNTs. The morphology, structure and composition of the ultrafine BNNTs are examined using X-ray diffraction, scanning and transmission electron microscopy, etc. A detailed growth mechanism is proposed. Then the thermal, electrical, optical and mechanical properties of the BNNTs are intensively studied. Similarities and differences between structural parameters and properties of synthesized ultrafine BNNTs in comparison with conventional, large diameter BNNTs are particulariy highlighted.

Chapter 3 explores the fabrication of microscale diameter BN tubes with thin walls via a vapor-liquid-solid and template self-sacrificing process. CL measurements on thin-walled microtubes are carried out to study their optical properties. The UV emission, including near-band-edge emission and impurity or/and the defect-related emission, are discussed. Then through modifying the synthesis method, B-C-N ternary microtubes are also fabricated. A comparison between BN and BCN microtubes, especially in regard of their structures, and CL and. field-emission properties, is made.

Chapter 4 develops an ethanol-thermal method to achieve surface functionalization of BNNTs. Through this simple and universal method, diverse metal oxide were coated on the surface of BNNTs, such as Fe_30_4, CeO_2, Cu_2O,Tb_2O_3,La_2O_3, Nd_2O_3 and $Tb_xCe_yO_z$., etc. A coating mechanism is deduced based on the detailed study of Fe_3O_4 coated BNNTs nanocomposites. The magnetic behavior of Fe_3O_4/BNNTs nanocomposites and optical properties of Tb_2O_3/BNNTs nanocomposites are presented.

Finally, Chapter 5 summarizes all the results and provides future perspectives and outlook of the BNNT research.

審 査 の 結 果 の 要 旨

本博士論文は、窒化ホウ素ナノチューブに関する研究･開発において近年問題となっている事柄について、網羅的に記述している。特に、窒化ホウ素ナノチューブの直径を小さく、かつチューブ壁を薄くする試み、さらに、窒化ホウ素ナノチューブの表面を磁気的、光学的に活性のある材料で修飾し新しい機能を付加する試みにおいて、ナノチューブ研究者の着目を集める特筆すべき結果をもたらしている。これらの成果は、窒化ホウ素ナノチューブの物性を、必要に応じて操作したり調整したりする、優れた手法を提供するものである。また、これにより、最新ナノテクノロジーの中で、窒化ホウ素ナノチューブという特異な材料の実用化に大きく前進したと言える。本著者は、本研究に関連する実験・理論の両面において十分な知識を持っており、かつ、優れた問題解決能力、高度な合成・解析技術、論文作成技量を有していることを、本博士論文によって示している。さらに付け加えると、本著者は本博士論文の中で、今後の研究課題に対して幅広く、かつ深遠なアイデアを持っていることも示している。

よって、著者は博士（工学）の学位を受けるに十分な資格を有するものと認める。