Poster-Tu-174 High-temperature spin polarization of high-mobility charge carriers in hybrid metal-semiconductor structures.

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Among troublesome barriers on the way to the development of the semiconductor spintronics, there are two principal ones - the lack of semiconductor materials and structures which would be ferromagnetic at high (room) temperature, and possess high enough mobility of charge carriers. In this connection, there may be promising hybrid ferromagnetic metal/semiconductor structures whose magnetic properties are significantly determined by the high-temperature ferromagnetism of the constituent metal [1].
We consider magnetic properties of the planar structure consisting of (i) a ferromagnetic metal, (ii) diluted magnetic semiconductor and (iii) the qu-antum well (by the example of the hybrid heterostructure Fe-Ga(Mn)As-InGaAs). In the framework of the mean-field theory, there is the significant amplification of the ferromagnetism induced by the ferromagnetic metal (Fe) in the system of magnetic impurities (Mn) due to their indirect interaction via the conductivity channel in the quantum well. As a result, the high-temperature ferromagnetism arises leading to the spin polarization of charge carriers (holes) localized in the quantum well and preserving their high mobility.

[1] F. Maccherozzi, e.a, Phys. Rev. Lett., 101 (2008) 267201

Poster-Tu-175 Magnetic properties of Langmuir-Blodgett films with iron ions.

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Langmuir-Blodgett films containing ions of 3d-elements present the object of intensive research in view of their application as materials for nanotechnology [1]. It is known that magnetic ions are responsible for the functional properties of the film. However, the state of these ions and their local surrounding is not yet ascertained. In the present study the magnetic susceptibility of Fe^{2+} and Fe^{3+} stearate films, obtained by coating of the stearic acid solution in hexane on the aqueous subphase containing $FeCl_3$ or Mohr salt, was investigated.
Two types of layered regular structures were synthesized: multistructures of iron stearate, which were obtained via consecutive transfer of iron stearate monolayers onto glass substrate and dispersions derived as a result of slow monolayers collapse. It should be noted that the susceptibility of all films does not showed a Curie-Weiss behaviour in temperature range from 77 to 400 K. In both types of films the low values of effective magnetic moments were found. For Fe^{3+} stearates μ_{eff} is increasing from 1.8 up to 2.6 μB with temperature rise from 77 to 400 K, while for Fe^{2+} stearates it is decreasing from 1.75 to 1.0 μB at the same temperature interval. Multimolecular layers of iron stearates having more regular structure than collapsed monolayers display essentially lower magnetic moments. For Fe^{3+} and Fe^{2+} the latter were equal to 0,4 – 1,5 μB and 0,35 – 1,25 μB correspondingly. This can be explained by assuming the presence of low spin configuration of Fe^{2+} and Fe^{3+} ions and exchange interaction between these ions.
Interestingly that after storage of films with Fe^{2+} during two month the character of temperature dependence of μ_{eff} is changing. μ_{eff} is increasing as it was in the case of Fe^{3+} but the interval of values remains the same (1,0 – 1,8 μB). This fact points to the distortion of local environment of magnetic ions (change of exchange angle) and consequently the change of its character as well as possible oxidation of Fe^{3+} and Fe^{2+} ions. The anomalies of magnetic behaviour will be discussed within the framework of the model of film structuring. This process causes strong superexchange interactions of various (ferro- and antiferromagnetic) types and formation of clusters of iron ions.

[1] O.Hiroshi et al. Thin Solid Films. 484 (2009) 310

Poster-Tu-176 Magnetic properties of nano-sized 5at%Fe-Al systems

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High energy ball milling is a promising materials processing technique and has been used to produce nanocrystalline structures. However, contamination from the milling medium can influence the material properties of the final nanostructured products. When stainless steel or hardened steel containers and balls are used for milling, a substantial amount of Fe can be intercalated. While in most cases contamination from the milling media is undesirable, in some cases, the mechanical and magnetic properties are seen to improve. To examine the effect of contamination, pure Al was milled in air using hardened steel (HS) vials/balls (sample 1). For comparison, Al was mechanically alloyed in tungsten carbide media with 5 at.% Fe (sample 2) as estimated from EDAX studies on sample 1. Ball to powder ratio was 20:1 for both. XRD and TEM on sample 1 show that Fe impurity from the milling medium is fairly well dispersed in the Al host. Mössbauer studies indicate that the magnetic contribution – in both cases largely due to un alloyed -Fe – is lesser in sample 2 which also shows greater alloying. DC magnetization shows that the saturation magnetization M_s in sample 1 is 50 emu/g and is about 30 times smaller at 1.6 emu/g in sample 2 with curie temperatures of 851 K and 588 K respectively. While field cooled and zero field cooled curves of both samples show thermal irreversibility, only sample 1 shows a spin-glass like transition. In conclusion, it is seen that the properties of mechanically alloyed Al- 5at.% Fe are significantly different from that of mechanically milled Al into which the same amount of Fe is introduced as impurity from the milling medium. These differences can be attributed to the way in which Fe is introduced into the system. When milling is done in HS medium, Fe is introduced gradually and presumably at a steady rate throughout the milling period. Hence, at the end of 10 hours, more of Fe as also Fe-rich Fe-Al phases are present in sample 1. This alters the bulk magnetic properties very much as compared to sample 2 in which 5 at.% Fe is alloyed with Al, where the entire quantity of Fe is available for possible alloying throughout the period of milling. This study thus shows that in nanostructured systems, magnetic properties in systems with the same nominal composition can vary drastically depending on the way in which the impurity is introduced.

Poster-Tu-177 Temperature evolution of self-organized stripe domains in ultrathin Fe films on MnAs/GaAs(001) studied by FMR and MOKE

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The magnetic behavior of an ultrathin Fe film (Fe thickness=4nm) epitaxially grown on MnAs/GaAs(001)[1] was studied as a function of temperature (T) using ferromagnetic resonance (FMR) and magneto-optical Kerr-effect (MOKE) techniques. When MnAs is in a uniform phase (hexagonal ferromagnetic α-MnAs phase at low T and orthorhombic non magnetic β-MnAs phase at high T), the Fe overlayer behaves as a single magnetic film, independent of the crystalline and magnetic state of the substrate. At intermediate T, when MnAs presents a self-organized phase with coexistence of α and β stripe domains (whose width, in the submicron range, varies with T), two Fe resonance modes are found in the FMR spectra, with very different temperature behavior for magnetic field applied perpendicularly to the stripes direction. Theoretical analysis of the FMR data is performed using a free energy density model which, in addition to the Fe anisotropy constants, takes into account the dipolar (stray) fields arising from the substrate [2]. In this way, an accurate determination of the temperature dependence of all the magnetic parameters of the ultrathin Fe overlayer could be obtained. The main achievements from the analysis of FMR data were confirmed by the complex temperature evolution of the MOKE magnetization loops measured in the same sample.

[1] M. Sacchi et al. Phys. Rev. B 77 (2008) 165317
[2] S. Tacchi et al. Phys. Rev. B 80 (2009) 155427