MICRONOVA
CENTRE FOR MICRO- AND NANOTECHNOLOGY
TKK – HELSINKI UNIVERSITY OF TECHNOLOGY

ROOM TEMPERATURE SPINTRONICS AND SPINTRONICS BASED ON Mn DOPED GaAs

ELECTRON PHYSICS LABORATORY

Spintronics is one of the fastest growing fields of nanoelectronics. Whereas normal electronics is based on the utilisation of electron charge, spintronics uses both the charge and the spin of electrons. The properties of spin make possible new devices and applications. At present, almost all commercial spintroncs devices are fabricated from magnetic metals. Semiconductor spintronics (SS), however, has many benefits compared to metal spintronics. For instance, SS is easier to integrate with conventional electronics, and allows the fabrication of multifunctional devices. The biggest obstacle to a breakthrough of semiconductor spintronics is to find materials which are ferromagnetic even at room temperature. Our aim is to develop suitable semiconductor materials for spintronics such as Mn-doped GaAs and GaN and fabricate spintronic devices, which will operate even at room temperature.

RECENT RESULTS:

We are one of the first groups in Europe that have successfully fabricated a room temperature ferromagnet by diffusing Mn into GaN using Molecular Beam Epitaxy (Fig 1.). In addition, first in the world we have also fabricated a magnetic Zener diode from Mn doped GaAs and GaAs (Fig 2. and Fig 3).

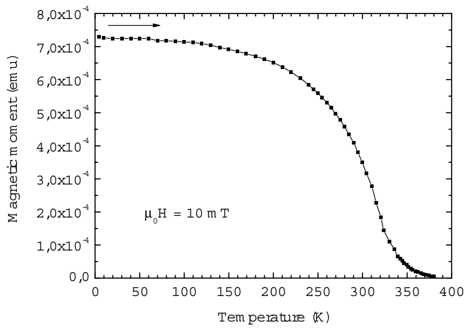

Figure 1: a) Magnetization as a function of temperature. The measurement is done at University of Leuven by Mr. Malfait . The result shows that our sample is ferromagnetic above room temperature (about 330 K).

b) MBE system used for growing the magnetic semiconductor structures. Our dual system allows the controlled deposition with atomic layer accuracy of semiconductors and metals in ultra high vacuum.

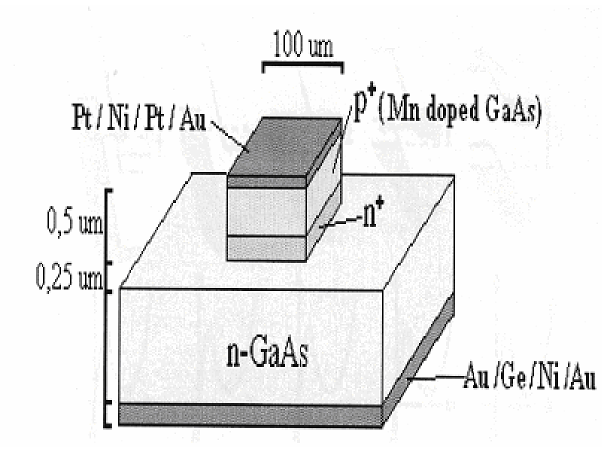

Figure 2: Structure of magnetic Zener diode. The structure is fabricated by MBE

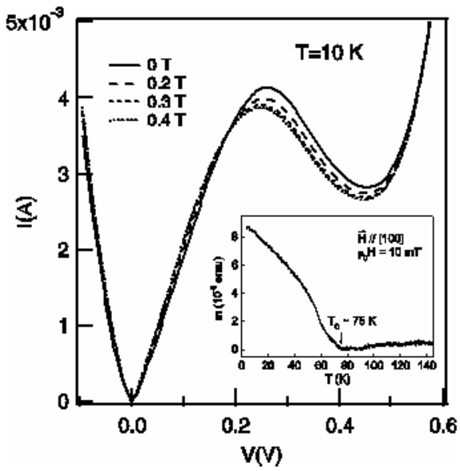

Figure 3: I-V characteristics of magnetic Zener diode with and without magnetic field.

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Research Collaborators:

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Saitama University, Japan
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Recent Publications:

1. H. Holmberg, N. Lebedeva, S. Novikov, P. Kuivalainen, M. Malfait, V.V Mohschalkov and P. Kostamo; *Magnetotransport properties of Room Temperature Ferromagnet (Ga,Mn)N*, IEEE Transactions on Magnetics **41**, pp. 2736-2738 (2005)
2. H. Holmberg , N. Lebedeva, S. Novikov, J. Ikonen, P.Kuivalainen, M. Malfait and V. Moschchalkov; *Large magnetoresistance in a ferromagnetic GaMnAs/GaAs Zener-diode*, Europhysics Letters **71**, pp. 1-6 (2005)
3. N. Lebedeva and P. Kuivalainen: *"Spin current through a ferromagnetic resonant tunneling quantum well"* , Physical Status Solidi (b) **242**, s.1660-1678 (2005)
4. H. Holmberg; *Magnetotransport properties of III-V diluted magnetic semiconductors GaAs:Mn and GaN:Mn*, Licentiate Thesis, 2005
5. N. Lebedeva, S. Novikov, T. Saloniemi and P. Kuivalainen: *"Magnetotransport properties of the diluted ferromagnetic semiconductor (Ga,Mn)As"* Physica Scripta **T114**, pp. 80-84 (2004)
6. N. Lebedeva and P. Kuivalainen: *"Theory of magnetotransport in ferromagnetic mesoscopic devices",* Physica Scripta **T114**, pp. 85-87 (2004)
7. N. Lebedeva and P. Kuivalainen: *"Modeling of ferromagnetic semiconductor devices for spintronics"*. Journal of Applied Physics, **93** (2003), pp. 9845-9864.