Poster Session A

Poster A

SP1, SP3, SP5 (1/3), SP5, SP8, SP10
Poster A

P-A.001

A wireless magnetic system for marine animal conservation

A. Kaidarova, M. A. Karimi, A. Shamim, N. Geraldi, C. M. Duarte, J. Kosel

Text The assessment of marine animal's behavioral responses to changing environments is a fundamental aspect for conservation efforts and for understanding the functioning of ecosystems. Traditionally, biologging units are used for animal monitor, which are bulky and mechanically inflexible, significantly limiting their applicability. We introduce an animal monitoring system comprising a compliant wireless communication module, wearable composite magnets and magnetic tunnel junction sensors. NdFeB/PDMS composite magnets are highly versatile with respect to the shape and size of the magnets. The magnetic and mechanical properties were tailored within a wide range by the filler concentration, while achieving a significant weight reduction (10 times) and mechanical flexibility. The magnetic field of the composite magnets is sensed by 3-axial magnetic tunnel junction sensor integrated onto a mini-board with a flexible battery. The measured data is transmitted via Bluetooth low energy communication standard to a smart phone and dashboard server for visualization and further analysis. A 2µm thick Parylene C coating ensures the systems survival in the harsh seawater environment, providing corrosion resistance, flexibility, and biocompatibility. The real-time monitoring was demonstrated across a range of animals and motion components, including the head and leg movements of crabs, giant turtles and sea turtles.

Poster Session A

Poster A

P-A.002

Analysis of the presence of biogenic magnetic nanoparticles in organs and tissues of animals and humans

S. Gorobets, O. Gorobets, M. Bulaievska

Text To date, biogenic magnetic nanoparticles (BMNPs) have been detected in representatives of three domains of life: prokaryotes, archaea, and eukaryotes, and a common mechanism of BMNPs biomineralization for all living organisms has been established (Gorobets et al., 2014).
The presence of BMNPs was studied mainly from the point of view of the orientation of organisms in the Earth's magnetic field. The idea of magnetoreception was deeply studied and continues to be studied, but no unequivocal experimental confirmation was found, even in the study of the orientation of migratory birds (Ritz et al., 2004) and migratory fishes (Gorobets et al., 2017) in the geomagnetic field, not to mention a human. However, the hypothesis of magnetoreception was useful, since intensive studies of the organs and tissues of animals began.
In work (Gorobets et al., 2018), the presence of BMNPs in organs and tissues of human was theoretically shown. In turn, the analysis of experimental data on the presence of BMNPs in organs and tissues of animals and humans, fully confirms the results of bioinformatic analysis.
The obtained results testify to the necessity to take into account the presence of BMNPs in human organs and tissues when using diagnostic methods, such as magnetic resonance tomography, when using of targeted drug delivery, as well as when people working in a strong magnetic fields.

Poster Session A

Poster A

P-A.003

Creation of magnetically controlled sorbents based on the biomass of the fungus Agaricus bisporus var. bisporus

S. Gorobets, O. Gorobets, K. Hetmanenko, L. Yevzhyk

Text It is known that heavy metals have a destructive effect on the body as a whole, they are difficult to remove, so the actual problem is the search for effective biosorbents. Such properties are possessed by sorbents from natural products, among which the polysaccharide chitin can be isolated. It has unique properties, such as biosemistnost, biodegradation and nontoxicity. Chitin is the main structural component of the cell walls of fungi, the outer covers of crustaceans and insects [1].

It is known that most fungi have in their composition chains of biogenic magnetic nanoparticles (BMN), which are good natural nanomagnets. The aim of the work was to separate components of the fungus Agaricus bisporus var. bisporus containing BMNs by means of high gradient magnetic separation [2].

The average size of particles of the fungus Agaricus bisporus var. bisporusbefore separation is 2.77 μm, after separation - 39.15 μm. Clustering of fungal particles with BMN was observed in the external magnetic field ofmagnetic separator.

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2.Gorobets S. V. HighGradient Ferromagnetic Matrices for Purification of Wastewaters by the Method of Magnitoelectrolysis / S.V. Gorobets, N.A. Mikhailenko // Journal of Water Chemistry and Technology. – Vol. 36. - No. 4. - 2014. - P. 153–159.

