Magneto-transport subbands spectroscopy in InAs nanowires

F. Vigneau [1], R. Leturcq [2], P. Caroff [2], Y-M Niquet [3], M. Goiran [1], B. Raquet [1]

[1]Laboratoire National des Champs Magnétiques Intenses, Toulouse, France
[2]Institut d'Electronique, de Microelectronique, et de Nanotechnologie, Lille, France
[3] Institute for Nanosciences and Cryogenics (INAC) CEA, Grenoble

Bertrand.raquet@lncmi.cnrs.fr

Semiconducting nanowires (sc-NW) are subject to intense research during the last ten years. They constitute 1-D electron gases of particular interest, in a bottom-up approach, for the developments of opto-electronic devices as well as for high frequency transistors and spintronics. These applications rely on the unique properties of their electronic band structures and on the control of the charge and spin dynamics. However, the band structure of an individual NW still suffers from a crucial lack of direct experimental characterisation.

Our strategy consists in playing with single InAs NW based transistors in the open quantum dot regime and under extremely large magnetic field. High magnetic fields are required for a full spin and orbital degeneracy lifting once the magnetic confinement overcomes the electronic one [1]. For a magnetic field applied perpendicular to the NW axis, the 1D electronic band structure gradually transforms itself into magneto-electric subbands with a flattening of the dispersion curves at zero-k, the onset of conducting chiral edge states and a Zeeman splitting together with an up-shift of the subbands energies accompanying the Landau diamagnetism.

Here, we give direct evidence of the 1D band structure of InAs NW on the two-probe conductance observed both as a function of the doping level and of the applied magnetic field perpendicular to the NW axis [2]. Large magneto-conductance modulations mediated by the Fermi energy reveal the magnetic field dependence of the 1D conducting states and their spin and orbital degeneracy. Under extreme magnetic field, a full magnetic depletion of the NW is also achieved, inducing a magnetic switch-off of the conductance. Our experimental results are consistently supported by numerical simulations of the magnetic band structure, revealing the key parameters of the electronic confinement in InAs NWs.

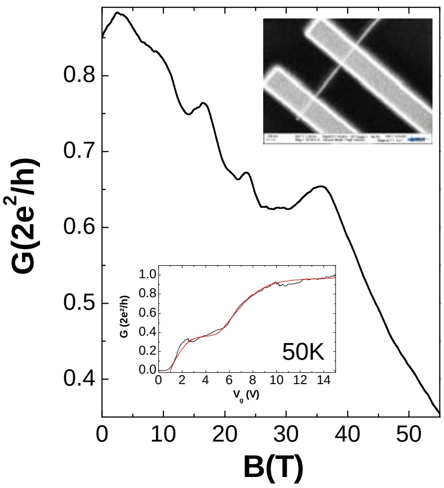

Figure 1 : Conductance under a perpendicular magnetic field, at 50K and for V_g equal 9V, obtained on a 31nm InAs NW device (SEM image in inset – IEMN) showing magneto-fingerprints of the electronic band structures. In inset (bottom), the $G(V_g)$ characteristic and its simulation (red curve) following the Landauer approach [2].

[1] B. Lassagne & al, Phys. Rev. Lett. 98, 176802 (2007); S. Nanot & al, Phys. Rev. Lett. 103, 256801 (2009).
[2] F. Vigneau & al, Submitted.