



Optical properties of nanotubes / Propriétés optiques des nanotubes

Foreword

A nanoworld of tubes: Opto-electronic applications of carbon nanotubes

Since their emergence in 1991, carbon nanotubes have attracted an intense worldwide research effort because of the combination of various effects: their structure is very simple and very stable, they are easy to synthesize and, above all, they display unique physical and chemical properties due to their reduced dimensionality. It can be emphasized that single walled carbon nanotubes are not only model systems for understanding at a fundamental level electronic properties of 1D systems but also very promising candidates for a wide range of nanoscience and nanotechnology applications.

This special issue of the *Comptes rendus de l'Académie des sciences* proposes an overview of the recent development of applications aiming at exploiting the physical properties of carbon nanotubes, by enlightening the research works done at an international level. We see it as an opportunity to gather, in a single volume, papers which illustrate how nanotubes are opening up opto-electronic applications.

Up to now, the carbon nanotube technology has reached a high maturity, be it for the synthesis techniques or post-synthesis manipulations (purification, sorting, deposition and further process). Indeed, the synthesis (by arc-discharge, laser ablation, chemical vapor deposition, etc.) of carbon nanotubes at a large scale with high quality and at a large scale is the basis to allow further studies on their properties and applications. This comes along with the widespread use of ensemble systems such as carbon nanotube disordered films, instead of individual carbon nanotubes, which are required in a large variety of applications. Besides, such breakthroughs as the sorting (metal and semiconductor) and chemical functionalization of carbon nanotubes add a further and useful degree of freedom.

This paves the way to new kind of applications, particularly in the opto-electronic domains, e.g. for the generation, the propagation control or the detection of light. For instance, the bolometric properties of carbon nanotube films have been discovered recently, while their efficient and broadband absorbance and efficiency in the infrared spectrum is still under study. Several families of devices are now emerging at the wide level: gas sensing, electronic circuitry, light emission, light detection. It must also be emphasized that an optical gain has recently been reported in carbon nanotube films. This drives high promises that future integrated photonic and opto-electronic devices could make use of the original and interesting properties of carbon nanotubes.

Let us conclude by this fact: so far, the research in carbon nanotube technology is mainly made by State organizations (in France: ONERA, the French aerospace lab, the Centre national de la recherche scientifique CNRS, the Commissariat à l'énergie atomique CEA; in America: the National Aeronautics and Space Administration NASA, the defence research and development Canada DRDC; in China: the Institute of Metal Research IMR of the Chinese Academy of Sciences; in Japan: the National Institute for Materials Science NIMS...). Nevertheless, some start-ups and small companies are bridging the gap with the industrial world (Nanomix, NanoIntegris...). May their example inspire the largest number and blow some innovation spirit into the carbon nanotube scientific community worldwide. Clearly, even if further effort is still to be done on the particular understanding and study of their optical and electronic properties, carbon nanotubes are already used in the conception and realization of opto-electronic devices.

This special issue of the *Comptes rendus* illustrates how one can grow, purify, sort, deposit, electrically contact, etch, include carbon nanotubes in a clean-room process, and make use of their properties in order to realize an operating device. It has developed from the minutes of a workshop entitled:

ONERA Scientific Days

A nanoworld of tubes: opto-electronic applications of carbon nanotubes

held in Châtillon, near Paris, on April 8th and 9th 2010, under the auspices of ONERA the French aerospace lab, the CNRS (French national research council), the GDRI Nanotubes and Graphene, the SFO (French optical society), CNano and the *Académie des sciences*.

The talks given at this workshop reflected the various aspects of the current technological state of carbon nanotubes.

- Synthesis and deposition: Hui Ming Cheng (IMR, China)
- Mass spectroscopy and electro-mechanical devices: B. Lassagne (CNRS/LPCNO, France)
- Two-dimensional carbon nanotube random networks: J.-C.P. Gabriel (CEA, France)
- Opto-electronic properties of CNTs: Ph. Mérel (RDDC, Canada)
- CNT synthesis for interconnects: H. Okuno (CEA/Liten, France)
- Carbon nanotubes based field-effect transistors: P. Bondavalli (Thales/TRT, France)
- Gas sensors: O. Ducloux (ONERA, France)
- Carbon nanotubes as sensors for infrared light: Ch. Koechlin (ONERA & LPN, France)

We wish you a pleasant and fruitful reading.

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