Available online at www.sciencedirect.com
ScienceDirect
Materials Research Bulletin 43 (2008) 2517–2526
Materials Research Bulletin
www.elsevier.com/locate/matresbu

Review

Recent advances in carbon nanotube-based electronics

Prithu Sharma *, Prerit Ahuja

Indian Institute of Technology Madras, Chennai 600036, India

Received 10 December 2006; received in revised form 24 June 2007; accepted 18 October 2007
Available online 23 October 2007

Abstract

CNT-electronics is a field involving synthesis of carbon nanotubes-based novel electronic circuits, comparable to the size of molecules, the practically fundamental size possible. It has brought a new paradigm in science as it has enabled scientists to increase the device integration density tremendously, hence achieving better efficiency and speed. Here we review the state-of-art current research on the applications of CNTs in electronics and present recent results outlining their potential along with illustrating some current concerns in the research field. Unconventional projects such as CNT-based biological sensors, transistors, field emitters, integrated circuits, etc. are taking CNT-based electronics to its extremes. The field holds a promise for mass production of high speed and efficient electronic devices. However, the chemical complexity, reproducibility and other factors make the field a challenging one, which need to be addressed before the field realizes its true potential.

Keywords: A. Nanostructures; B. Vapor deposition; C. Atomic force microscopy; D. Electrical properties; D. Thermal conductivity

Contents

* Corresponding author. Tel.: +91 9840286464; fax: +91 44 22574752.
E-mail addresses: prithu129@gmail.com, prithu@iitm.ac.in (P. Sharma).

0025-5408/$ – see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.materresbull.2007.10.012

1. Introduction

In 1991 Iijima synthesized new type of fullerenes, quasi-one-dimensional crystalline structures of carbon atoms, generally referred to as carbon nanotubes [1]. A nice thing about nanotechnology is that as we look into the options, they expand and become truly incredible. Nanotubes are promising building blocks for nanoscale electronic circuits, and they possess novel properties due to their small sizes, which offer exciting possibility for smaller and faster devices with better performance. In the rapidly developing field of nanotechnology – doing things at a scale 100,000 times narrower than a human hair – nanodevices are becoming an increasingly key component in everything from drug delivery to improving or even replacing the microprocessors in computers or optical switches in telecommunications networks. Nanotubes, tiny hollow carbon filaments about one ten-thousandth the diameter of a human hair, are already famed as one of the most versatile materials ever discovered. A hundred times as strong as steel and one-sixth as dense, able to conduct electricity better than copper or to substitute for silicon in semiconductor chips, carbon nanotubes have been proposed as the basis for everything from elevator cables that could lift payloads into Earth orbit to computers smaller than human cells. Increasing efficiency through smaller components is the key towards miniaturization of technology. The use of carbon nanotubes could find successful use from sophisticated, niche applications to everyday electronics.

2. Approaches

2.1. Engineering carbon nanotubes and nanotube circuits

A simple and reliable method has been demonstrated for selectively removing single carbon shells from MWCNTs and single-walled nanotube (SWCNT) ropes to tailor the properties of these composite nanotubes is called electrical breakdown. Different shells of MWCNTs can be characterized individually by removing the shells stepwise. By choosing among the shells, we can convert a MWCNT into either a metallic or a semiconducting conductor, as well as directly address the issue of multiple-shell transport. With SWNT ropes, similar selectivity allows us to generate entire arrays of nanoscale field-effect transistors based solely on the fraction of semiconducting SWCNTs [2].

2.2. Manipulating CNT

The successful integration of SWCNTs with the current silicon infrastructure is critical to ensuring the economic success of nanotube-based electronics. Prior to large-scale integration, though, the fundamental physical properties of