Poster Session A

Poster A

P-A.004

Development of a magnetic separator for the recovery of magnetic nanoparticles from biomedical and environmental applications

K. Simeonidis, M. Tzirini, G. Mitraka, E. Kaprara, T. Samaras

Text The complete recovery of magnetic nanoparticles at the end of their operational cycle in biomedical treatments or drinking water processes is a requirement of high priority able to determine the successful implementation of each technology. This study describes the design of a magnetic separator easily-scalable to operate under the conditions met in the flow of blood in an artery or natural water in a pipe where nanoparticles are dispersed. The configuration consists of cylindrical permanent magnets (radius 1-2 cm) arranged along the sides of the fluid flow at various distances and polarities. The recovery (separation) efficiency for each setup was predicted by computing the tracks of several nanoparticles after solving the motion equation with the Runge-Kutta scheme (Matlab). Acting magnetophoretic force was obtained by Mathematica. As a proof of concept, the optimized setup was evaluated in a continuous-flow system with a Fe_3O_4 nanoparticles dispersion fed at various concentrations, flow velocities and fluid viscosities. The same system was also adopted in a water purification process towards the removal of arsenic and antimony species using FeOOH-loaded Fe_3O_4 nanoparticles.

This study was implemented within the frame of the action “Supporting Postdoctoral Researchers” of the Operational Program “Development of Human Resources, Education and Lifelong Learning 2014-2020” of IKY State Scholarships Foundation and is co-financed by the European Social Fund and the Greek State.

Poster Session A

Poster A

P-A.005

Engineered magnetic nanoparticles composite as a potential drug carrier for breast cancer treatment

R. Sarkar, J. Panda, B. S. Satapathy, B. Mukherjee, B. Tudu

Text Magnetically-guided nanodrug delivery system has gained wide attention for the improvement of cancer treatment strategy. In our study, we developed a polymer based iron oxide nano-carrier for drug delivery. The core portion is designed as superparamagnetic. The surrounding polymeric layer provides protection and renders them suitable for in vivo application. The characterization of the synthesized iron oxide nanoparticles (IONP) were done by XRD, SEM, TEM, DLS, FTIR and VSM. The diameters of IONPs are found to be 18-20 nm. The magnetization curve showed the superparamagnetic behavior of the IONPs with saturation magnetization of 72 emu. g-1 at room temperature. Powder x-ray diffraction analysis showed well crystallinity. The IONPs then loaded with the drug in polymer matrix (IODPM) are found to be spherical in shape and of uniform size distribution in the range of 180-200 nm. The IODPM showed impressive internalization efficiency and satisfactory cytotoxicity in MCF-7 cells as found from the confocal microscopy and MTT assay. IODPM showed reasonable drug loading capacity with a sustained drug release over the experimental time period and improved Pharmacokinetic (PK) parameters. The higher saturation magnetization, controllable size, satisfactory drug loading, sustained release, predominant cancer cell uptake, effective cytotoxicity along with improved PK profile of IODPM could make it a promising drug delivery strategy for cancer therapy.

Poster Session A

Poster A

P-A.006

Extremely Low Frequency Magnetic Effects on Thyroxine-Inducing Forced Metamorphosis of Mexican Axolotl (*Ambystoma mexicanum*)

H. Nakagawa, T. Tadokoro, M. Ohuchi

Text The experimental applications utilizing axolotls (*Ambystoma mexicanum*) must be favorable for a direct investigation with respect to aquatic-terrestrial transformations. This is because the axolotl has been the best understood “neoteny” which refers to a paedomorphosis. Accordingly, juvenile axolotls can be easily metamorphosed to mature salamanders by a function of thyroxine. In this study, we will report the influence of extremely low frequency (ELF) magnetic fields on axolotl metamorphosis induced forcibly with a thyroid hormone.
Mexican axolotls (32 individuals, about 5 months old, approximately 80 mm) were individually kept in 0.5-L square boxes containing 0.4 μM L-thyroxine (T_4) (0.4 L) without aeration at a temperature of 24ºC under an illumination of 250 $\mu Em^{-2}s^{-1}$ on a 12 : 12 h L : D photocycle. Following a soak with a thyroid hormone for 60 h, the T_4 solution was displaced by a dechlorinated water. Exposures of T_4-administrated axolotls to ELF fields (5.0 mT at 10–100 Hz) were performed using an air-cored coil system. The morphological changes of the axolotls influenced by the prestimulation of the T_4 were monitored every day, and the changes were evaluated minutely.
From our experimental results, we found that the initiation timings of ELF field exposure did affect the metamorphic rapidity of the T_4-administrated axolotls. Our data could prove to be helpful for future reference with respect to a magnetic control study of amphibian metamorphosis.

