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Location and web-site *(LNCMI-T or G)*	LNCMI-T (http://www.toulouse.lncmi.cnrs.fr/)
Level required *(M1-M2 ...)* **Year**	M2 2013
Title of the subject	Electronic properties of In As nanowires under strong magnetic field.

Summary*(5 lines maxi)*

Semiconducting nanowires are fascinating objects showing new fundamental electronic properties as well as a large potential for the future nano-electronic and optoelectronic devices. The goal of the training period is to investigate the energy spectrum and charge transport mechanisms of a model system, InAs NW, through electronic transport under extremely high magnetic field and at low temperature.

Detailed subject

Semiconducting nanowires (SC-NW) with diameters ranging from 3 to 50nm, represent a specific class of systems in the wide family of nano objects thanks to their versatile physical properties arising from the large variety of material that can be chosen as basic constituent as well as from the rapidly improving growth methods. Due to these specific characteristics in the nano-world, SC-NW are very unique objects at the forefront in the investigation of fundamental phenomena at the nanoscale as well as in the development of electronic and optoelectronic devices. The one dimensional (1D) structure of these objects and their size modify deeply the dynamics of the charge carriers. At this scale, quantum effects essentially drive the electronic properties through the emerging 1D subbands resulting from the quantum confinement, accompanied by a drastic redistribution of the density of electronic states (DOS), as well as through the modification of the electron – electron correlations.

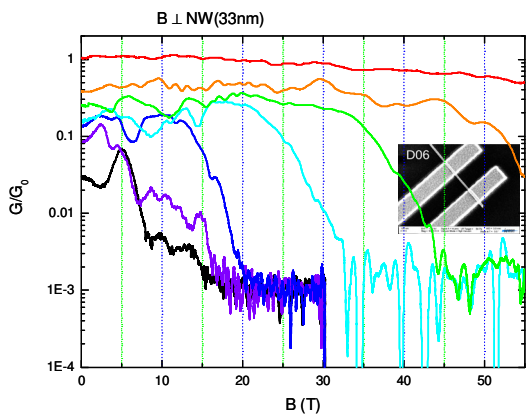
The magnetic field is well known to be a very powerful tool for studying the fundamental properties of electrons and holes embedded in nano-objects as it couples directly to both their motion and their spin. Magneto-conductance measured under very strong magnetic field and in a wide temperature range provides essential information on the carrier energy spectrum, its magnetic field evolution and allows to probe the different transport modes, from ballistic to diffusive, which can be encountered in these systems. In addition, the magneto-conductance measurements realised under light excitation can reveal directly transitions between magneto-electric subbands.

In this context, InAs nanowires [1,2] are promising candidates for the investigation of the electronic properties under high magnetic field thanks to the high carrier mobility and the strong spin-orbit coupling realised in this material. One can expect to resolve the energy band spectrum including the spin dependant effects in the samples with the highest mobility (~ 30 000 $cm^2/V.s$)

The group *"Nano-object and semiconducting Nanostructures"* at the LNCMI-Toulouse is currently involved in nano-science under high magnetic field (60T) mainly via dedicated magneto-transport experiments on single nano-objets [3, 4] .

Recent high field experiments performed in InAs NW with moderate mobility (~1500cm^2/V.s) in a FET configuration have revealed a magnetic field induced transition toward an insulating phase [5], pre-existing to this transition the magneto conductance exhibits well defined structures representative of both the magneto-electric subbands involved in the charge transport and universal conductance fluctuations. Band structure calculations including the magnetic field effect [6] are in qualitative agreement with these recent results.

The candidate will take part in the activities of the *"Nano-object and semiconducting Nanostructures"* group at the LNCMI-Toulouse. This axis is developed in collaboration with a group at IEMN-Lille (R. Leturcq) for sample elaboration and a group at CEA Grenoble for theoretical calculations (Y.M. Niquet). Some experiments are also performed in collaboration with a group at Pavia University (V. Bellani). The main objective of the work proposed during this training period will be the exploration the 1D band structure and transport mechanisms under high field/low temperature in samples with enhanced mobility. For this purpose the student will have to get familiar with nano-connection techniques and nanotechnology processes in clean room as well as with transport measurements under extreme conditions of magnetic field and temperature. The candidate will progressively be in charge of the magneto-transport measurements, with a specific task aiming at investigating the photoconductive response under high magnetic field.



Conductance (in unit of e^2/h) vs magnetic field at different carrier concentration fixed by the gate voltage (from V_g= 30V (red) to Vg=-1V (black).
In inset: SEM image of the device with drain source distance L=370nm.

Publications linked to the theme

-[1] S. A. Dayeh, *Semicond. Sci. Technol.* **25,** 2010
-[2] Dong Liang et al. , *Nano lett.* 12, 3263 (2012)
-[3] A. Kumar & al, *Phys. Rev. Lett*. **107**, 126806 (2011).
-[4] R. Ribeiro & al, *Phys. Rev. Lett*. **107**, 086601(2011).
-[5] V. Prudkovskiy et al., HMF 2012
-[6] YM Niquet, Private communication.

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This Master training could be extended into a PhD within the same research subject.	
Education/skills expected : Master in Physics (condensed matter) is required	
Salary [1]:	700€/month
Supervisors :	Pr. Michel Goiran and Pr. Bertrand Raquet
Tel :	33 (0)5 62 17 28 63
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[1] M1 = 436€/month
M2 = 700€/month