Magnetic Interfaces and Nanostructures
Room 134/135 - Session MI-TuP
Emerging Materials & Nanostructures Poster Session

MI-TuP1 Structural, Electronic and Magnetic Properties of Chalcopyrite Magnetic Semiconductors: A First Principles Study*, S. Picozzi,* Univ. L'Aquila, Italy*; A. Continenza,* INFM - Univ. L'Aquila, Italy*; W.T. Geng, Y.J. Zhao, A.J. Freeman,* Northwestern University

Stimulated by recent experimental observations of room--temperature ferromagnetism of Mn@sub x@Cd@sub 1-x@GeP@sub 2@, we investigate the structural, electronic and magnetic properties of chalcopyrite systems as a function of Mn concentration by means of the first--principles density-functional-theory-based FLAPW (H.J.F.Jansen and A.J.Freeman, Phys. Rev. B 30, 561 (1984).) code. These new materials transcend the limitations (such as defect formation, and too low operating temperatures for spin injection and ferromagnetic properties) of the magnetic zinc-blende systems explored so far (e.g. Ga@sub x@Mn@sub 1-x@As) for spintronics applications. We investigate the effect of the anion (P vs As) and cation (Cd vs Zn) substitution in Mn-doped systems. Our calculations indicate that the antiferromagnetic alignment is the most stable ordering for the Mn-rich systems, at variance with that experimentally reported. Moreover, we focus on the dependence of the total magnetic moment per Mn atom and of the band gaps as a function of the Mn concentration in the different systems.

MI-TuP2 Component-resolved Electroluminescence from Spin-LED Structures: Implications for Quantifying Electrical Spin Injection in Semiconductors*, B.T. Jonker,* *A.T. Hanbicki, Y.D. Park, B.R. Bennett,* Naval Research Laboratory*; M. Furis, G. Kioseoglou, D. Coffey, A. Petrou,* State University of New York, Buffalo

The spin-polarized light emitting diode (spin-LED)@footnote 1@ has emerged as a very effective tool for accurately quantifying electrical spin injection in a model independent manner.@footnote 2@ The quantum selection rules which describe the radiative recombination process provide a direct and quantitative link between the circular polarization of the electroluminescence (EL) and the spin polarization of the electrically injected carriers. While these selection rules apply only to the free exciton and free carrier radiative recombination, the EL spectrum often consists of contributions from various recombination processes whose relative spectral weighting depends upon details of the LED heterostructure, such as doping, impurities and interface roughness. Common contributions include donor and acceptor-bound excitons, phonon replicas, and recombination mediated by various impurity levels or complexes. These components may completely dominate the spectrum in many instances. We resolve and identify such components in the EL spectra from several GaAs quantum well-based spin-LED structures by correlating reflectivity measurements with their dependence on doping, temperature and magnetic field, and examine the circular polarization of each. We show that these components exhibit markedly different polarizations which do not accurately reflect the electrical spin injection efficiency. Certain of these features derive from many-body effects, and may provide insight into related spin relaxation processes. We show that a reliable measure of spin injection efficiency can be obtained only if one takes care to spectroscopically resolve and accurately identify the origin of the components of the spin-LED EL spectrum. This work was supported by the DARPA SpinS program and ONR. . @FootnoteText@ @footnote 1@ B.T. Jonker, US patent # 5, 874,749 (filed 1993, issued 1999). @footnote 2@Fiederling, et al, Nature 402, 787 (1999), Jonker, et al. PRB 62, 8180 (2000), Park et al, APL 77, 3989 (2000).

MI-TuP3 Magnetic and Structural Properties of Fe- and Mn-Implanted SiC*, N. Theodoropoulou,* *A.F. Hebard,* University of Florida*; S.N.G. Chu,* Bell Laboratories, Lucent Technologies*; M.E. Overberg, C.R. Abernathy, S.J. Pearton,* University of Florida*; R.G. Wilson,* Consultant*; J.M. Zavada,* U. S. Army European Research Office, UK

P-type 6H-SiC substrates were implanted with Mn@super +@ or Fe@super +@ at doses of 3-5x10@super 16@ cm@super -2@ under conditions that avoided amorphization (substrate temperate ~350°C). After annealing at 700-1000°C, the magnetic properties of the samples were examined by SQUID magnetometry. The Mn-implanted SiC did not show any magnetization, remaining paramagnetic, but the Fe-implanted samples showed ferromagnetic properties below 200 K for the highest dose employed. The origin of the ferromagnetism is not the formation of secondary phases involving precipitation of the Fe. Results for Ni and Co implantation will also be presented, along with a comparison of data for implantation of the same elements into p-GaN epitaxial layers.