Poster Session A

Poster A

P-A.007

Facile Synthesis of Magnetic-Silica-Mannan Nanocomposites for Enhancement in Internalization and Immune Response by Dendritic Cells

K. Rodponthukwaji, P. Ritprajak, N. Insin

Text Magnetic nanoparticles have drawn much attention in biomedicine because their attractive properties such as biocompatibility, stability. Moreover, superparamagnetic property is also very attractive and unique. Vaccination is one of the applications that can utilize a magnetic delivery system to direct antigens and adjuvants to the targeted immune cells. Mannan has been reported as a good adjuvant, we were interested in producing magnetic-silica-mannan nanocomposites (MS-mannan) as a delivery system to target dendritic cells. In this work, we synthesized magnetic-silica nanocomposites (MS) via a simple thermal decomposition method. The nanocomposites clearly showed spherical shape with magnetic nanoparticles deposited on the surface. Subsequently, the obtained nanocomposites were modified with mannan. The obtained MS-mannan demonstrated negative charge. Under an external magnetic field, MS-mannan particles could facilitate intracellular uptake. Due to dual-functionality of mannan and magnetic nanoparticles and the abundance of mannose-receptors on dendritic cells, the MS-mannan nanocomposites greatly enhanced cellular uptake compared to the MS particles. Moreover, the dendritic cells exposed to MS-mannan nanocomposites showed high percentage of cell viability and performed a good immune response. The nanocomposites from this work can be beneficial for the development of effective delivery of antigen to targeted immune cells with enhanced immunization.

Poster Session A

Poster A

P-A.008

Fe_3O_4@mSiO_2 Nanoparticles: The Effect of Silica Shell Thickness on Magnetic and Proton Relaxometric Properties

T. G. St. Pierre, N. I. Taib, R. Woodward, M. J. House

Text Here, we report the effect of silica shell thickness on the changes in proton relaxivities (r_2 and r_1) and magnetic properties. Starting from hydrophobic 7-nm of Fe_3O_4, we have coated Fe_3O_4 with CTAB for phase transformation from hydrophobic to hydrophilic. Core-shell structure Fe_3O_4@mSiO_2 with different silica shell thickness have been obtained. The obtained Fe_3O_4@mSiO_2 have been characterized by TEM, FTIR, SQuID and the proton relaxivities of the nanoparticles have been determined. The presence of silica did alter the relaxivity with slightly increased the r_2, and dramatically decreased the r_1 of Fe_3O_4@mSiO_2. We find that the r_2 and r_1 relaxivity decreased with the increasing of silica shell thickness. Moreover, the high r_2/r_1 ratio shows that Fe_3O_4@mSiO_2 may serve as T_2 contrast agents in MRI.

Poster Session A

Poster A

P-A.009

FeCrNbB ferromagnetic particles with shape anisotropy for cancer cell destruction by magneto-mechanical actuation

H. Chiriac, E. Radu, M. Tibu, G. Stoian, G. Ababei, L. Labusca, D.-D. Herea, N. Lupu

Text Magnetic particles (MPs) were found useful in different cancer treatment applications such as magnetic hyperthermia and magnetic controlled delivery of antitumoral drugs at the targeted site of a tumor. Lately, cancer cell destruction techniques involving the movement of magnetic particles in alternative magnetic field were revealed [1].
In this work, we have tested the efficiency of a new type of glassy magnetic particles (MPs) prepared by wet milling of Fe-Cr-Nb-B precursor glassy ribbons [2], for cancer treatment by magneto-mechanical actuation in low magnetic fields (1÷20 Oe). The rectangular form of Fe-Cr-Nb-B MPs induces important magnetic shape anisotropies which, in association with a large saturation magnetization, generates an improved magneto-mechanical torque in a rotating magnetic field, producing important damages on the cellular viability of MG-63 human osteosarcoma (HOS) cells. The MPs concentration, frequency and intensity of the applied magnetic field, or the time of exposure have a strong influence on the cancer cells viability. The novel MPs can be used for the magneto-mechanical actuation alone or in association with hyperthermia and can also be transported to the tumor sites by means of stem cells carriers.
Acknowledgment – Work supported by the Nucleu Programme (Project PN 16 37 01 02 and PN 18 06 01 01).
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[2] Chiriac et al., J Appl Phys 115, 17B520 (2014)

