Preface

This volume is based on some representative contributions presented in the workshop: "Trends in nanophysics: theory, experiment, technology", which took place in Sibiu, Romania, 23–29 August 2009, being organized by ICTP-Trieste, IAEA, IFIN-HH – Bucharest and ULB – Sibiu. The aim of this workshop was to facilitate experts and active researchers to exchange ideas and information on the most recent results in nanophysics and nanotechnology. It was also an opportunity for young researchers and for researchers from developing countries to enlarge their knowledge and to approach new themes in this area.

In fact, the articles contained in this book represent written and enriched versions of the workshop oral presentations. The topics covered by them are the following:

1. Ordered atomic-scale structures
2. Nanowires: growth and properties
3. Transport phenomena in nanostructures
4. Optical properties of nanostructures
5. Magnetic nanophases; magnetic and non-magnetic nanocomposites
6. Nanofluids and flows at nanoscale

1 Ordered Atomic-Scale Structures

The quest of a reliable method for fabricating ordered atomic-scale structures is a prerequisite for future atomic-scale technology – the ultimate goal of nanosciences. In his lecture devoted to this subject, Schneider reviews selected examples concerning atomic and supra-molecular self-assembly investigated by low temperature scanning tunneling microscopy: two-dimensional arrays of individual Ce atoms on a metal surface; the behaviour of the superconductor energy gap in ultra-thin Pb islands and the conservation of chirality in a hierarchical supra-molecular self-assembly of pentagonal symmetry of rubene on an Au surface. Another key issue for the success of many nanotechnologies is our ability to understand the mechanics of nano-objects, such as nanotubes and nanobelts. Dumitrica's contribution is devoted to an ingenious symmetry-adapted atomistic scheme, based on a quantum-mechanical description of chemical bonding, that performs calculations under

helical boundary conditions. As an application, the nanomechanical response of carbon nanotubes and thermodynamical stability of silicon nanowires are obtained.

2 Nanowires: Growth and Properties

Growths and properties of nanowires are a central issue of nanoscience and nanotechnology. Lakhtakis's paper presents a new class of assemblies of nanowires, named sculptured thin films, that can be fabricated typically via physical vapor deposition onto rotating substrates. Their optical properties can be tailored by varying their morphology. The optical, thermal, chemical, and biological applications of sculptured thin films are reviewed. Stoica's contribution is focused on growths and optical properties of an important class of semiconductor nanowires – GaN and InN ones, obtained by self-assambling, with a catalist-free molecular beam epitaxy technique. The optoelectronic properties, as well as the influence of surface effects on the growth and properties of these nanowires are carefully analyzed.

3 Transport Phenomena in Nanostructures

The permanent requirement of shrinking the semiconductor devices in integrated circuits request a good understanding of transport phenomena in nanostructures. A comprehensive review of such topics is given in the presentation of Kuhn and Paraoanu, devoted to electronic and thermal sequential transport in metallic and superconducting two-junction arrays. The authors analyse Coulomb-blockade thermometers, superconductor-insulator-normal-insulator-superconductor structures, and superconducting single-electron transistors. Racec et al. present a general theory of multi-channel scattering for a general two-dimensional potential, based on the R-matrix formalism; it allows a semi-analytical treatment of the problem, and yields a powerful and efficient numerical method, with applications to nanostructures with quantum dots. In the review of Nemnes et al., planar nanoscale transistors and cylindrical nanowire transistors are analyzed in the framework of coherent transport. The Landauer-Buttiker formalism is efficiently implemented using also a R-matrix approach. The advantages of new geometries, like the cylindrical nanowire transistors, are discussed. As charge fractionalization has been observed experimentally in quantum wires, this fundamental phenomenon deserves special attention. In his lecture, Leinaas discusses the issue of fractional charge and statistics in Luttinger liquids – one of the most popular models describing one-dimensional systems of fermions.

4 Optical Properties of Nanostructures

If trapping and moving of dielectric nanoparticles with laser beams constitute a well understood issue, the situation of metallic nanoparticle is quite different. In Prof. Crozier's contribution, it is explained how the propulsion of gold nanoparticles by

surface plasmon polaritons was demonstrated experimentally. The optical forces are enhanced, due to the field enhancement provided by plasmon polaritons and near-field coupling between the gold particle and the film. The plasmon spectra of plasmons excited in metallic nanoparticles and nanowires are discussed also in a theoretical paper, by Villo-Perez, Mišković, and Arista. They apply Bloch's hydrodynamic model of an electron gas to describe plasma excitations in thin metallic films, obtaining a good description of the excitation, propagation and decay of bulk and surface modes, in different geometries. A two-fluid model, in which the σ and π electrons of carbon are the constituents of these fluids, is used in order to obtain the plasmon spectra in carbon nanotubes.

5 Magnetic Nanophases; Magnetic and Non-Magnetic Nanocomposites

Nanomagnetism is important for both fundamental and applicative reasons. Functionalized nanocomposites consisting of magnetic nanoparticles (Co, Fe), embedded in dielectric matrices, have a significant potential for the electronics industry. In the contribution of Timonen et al., the theory of such materials is reviewed; also, the authors present a novel measurement method used for the characterization of the electromagnetic properties of composites with nano-magnetic insertions. The article of Tolea et al. is devoted to spring magnets, consisting of interfaced hard (containing rare earths, iron and boron) and soft (containing iron and boron) magnetic nanophases, coupled by exchange interactions. Their magnetic properties depend on the thermal treatment and of amount of added iron, the optimal situation corresponding when hard and soft magnetic phases coexist with a small amorphous phase. Kuncser et al. describe how Mossbauer spectroscopy, applyed in complementarity with magnetic and structural techniques, can be used in order to obtain a comprehensive characterization of the magnetic configuration and magnetic relaxation of nanoparticles. The contribution of Jovanovic et al. is devoted to non-magnetic nanocomposites: silver nanoparticles embedded in a hydrogel, synthetized in situ by gamma iradiation. The plasmon spectra of nanoparticles are described and the biomedical applications are discussed.

6 Nanofluids and Flows at Nanoscale

The characterization of nanofluids, consisting of dispersed magnetic nanoparticles in a liquid carrier, is important mainly due to the the specific applications of such complex magnetic systems. Prof. Chicea's contribution is focused on magnetite nanoparticle aggregation dynamics in an aqueous suspension and on its effects on the modification of the rheological properties of the fluid.The time variation of the average diameter of the aggregates is obtained using light scattering techniques. Last but not the least, Prof. Niemela's contribution reviews some of the nano-physics appearing in the turbulent flow of classical and quantum fluids.

We hope that the diversity of themes and the clarity of contributions, written by leading experimental and theoretical researchers in these fields, recommend this volume as a useful and attractive lecture for researchers or students interested in nanophysics.

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