MI-TuP4 Magnetism and Transport in Manganite-based Trilayers A/B/A (A: La@sub 0.6@Sr@sub 0.4@MnO@sub 3@; B: La@sub 0.9@Sr@sub 0.1@MnO@sub 3@, La@sub 0.67@Ca@sub 0.33@MnO@sub 3@)*, L.B. Steren,* *M. Sirena, M. Granada, J. Guimpel,* Centro Atomico Bariloche and Instituto Balseiro, Argentina

We have studied the physical and structural properties of trilayers based on manganites compounds. Different ferromagnetic spacers, insulator (B1) and metallic (B2), have been used in order to compare the magnetotransport effect and interlayer coupling of both systems. Thin films and trilayers have been grown by dc sputtering. Films of La@sub 0.6@Sr@sub 0.4@MnO@sub 3@ ("A"}), La@sub 0.67@Ca@sub 0.33@MnO@sub 3@ ("B2") and La@sub 0.9@Sr@sub 0.1@MnO@sub 3@ (``B1"}) with thickness varying from 5nm to 50nm have been first prepared in order to study the intrinsic properties of these materials. "A" thin films are ferromagnetic with a Curie temperature around room temperature. These manganites present a metal-insulator transition below T@sub C@ and exhibit colossal magnetoresistance. A similar behaviour has been found in the "B2" films, with lower characteristic temperatures. "B1" are also ferromagnetic but present different transport properties : They are insulators between 4.2K and room temperature. All the compounds preserve its general properties, even for the smaller thicknesses. However, an important depression of the Curie point is observed as the films thickness is decreased. The trilayers have been prepared with different A and B thicknesses (10 nm <th@sub A@<50nm and 5 nm <th@sub B@< 15 nm). Strongly textured X-ray difraction patterns have been observed in the heterostructures. The magnetic coupling between A layers has been studied through temperature and field dependence of magnetization curves. Remanent magnetization curves show a single ferromagnetic transition around 200K. A metal-insulator transition is observed below the Curie point. Both results suggest a ferromagnetic coupling of the system. However, the role of the ferromagnetic spacer in the coupling cannot be explained by these measurements only. Complementary measurements of ferromagnetic resonance are under progress in order to better understand the interlayer coupling in these systems.

MI-TuP5 Observation of the Two-stage Magnetic Transition and the CMR Effect in Aged La@sub 0.5@Sr@sub 0.5@CoO@sub 3-@@delta@ Films Prepared by Laser Ablation*, V.G. Prokhorov,* Institut of Metal Physics, Ukraine*; J.S. Park, S.Y. Park, Y.P. Lee,* Hanyang University, Korea*; K.W. Kim,* Sunmoon University, Korea*; V.M. Ishchuk,* Insitute of Single Crystals, Ukraine*; I.N. Chukanova,* Institute of Single Crystals, Ukraine

The magnetic and transport investigations have been carried out for the as-deposited and the long-time aged La@sub 0.5@Sr@sub 0.5@CoO@sub 3-@@delta@ films prepared by pulsed laser deposition. It was shown that a decrease in the oxygen concenturation during aging of the film leads to the tetragonal distortion of the crystal lattice, to a shift of the metal-insulator transition temperature to a lower temperature(T@sub p@ = 250 K), and to the observation of a CMR effect (up to 3 % at magnetic field of 5 T). In addition to the usual ferromagnetic transition at T@sub c@ = 250 K, the second magnetic transition was observed at T@sub M@ = 50 K that is treated as the appearance of a cluster glass magnetic state. The non-monotonic behavior of the resistance observed in the low-temperature range, T < T@sub p@, is explained by the weak localization of the carriers.

MI-TuP8 Temperature Dependence of Line Width of Ferromagnetic Resonance in Nickel-Zinc Ferrites*, S.C. Byeon,* University of Alabama, US*; C. Alexander,* University of Alabama*; H.B. Hong, T.Y. Byun,* Seoul National University, Korea*; C.K. Kim,* Hanyang University, Korea*; K.S. Hong,* Seoul National University, Korea

The systematic temperature dependence in line width of ferromagnetic resonance with the Fe content was observed at X band (9.78GHz) in (Ni@sub 0.5@Zn@sub 0.5@)@sub 1-x@Fe@sub 2+x@O@sub 4@ (-0.2@<=@x@<=@0.2). The line width of the stoichiometric composition (x = 0) showed minimum value, 50 Oe. In contrast, the line width of the non-stoichiometric compositions sharply increased to 210 Oe with increasing non-stoichiometry (x). The mechanism for this line width broadening was investigated using thermoelectric power and electrical resistivity, since the contribution of anisotropy and porosity to the line width was negligible in this compositional region. In Fe excess region, Fe@super 2+@ ion concentration increased with increasing Fe content, resulting in line width broadening due to relaxation. But, it was suggested that Ni@super 3+@ and Fe@super 2+@ ions coexist in Fe deficient region. Therefore the increase of line width in nickel-zinc ferrites originated from the Fe@super 2+@/Fe@super 3+@ magnetic relaxation in Fe excess region, and the Fe@super 2+@/Fe@super 3+@, Ni@super 2+@/Ni@super 3+@ magnetic relaxation in Fe deficient region.