Poster Session A

Poster A

P-A.010

Green Synthesis of Iron Oxide Nanoparticles (Fe_3O_4-NPs) using *Azadirachta Indica* Aqueous Leaf extract

N. I. Taib, F. Abdul Latif, N. D. S. Zambri

Text On treatment of aqueous solutions of ferrous and ferric salts in alkaline medium with Azadirachta indica leaf extract, the rapid formation of stable magnetite nanoparticles (Fe_3O_4-NPs) is observed to occur. Our synthesis method had utilized a much cheaper and less toxic iron precursor with environmental benign and non-toxic Azadirachta indica leaf extract was being used as a reducing and stabilizing agent. The structural and properties of Fe_3O_4 was investigated by X-Ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), Fourier Tansform Infrared (FTIR) spectroscopy and High Resolution Transmission Electron Microscopy (HRTEM). Results confirmed this protocol as simple, rapid, one-step, eco-friendly, non-toxic and can potentially useful in various applications.

Poster Session A

Poster A

P-A.011

Magnetic core-shell nanoparticles for biomedical applications: Properties of Fe_3O_4 MNPs core coated by mesoporous SiO_2

J. Szűcsová, A. Zeleňáková, O. Kapusta, L. Žid, E. Beňová, V. Zeleňák

Text During the last two decades, biocompatible and non-invasive materials for intelligent drug delivery systems based on mesoporous silica have attracted special attention, considering a big potential in biomedical applications. Multifunctional core–shell composites were investigated as potential drug carriers or/and agents for magnetic hyperthermia therapy. The silica nanoparticles are unique for their tailored mesoporous structure and high surface area compared to volume ratio, and as drug delivery systems they show many advantages over applying the drugs in traditional way. In presented work, core-shell mesoporous silica nanoparticles with ferromagnetic core and $mSiO_2$ shell, with pores that can incorporate drug molecules, were synthesized. A magnetic core composed of a Fe_3O_4 nanoparticles with average size up to 50 nm and coated with mesoporous silica with cavities were prepared through combination of co-precipitation and self-assembly methods. Magnetic properties were investigated using SQUID-based magnetometry in temperature range 2-400 K. Hydrodynamic properties, such as size, Zeta potential and isoelectric point, were measured by dynamic light scattering method. The comparison of the magnetic properties of blank Fe_3O_4 versus Fe_3O_4@$mSiO_2$ confirm the high value of M_S~35 emu/g and combination of superparamagnetic and ferromagnetic behavior in both systems. In addition, the effect of diamagnetic SiO_2 shell on mutual inter-particle magnetic interactions was studied.

Poster Session A

Poster A

P-A.012

Magnetic hyperthermia: Heating modification via easy axis alignment driven by Brownian rotation.

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Text Magnetic hyperthermia is a cancer therapy which utilises magnetic nanoparticles to generate heat to weaken or kill cancer cells. The nanoparticles are injected into cancerous tumours and an alternating magnetic field is applied across the patient leading to localised heat generation via hysteresis. The therapy's efficacy depends upon the heat generated and also the rate at which heat is dissipated into the tumour. The current project explores the significance of Brownian rotation on the heat produced via magnetic hyperthermia. A novel dynamic model has been developed, accounting for both Néel and Brownian rotation mechanisms via a modified LLG solver. The model has shown the presence of significant easy axis alignment during the hyperthermia process. At an applied field maximum of $0.45H_k$ the system's easy axes align perpendicular to the applied field. At $1.5H_k$ the easy axes align towards the field showing probability maxima at 5° and 175° from the field direction. Between these field strength maxima, a trimodal probability distribution is present revealing both perpendicular and concurrent alignment towards the field. It is postulated that the easy axis alignment is the result of the interrelationship of timescales within the system; specifically, the field sweep rate, easy axis and magnetisation timescales. The easy axis alignment in large fields gives rise to hysteresis and heating, whereas the perpendicular alignment leads to hard axis-like loops with reduced heating.

