Proceedings of the E-MRS 2007 Symposia L and M: Electron Transport in Low-Dimensional Carbon Structures and Science and Technology of Nanotubes and Nanowires

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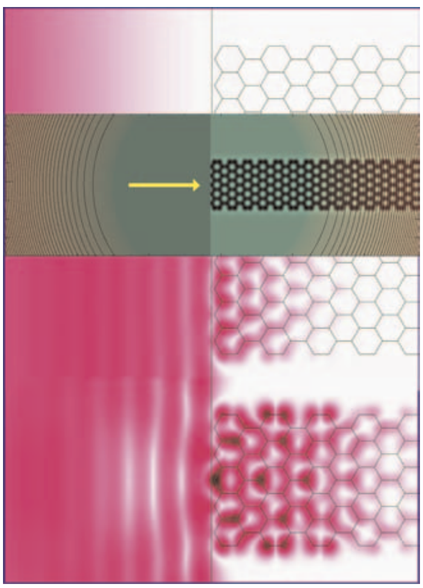

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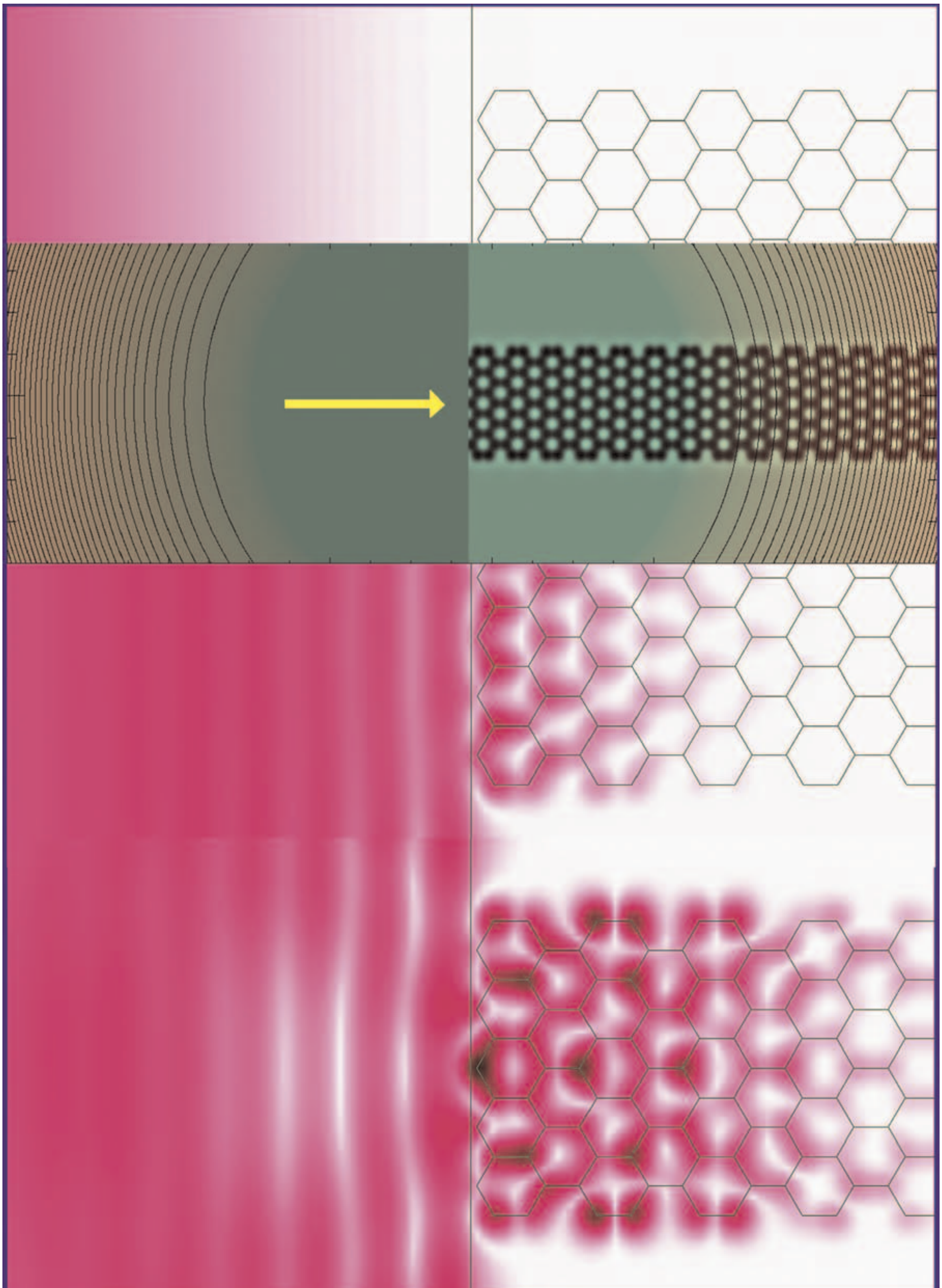
Snapshots from the 3D Wave Packet Dynamical Simulation of Electron Transport through a Graphene Nanoribbon (Courtesy of Geza I. Mark.)



