

*Seminaire SOLEIL*

## Magnetic and structural properties of GaMnAs nanometric layers

### Problems and perspectives

**Dr. Khashayar Khazen**

(Institut des Nanosciences de Paris (INSP) Université Paris 6)

*Invité par Fausto SIROTTI*

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**Séminaires**

The application of diluted ferromagnetic semiconductors (DMS) for spin polarized current injection and the manipulation of such currents, the relatively long spin coherence lengths and the compatibility of the material with the current microelectronics technology have attracted much attention and result in a still growing number of studies on these materials. In addition to potential applications the physics due to the influence of many controllable parameters make these systems particularly interesting.

Among the different ferromagnetic DMS Ga<sub>1-x</sub>Mn<sub>x</sub>As thin layers with  $x > 0.01$  present the highest Curie temperature of 190K. In GaMnAs the Mn dopants introduce holes in the valence band of GaAs and at the same time the five 3d-electrons of the MnGa<sup>2+</sup> state provide localized magnetic moments of  $S=5/2$ . A long range ferromagnetic order is achieved via the coupling between these free holes and the Mn<sup>2+</sup> moments; the interaction can be described theoretically within the Zener kinetic exchange model. Hence the magnetic properties of GaMnAs depend strongly on the hole concentration and the conductivity regime. Although the magnetic moments and the hole concentrations in GaMnAs are coupled due to their common origin, it has been shown that it is possible to separate them via hydrogen passivation of the samples [1]. This approach allowed us to study in detail the effect of the hole concentration on the magnetic properties of the system [2]. Application of ferromagnetic resonance measurements provided us with the micromagnetic parameters of the samples such as the magneto-crystalline anisotropy constants, g-factors, exchange integrals etc. and their evolution as a function of temperature and hole concentration. We also studied the relaxation of the magnetization and corresponding damping factor. While the hydrogen passivation is very useful for quasi-permanent hole concentration modification and magnetic patterning, the depletion of ultrathin ( $\leq 5$ nm) GaMnAs layers in reversed bias p+/n diode structures is another way to modify temporarily the magnetic properties. First results of such voltage controlled FM were recently reported [3]. Integration of GaMnAs layers in multilayer systems requires the control of interface states, a subject not yet studied at all but known to be of prime importance in spintronics technology. Although the hole concentration is a convenient parameter for the control of the magnetic properties of GaMnAs, it can not be used to further increase the Curie temperature which is an essential limitation for the use of this material in spintronics technology. The main parameter allowing to increase the TC is the Mn concentration but its increase above  $x=0.07$  seemed to be limited by the low equilibrium solubility of the Mn dopant in GaAs. Nevertheless, layers with Mn concentrations above  $x=0.07$  have been successfully grown recently [4]. We have studied the effect of Mn concentration on the magnetic properties of such highly doped layers by FMR measurements and ion beam analysis (IBA) techniques. The results obtained showed the increasing importance of the structural and interfacial properties of highly doped ultrathin layers which had not been sufficiently taken into account in the previous studies and require new and original experimental approaches.

[1] L. Thevenard et al. Phys. Rev. B **75**, 195218 (2007)

[2] Kh. Khazen et al. Phys. Rev. B **77**, 165204 (2008)

[3] M. H. S. Owen, et al. New J. Phys. **11** (2009) 023008

[4] S. Ohya et al., Appl. Phys. Lett. **90**, 112503 (2007)

**Formalités d'entrée :** accès libre dans l'amphi du Pavillon d'Accueil. Si la manifestation a lieu dans le Grand Amphi Soleil du Bâtiment Central, merci de vous munir d'une pièce d'identité (à échanger à l'accueil contre un badge d'accès).

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Division Expériences - L'Orme des merisiers - Saint-Aubin - BP 48 - 91192 GIF S/YVETTE Cedex

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Secrétariat Division Expériences : [sandrine.vasseur@synchrotron-soleil.fr](mailto:sandrine.vasseur@synchrotron-soleil.fr)