Poster Session A

Poster A

P-A.013

Magnetoplasmonic biosensing with PC-based multilayered structures

I. Savochkin, D. Ignatyeva, P. Kapralov, G. Knyazev, S. Sekatskii, G. Dietler, V. Belotelov

Text We present the results of the biosensing experiments using the novel type of the magnetoplasmonic multilayered structure. This structure contains alternating SiO2/Ta2O5 layers of 1D photonic crystal covered with a ferromagnetic thin metal layer of Co (8 nm width) and 25-nm thick dielectric layer that prevents Co from oxidation. Such structure supports excitation of the ultralong surface plasmon polariton wave in Co layer [1]. Magnitude of the measured transverse magnetooptical Kerr effect in the structure is 10% and the shift of the optical and magnetooptical resonance due to the refractive index of external medium change allows for the sensitivity up to 5·10^5%/RIU. Series of sensing experiments with propanol solutions of different concentrations were carried out to measure the sensitivity of the structure to the bulk refractive index change. After that, we performed sensing structure surface preparation by its modification with living E. Coli bacteria homogeneous and uniform layers. Using magnetoplasmonic measurements the kinetics of bacteria E.Coli interactions with monoclonal antibodies and bacteriophages T4 and T5 was studied.
The work was supported by RFBR, grant no.16-02-01065.
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Poster Session A

Poster A

P-A.014

Mapping the neuronal currents with spin electronics sensors

M. Pannetier Lecoeur, C. Chopin, J. Torrejon-Diaz, A. Solignac, E. Paul, C. Fermon

Text The electrical activity of neurons due to ionic currents generates magnetic fields which can be measured at large scale with helium-cooled magnetometers such as SQUIDS but local mapping requires micron-size sensors operating at physiological temperature. We have recently demonstrated that Giant Magnetoresistive (GMR) sensors can be used to detect neuronal magnetic signature within living tissues. Here we show probes developed on spin electronics principles to allow mapping of the neuronal activity within the various layers of the cerebral cortex. We have designed and fabricated needle-shape probes comprising an array of magnetic and electrical sensors to combine both information on the amplitude, direction and localization of the signal. Thanks to technique to locally orient the pinned layer of the GMR sensors we can access a 2D-mapping of the currents. The temporal resolution of these probes allows recordings of both single individual event such as Action Potential, as well as collective neuronal response. Such probes can open a new experimental way to access without contact of the information transmission processes in brain structures.

References:
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Poster Session A

Poster A

P-A.015

Modelling of magnetic nanosystem transport in a microvascular network

A. Manzin, M. Vicentini, R. Ferrero

Text Magnetic nanosystems can be advantageously used as contrast agents for MRI or mediators for hyperthermia treatment, as well as to label, deliver and separate biomaterials, also thanks to the capability to be magnetically manipulated, independently of microfluidic and biological processes. In *in vivo* applications, one crucial aspect is the control of their transport in the tissue microvasculature and their successive release into target areas, mechanisms that can be driven by external magnetic field gradients [1].
In this context, we present a numerical model for the simulation of magnetic nanosystem transport within a microvascular network, under the action of magnetic and viscous forces. The model, based on the coupling of the Landau-Lifshitz-Gilbert equation with classical Newtonian dynamics [2], is applied to investigate the role of various factors, like the spatial distribution of the external magnetic field, the viscous drag (simulated by means of Stokes' law) and the interparticle effects (e.g. the magnetostatic dipolar interactions). We also study the influence of the nanosystem shape and size on transport mechanism, accumulation and tendency to aggregate, by comparison to standard spherical nanoparticles. The focus is on magnetic nanodisks and nanorings, which have been recently proposed as efficient heat mediators for hyperthermia therapies [3].

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[3] Adv. Funct. Mater. 2015, 25, 812–820.