MI-TuP9 Magnetic Circuits for Atomic Matter Waves*, M. Vengalattore, W. Rooijakkers,* Harvard University*; S.A. Lee,* Colorado State University*; T. Deng, G.M. Whitesides, M. Prentiss,* Harvard University

Atom optics is an important branch of physics in which the quantum nature of atoms is exploited to realize systems equivalent to photonics. An example is the (single mode) atomic waveguide as compared to the (single mode) optical fiber. Another example is the atom laser, based on matter wave amplification, realized in 1997.@footnote 1@ The production of these matter waves, which are coherent over distances > 10 cm has facilitated applications such as interferometry. Since atoms have a much larger mass than electrons or photons, they offer the unique possibility of doing ultrasensitive gravitational field measurements. Furthermore, since the interactions can be controlled, neutral cold atoms provide a promising system for quantum computation. Following the integration in optics and electronics it makes sense to pursue miniaturization of atom-optical systems. This will allow for the realization of more complex functions on a relatively small surface. Arguably magnetic field gradients provide the most versatile means for non-dissipative manipulation of atoms. In this paper we describe a newly developed waveguide for coherent transport of atoms and possible future applications of this technology. Our waveguide consists of four parallel strips of ferromagnetic material, wound with kapton isolated wire. This configuration results in a magnetic field minimum above the surface. The position of this minimum can be controlled by varying the currents in the wires. Weak field seeking atoms can be trapped in this minimum by using laser cooling techniques, forming a magneto optical trap (MOT).@footnote 2@ Atoms from the background vapor are decelerated by laser beams and accumulate in the magnetic minimum. To provide damping in all directions the surface above the magnetic strips has been made reflective with a gold layer. In our experiment we use diode lasers with a wavelength of 852 nm to cool @super 133@Cesium atoms. The fluorescence of the atoms can be imaged onto a CCD camera. We have created very long (aspect ratio 1:500) and thin (20 mm) clouds. In our waveguide we obtain a gradient of 3 kG cm@super -1@ A@super -1@, and by further miniaturization we anticipate a further increase by a factor 10@super 3@. The next step is fabricating more complex structures. One example is the quantum point contact: a constriction through which the conductance of matter waves shows steps as a consequence of the quantum mechanics.@footnote 3@ Another example is a magnetic storage ring for atoms. Connecting up both ends of our waveguide seems a logical extension of our previous work. We are pursuing the propagation of matter waves in such a device, which may then be used as an interferometer for ultrasensitive inertial sensing. Presently we use mu-metal sheet to construct these devices. Alternatively we have also been using lithography@footnote 4@ and permalloy deposition. We continue our search for materials capable of generating large magnetic field gradients on a small substrate with the possibility of designing complex circuits for ultracold atoms. @FootnoteText@@footnote 1@M. Andrews, C. Townsend, H-J Miesner, D. Durfee, D. Kurn and W. Ketterle, Science 275, 637 (1997). @footnote 2@E. Raab, M. Prentiss, A. Cable, S. Chu and D.E. Pritchard, Phys. Rev. Lett. 48, 596 (1982). @footnote 3@J. H. Thywissen, R.M. Westervelt and M. Prentiss, Phys. Rev. Lett. 83, 3762 (1999). @footnote 4@N. H. Dekker, C. S. Lee, V. Lorent, J. H. Thywissen, S. P. Smith, M. Drndic, R. M. Westervelt and M. Prentiss, Phys. Rev. Lett. 84, 1124 (2000).

MI-TuP10 Investigation of MFM Tip Induced Magnetization Reversal of Magnetic Nanostructures*, X. Zhu, P. Grutter,* McGill University, Canada*; V. Metlushko,* University of Illinois at Chicago*; B. Ilic,* Cornell University

Magnetic Force Microscopy (MFM) has become a standard technique to study the magnetic reversal of nanoparticles. However, the magnetic tip stray field contribution to the reversal characteristics has not been systematically investigated. Here we compare data obtained in different operation modes of MFM such as tapping/lift mode or non-contact mode. We investigated e-beam patterned permalloy arrays with nominal thickness of 30nm, with aspect ratios of 1:1 up to 10:1, with widths of 100nm, 150nm and 200nm, and different spacing. Si cantilevers coated with 10nm to 90nm of CoPtCr, NiFe or NiCo are used as magnetic probes. Previously, we have found that the particle moment can easily be reversed when MFM measurements are performed in tapping and lift mode.@footnote 1@ This is associated with the fact that during tapping the tip stray field can be very substantial during part of the tip oscillation cycle. In the present study, we performed MFM measurements in the non-contact mode in our homebuilt vacuum MFM to further characterize how the magnetic tip influences the magnetic sample state. For large tip-sample separation (typically >100nm), and for large aspect ratio particles, we found that the magnetized tip very seldom reverses particle moments. These particles mainly form single domains due to their shape anisotropy. Within a few (

