



QUANTUM NANOELECTRONICS

Led by Prof. Adrian Bachtold, the Quantum NanoElectronics Group specialises in the electrical and mechanical properties of carbon nanotubes and graphene. These structures are so tiny that quantum effects start to play a dominant role. For example the energy levels are quantised, just like in atoms and molecules. Interestingly, these structures are large and robust enough to be implemented in a variety of different microfabricated devices, which allow the tuning of their quantum properties.

BACKGROUND

Carbon nanotubes and graphene form a class of nanoscale objects with exceptional mechanical and electrical properties, which have generated great excitement in recent years. The breaking strength is record-high and the elastic modulus is extremely large, of the order of 1 TPa. Their high strength is accompanied by their ability to buckle to a large extent in a reversible manner (up to about 20%). Such remarkable mechanical properties make nanotubes and graphene easy to manipulate and to electrically contact. Transport measurements on individual tubes have shown that they transport current over lengths as long as 1 cm. This is exceptional since a single defect usually suppresses the current to zero for one-dimensional conductors. In addition, nanotubes can be metallic or semiconducting depending on the chirality of the tube. As for graphene, the mobility can be in excess of $100\,000\text{ cm}^2/\text{Vs}$ at room temperature, higher than any known semiconductor. The aim of the group is to take advantage of the unique properties of carbon nanotubes and graphene for different classes of experiments.

RESEARCH ACTIVITIES INCLUDE:

Nanotubes as molecular connectors.

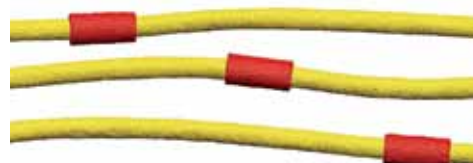
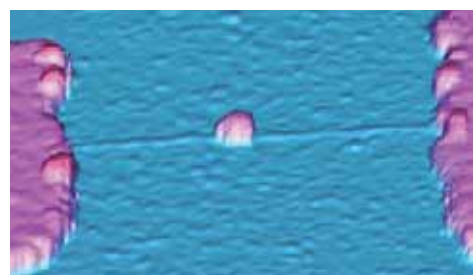
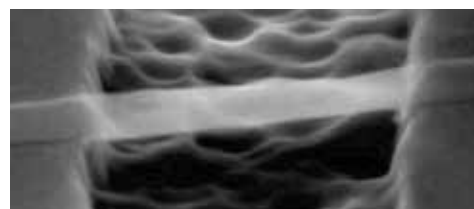
The Group uses nanotubes as molecular connectors in order to electrically contact smaller molecular systems. In particular, the group is exploring a radically new approach to probe the spectrum properties of highly resistive molecular systems (called electron counting spectroscopy).

Graphene electronics. The goal is to obtain graphene devices with the highest mobil-

ity. The race for the improvement of mobility is important for nanoelectronics (it should for example increase its speed) and for discovering new physics in two dimensional systems.

Nanotube & graphene electromechanical oscillators. Two sets of experiments are carried out, one on inertial mass sensing and one on the exploration of quantum motion. These two topics are currently generating intense activity in the community of nanoelectromechanical systems (NEMS). Experiments are usually carried out using microfabricated silicon resonators but the ultra low mass of nanotubes and graphene presents an enormous advantage. It drastically improves the sensitivity of mass sensing and it dramatically enhances the amplitude of the motion in the quantum regime.

Motors. The group is developing nanomotors based on nanotube and graphene. Only a few man-made nanomotors have been demonstrated so far for multiple reasons; for instance technical challenges in fabrication, and friction forces that are often so strong that they hinder motion. Because of their unique properties, nanotubes and graphene represent a material of choice for the development of new nanomotors. One important open question is how electrical, thermal or chemical energy can be transformed into mechanical energy in order to drive motion at the nanoscale level.



PROF. ADRIAN BACHTOLD
GROUP LEADER

Prof. Adrian Bachtold graduated Ingénieur Physicien at the Ecole Polytechnique Fédérale de Lausanne in 1996 and obtained his PhD from the University of Basel in 1999. He was a postdoctoral researcher at Berkeley and Delft. In 2001 he became Chargé de recherche CNRS at the Ecole Normale Supérieure in Paris. In 2005 he went to Barcelona as the principal investigator of the Quantum NanoElectronics group. He was a researcher of the CSIC and is now a professor of the Catalan Institute of Nanotechnology (ICN). He is the recipient of several awards, including the IBM award of the Swiss Physical Society, the medal of the CNRS and an EURYL award.