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Preface

Science and technology of nanotubes, nanowires and graphene

The successful application of nanomaterials for nanotechnology faces four main challenges: materials preparation, characterization, device fabrication and integration. The physical properties of nanomaterials strongly depend on their atomic-scale structure, size and chemistry but also on their organization and aggregation. To fully exploit the technological advantages offered by these self-assembled molecular structures it is essential to acquire the ability to select, control and manipulate individual or aggregated nanomaterials. There has been much progress in the synthesis and characterization of nanostructures such as nanotubes, nanocrystals, atomic wires, organic and biological nanostructures, molecular junctions and graphene layers. However, immense challenges remain in understanding their properties and interactions with external probes to realize their tremendous potential for applications. Some of the frontiers in nanoscience include molecular electronics, nanoscale opto-electronic devices, nanomechanics, light harvesting and emitting nanostructures. Nanotubes, nanowires and graphene dominate the pursuit for materials for future nanotechnology applications.

Carbon nanotubes are a unique platform for many fundamental studies of quantum physics in low-dimensional systems, and several unexpected physical phenomena have been discovered. Recent breakthroughs in the high-yield, structure-selective manufacturing and techniques for separating metallic and semiconducting nanotubes promise to make commercial applications of this material real. Large efforts in the area of chemical modification and manipulation have allowed the design and fabrication of well-controlled architectures. Substantial progress has also been made in fabricating electronic devices, sensors, field-emission displays and nano-electro-mechanical systems using nanotubes and nanotube-based mesostructures.

One-dimensional nanowires are also receiving increasing attention because of their potential applications in electronics and photonics. Device performance typically depends on the material structure and crystallinity, but assembly is also a critical issue for applications. Fabrication of several types of one-dimensional nanostructures, such as nanowires, nanorods, nanosaws and nanoribbons, has been successfully demonstrated by several growth methods for elemental semiconductors, such as Si and Ge, as well as for III–V and II–VI compounds. Nanotubes of various non-carbon materials have been found and characterized. Theoretical modelling of these structures continues to reveal fascinating attributes. The electronic functionality of these materials, based on the directional transport of charges or energy, makes them ideal building blocks for interconnecting individual quantum systems in supramolecular architectures, field effect transistors or photonic wires. The large surface to volume ratio results in a pronounced sensitivity to environmental conditions making them suitable as sensors in nanoscale devices.

Graphene is the latest carbon allotrope to be experimentally discovered, and it is now at the centre of a significant experimental and theoretical research effort. In particular, near-ballistic transport at room temperature and high carrier mobilities make it a potential material for nanoelectronics, especially for high-frequency applications. It is now possible to produce graphene samples with areas exceeding thousands of square microns by means of micromechanical cleavage of graphite, and much larger by "epitaxial" growth on SiC. An ongoing effort is being devoted to large-scale production and growth on different substrates of choice. Graphene nanoribbons are the counterpart of nanotubes in graphene nanoelectronics.

This volume contains the Proceedings of the European Materials Research Symposium L on "Electron Transport in Low-Dimensional Carbon Structures" and Symposium M on "Science and Technology of Nanotubes and Nanowires" held on May 28 to June 1, 2007—in Strasbourg, France. The symposia covered the progress in design, manufacturing and characterization of nanotubes, nanowires and graphene, and new developments leading to possible commercial applications of these materials. In particular several sessions focussed on:

- Progress in the synthesis of nanotubes/nanowires/graphene.
- Progress in the assembly of nanotubes/nanowires into well-controlled architectures.
- Electron and spin transport.
- Light absorption, emission and scattering.
- Carrier interactions, ultrafast dynamics of carriers, excitons, and phonons, band structure and optical spectra.

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- Novel characterization techniques.
- Theoretical modelling of growth, electronic and optical properties.
- Fabrication and characterization of nanotube/nanowires/graphene devices, sensors, actuators.
- Nanocomposites.
- Applications and commercialization.
- Health/toxicity related issues.

We hope that these proceedings will provide the readers with a survey of most recent developments in these exciting fields of nanotechnology.

The symposia were sponsored by:

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