Internship proposal

Internship title	**Electron spin dynamics in semiconductors: charge/spin coupling effects**
Location	Laboratoire PMC – Ecole Polytechnique – Route de Saclay – 91128 Palaiseau
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Web site	http://pmc.polytechnique.fr/spip.php?article549&lang=en
Comments	Possibility to go on with a PhD ? Yes Envisaged fellowship ? Ministerial scholarship, AMX, AMN

PROJECT :

We have recently developed a polarized microluminescence imaging technique that permits the optical injection of spin-polarized electrons over a Gaussian spot of diameter 0.4 microns. The resulting non-uniform spatial density of spin-polarized electrons gives rise to a diffusion of both charge and spin. When the photo-carriers recombine and emit light, the selection rules dictate that any remaining spin-polarized electrons give rise to circularly polarized photons. An analysis of the luminescence intensity and polarization images yields the spatial distribution of the charge and the spin. The ratio of these two images is the spin polarization map. This technique has recently proven to be useful for the study of novel coupling phenomena in 3D semiconductors during spin-polarized carrier transport (see Fig. 1).

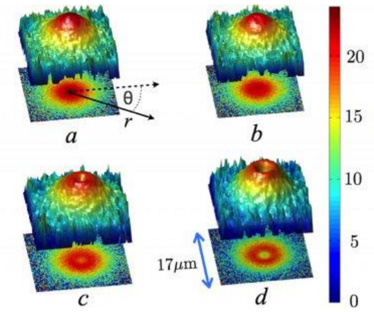

Fig. 1: Spin polarization maps as a function of the excitation power. (a) At low power the electrons can be treated as classical particles and the polarization decreases monotonically with distance because of spin relaxation. As the power is increased in (b), (c) and (d), a polarization minimum appears at the centre. The counter-intuitive increase in the polarization with distance is a direct result of the quantum nature of the electrons.

In the internship we propose to extend the use of this technique to the study of spin transport in semiconductor nanowires (NW). We have nanowires of diameter 5-10 nm, of exceptional quality and length (100µm) and a newly-built experimental setup which enables to excite the NW by a tightly-focused laser at cryogenic temperatures. The goal is to establish electrical contacts to these NW and to image the spatial profile of the luminescence intensity and polarization along the NW as a function of electric field. This should allow us to observe new effects specific to 1D spin transport such as:

- The effect of the statistical nature of the transported particles at high densities – the so called Pauli blockade regime which manifests itself by a spin-dependence of the charge diffusion constant (in the same way as for Fig. 1). Due to the small 1D density-of-states, one expects to observe this effect even at elevated temperatures.
- The effects of the 1D spin-orbit interaction on the orientation of the photoelectron spin and on the possibility to generate a spin polarization.
- In quantum NW, the transport in the extreme quantum limit in which, using appropriate excitation laser energy, only one electron subband is populated.

The internship is principally an experimental one, and would suit a student interested in fundamental semiconductor physics and spintronics. There will be opportunities for a successful intern to continue with a PhD.