Poster Session A

Poster A

P-A.016

Optimizing magnetic characteristics of soft nano-ferrites particles by controlling stoichiometric ratios of cations for diagnostic and therapeutic agent applications

M. Jeun, S. Park, K. H. Lee

Text For several decades, soft nano-ferrite particles (SNFPs) have attracted a lot of attention from the biomedical fields. Accordingly, a great deal of works relevant to theoretical or practical researches of the SNFPs has been intensively conducted. In this study, we precisely controlled the stoichiometric ratio of cations in SNFPs to improve their magnetic characteristics and demonstrated their applicability to be used as diagnostic and therapeutic agents. The cations in the SNFPs were systematically controlled during the thermal synthesis process (HTTD: High Temperature Thermal Decomposition method). Then all the synthesized SNFPs were coated with lipid layer to disperse into liquid environments. The magnetic and structural characteristics of all the SNFPs were investigated to determine the optimized stoichiometric ratio. In addition, the behaviors in several types of buffer solutions were studied. In order to demonstrate the applicability of the optimized SNFP to biomedical agents, we used the SNFP in magnetic-based infectious disease diagnostic system and thermal treatment model as an agent. The optimized SNFP significantly improved the detection sensitivity of the magnetic-based diagnostic system as well as enhanced the efficiency of the thermal treatment system.

Poster Session A

Poster A

P-A.017

Response of individual and groups of magneto-tactic bacteria to external magnetic fields

T. Hageman, M. Pichel, L. Abelmann

Text We observed individual magneto-tactic bacteria (MSR-1) inside microfluidic chips under application of magnetic fields. We were able to proof that their trajectory is governed by the balance between magnetic torque and rotational drag torque,as has been suggested in literature but never been proven experimentally. We provide a model for the field dependent magnetic torque, including determination of the saturation torque, and determine the rotational drag for spiral shaped bacteria with different winding diameter and density. We observed single bacteria swimming in an eight-shaped pattern for hours, and show how they slowly loose speed and stop after 10-30 minutes. Next to observation in microfluidic chips, we analyse the transmission and scatter of a light beam through a colony of bacteria inside a cuvette, under application of a 3D magnetic field. With this simple setup we determined the density of bacteria, the fraction of the colony that responds to a magnetic field, the relation between magnetic moment and rotational drag coefficient, and, for MC-1 bacteria, the swimming speed distribution. The information obtained in these experiments on the physical properties of crucial importance to the application of magneto-tactic bacteria in drug delivery. We will present the first experiments of magneto-tactic bacteria attempting to traverse the human respiratory mucus.

Poster Session A

Poster A

P-A.018

Self-assembled metamagnetic FeRh nanoparticles

L. Motyčková, J. A. Arregi, J. Líška, V. Uhlíř

Text The vast majority of magnetic nanoparticles employed for biomedical applications are based on ferromagnetic compounds. This type of particles exhibit superparamagnetism upon size reduction and can be remotely controlled via magnetic field gradients, or heated by means of high-frequency alternating magnetic fields for therapeutic applications [1]. Here, we focus on the potential of another class of magnetic materials featuring metamagnetism. The FeRh-alloy presents a first-order phase transition from antiferromagnetic to ferromagnetic state just above room temperature (~360 K), where the magnetic order can be controlled by magnetic fields, temperature, electrical currents, hydrostatic pressure, or optical beams. Another remarkable property of FeRh consists in the extraordinary amount of latent heat released across the transition [2]. In this work, we grow self-assembled FeRh nanoparticles exploiting the observation that metallic films deposited on oxide substrates tend to grow in the shape of nanoislands as a way to minimize their surface energy. We have sputter deposited FeRh on MgO substrates using different temperature protocols, identifying those that cause FeRh films to segregate into sub-micron-sized islands as well as optimizing the conditions for which a large fraction of particles undergoes the phase transition slightly above room temperature.