MI-TuP11 Magnetic Anisotropy in Epitaxial Fe(001) Micrometric Squares by Magneto Optical Torque*, D. Jaque,* Universidad Complutense de Madrid, Spain*; G. Armelles,* Instituto de Microelectrónica de Madrid, CNM-CSIC, Spain*; J.I. Martín,* Universidad de Oviedo, Spain*; P. García-Mochales,* ***J.L. Costa-Krämer****, F. Briones,* Instituto de Microelectrónica de Madrid, CNM-CSIC, Spain*; J.L. Vicent,* Universidad Complutense de Madrid, Spain

Magneto Optic (MO) studies are performed on regular arrays of 200 Å thick Fe (001) epitaxial tiles with different micrometric lateral sizes. MO studies are performed both on reflected and diffracted spots and analyzed in terms of the homogeneity of the magnetization within the tile. These are compared with predictions from micromagnetic simulations. The MO response to a rotating magnetic field (Magneto Optical Torque - MOT)is also measured in these structures, finding a clear evolution from the biaxial crystalline anisotropy towards an uniaxial one as the tile lateral size is reduced at constant thickness.

MI-TuP12 Annealing Effect on Structure and Magnetism of CoNi Pattern Quantum Dots*, **H.L. Li**, C.W. Wang, D.H. Qin, M.K. Li,* Lanzhou University, P. R. China

NiCo alloy nanowires were prepared by AC electrodeposition into self-assembled porous anodic alumina template. Then the sample was annealed at 500 °C, 6 hours, with argon as protected gas. The composition, microstructure and magnetism of samples used in this work were characterized by atom absorbed spectrum, transmission electron microscopy (TEM), scanning electron microscopy (SEM), x-ray diffraction (XRD), and vibrating sample magnetometer (VSM). XRD results showed that there were preferred orientation in CoNi nanowire arrays with Ni content range from 0.2 to 0.8 during electrodeposition, while random orientation was observed after the sample was heat-treated. Though the shape anisotropy was very high in the sample, it is found that the squareness (Mr/Ms) of the hysteresis of the samples (Ni content is in the range of 0.2 to 0.8) was only about 0.6 before annealing, and increased to about 0.9 after annealing. As its high bit density, such media may be used as high-density quantum magnetic disks. A qualitative discussion was given and explanation of reversal mechanism was offered in term of localized magnetization model.

MI-TuP13 Magnetic Coupling in Epitaxial Fe/MgO/Fe Arrays of Micro Tunnel Junctions*, **J.L. Costa-Kramer**, J.V. Anguita,* Instituto de Microelectronica de Madrid, CNM, CSIC, Spain*; J.I. Martin,* Universidad de Oviedo, Asturias, Spain*; C. Martinez-Boubeta, A. Cebollada, F. Briones,* Instituto de Microelectronica de Madrid, CNM, CSIC, Spain

The magnetic properties of planar 100 Fe/ x MgO / 100 Fe epitaxial ferromagnetic micro tunnel junction arrays have been measured for different lateral sizes of the junctions (1-50 Âµm) and barrier thicknesses; (x=10,20,50,70). When the top and bottom electrodes magnetizations are uncoupled, they orient antiparallel in zero field due to the magnetostatic energy gain. On the other hand, the two electrodes magnetizations orient parallel when direct exchange couples them effectively through the barrier, most probably due to a critical density of pinholes. We find that both, lateral size and barrier thickness influence the ratio of junctions with their electrodes magnetization antiparallel to those in which they orient parallel. For a given barrier thickness, there is a threshold below which mostly all of the junction electrodes couple antiparallel. This happens at about 4 Âµm lateral size for electrodes separated by a barrier of 10 MgO (close to only two MgO unit cells). The field ranges where these phenomena occur agree reasonably well with the predictions from a simple analytical model, in which we solve the energetic balance between magnetostatic energy gain and orientational energy loss for our Fe/MgO/Fe sandwich geometry. In addition, and comparing with our previous results with single layer Fe microtile arrays, we confirm the intuitive picture that the micro sandwich structures can be placed closer than the single layer structures before they interact magnetically with their closest neighbors. This is due to a preferred closure of the magnetic flux between top and bottom electrodes in the sandwich structure, reducing considerably the magnetic field at the closest neighbors positions.

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