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Poster Session A

Poster A

P-A.019

Solution for whole-body magnetic fluid hyperthermia treatment considering adverse effects

H. Mamiya, B. Jeyadevan

Text Magnetic fluid hyperthermia therapy is considered as a promising treatment for cancers including unidentifiable metastatic cancers that are scattered across the whole body. However, a recent study on heat transfer simulated on a human body model showed a serious side effect: occurrences of hot spots in normal tissues due to eddy current loss induced by variation in the irradiated magnetic field. The indicated allowable upper limit of field amplitude H_{ac} for constant irradiation over the entire human body corresponded to approximately 8 kA/m at a frequency f of 25 kHz. The limit corresponds to the value Hacf of 2×10^8 $Am^{-1}s^{-1}$ and is significantly lower than the conventionally-accepted criteria of 5×10^9 $Am^{-1}s^{-1}$. The present study involved evaluating maximum performance of conventional magnetic fluid hyperthermia cancer therapy below the before-mentioned limit, and this was followed by discussing alternative methods not bound by standard frameworks by considering steady heat flow from equilibrium responses of stable nanoparticles. Consequently, the clarified potentials of quasi-stable core-shell nanoparticles, dynamic alignment of easy axes, and short pulse irradiations indicate that the whole-body magnetic fluid hyperthermia treatment is still a possible candidate for future cancer therapy [1].

[1] Mamiya et al. J. Nanomater. (2017) 1047697.

Poster Session A

Poster A

P-A.020

Structure and magnetic properties of nanocomposite silica/Fe-O spheres

P. Pawlik, K. Pawlik, M. Laskowska, Ł. Laskowski, M. Zubko, M. Dulski

Text A novel type of spherical particles composed of mesoporous silica spheres (MCM-41) and iron-oxide magnetic nanoparticles filling in their pores, were successfully synthesized. The globular silica matrix was obtained with use of a modified Stöber process. In this technique the mesoporous silica spheres were synthesized from tetraethyl orthosilicate compounds dissolved in an aqueous solution containing ionic surfactant, ammonia and ethanol as described in [1, 2]. This process leads to formation of porous silica spheres in sizes ranging from 100 to 200 nm with pore diameters of 1.5 nm. Subsequent precipitation of iron-oxide inside pores of the silica template results in superparamagnetic behavior of the composite samples due to a presence of elongated Fe-O nanoparticles taking the shape of the silica pores. Such nanocomposite structures having significant magnetization strength can be successfully employed for medical applications, such as a drug delivery or a heat generation in magnetic hypothermia treatment. In the present work the studies of microstructure were performed using transmission electron microscopy while the phase composition was determined using vibrational spectroscopies, X-ray diffractometry and Mössbauer spectroscopy. The magnetic properties were measured using vibration sample magnetometry.
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Poster Session A

Poster A

P-A.021

Surface Functionalised Transition Metal Oxide Nanostructures: Novel Properties and Biomedical Applications

K. Mandal, I. Chakraborty, S. Talukdar

Text Transition metal oxide nano-hollow spheres (NHSs) are found to be potential candidates for many applications particularly in biomedical research because of their high magnetic saturation, large surface area, good dispersion in liquid, improved ability to withstand cyclic changes in volume and better imaging. They are successfully used to encapsulate and control the release of sensitive materials such as drugs, cosmetics and DNA.
Recently we reported intrinsic multicolour fluorescence in ferrite nanoparticles upon functionalization with organic ligands such as Na-tartrate, malate and citrate because of ligand to metal charge transfer and Jahn−Teller distorted d−d transitions [1, 2]. In the present paper, we report the preparation of ferrite NHSs with diameter 100-500 nm and their surface functionalisation with Na-Tartrate and Na-Folate. The size dependence magnetic properties of surface functionalized NHSs are found to be better than that of the corresponding solid particles. The above materials exhibit excellent photoluminescence properties which improve with the increase in pH and in presence of a magnetic field. Functionalized NHSs can be loaded with cancer drugs such as doxorubicin and can be targeted towards cancer cells. DNA can also be successfully attached with them [2].
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Poster Session A

Poster A

P-A.022

Synthesis and Properties of Bi-Phasic and Core-Shell Structure Magnetic Nanoparticles for Biomedical Applications

A. Kamzin

Text This review focuses on the recent progress in synthesis and characterization of engineered magnetic BP and CS structures in terms of their fundamentals of magnetism, hyperthermia applications, magnetic resonance imaging, and drug delivery, as well as the synthesis approaches and application examples.
BP MNP consists of two magnetic materials with opposite magnetic properties, for ex. hard (spinels ferrites, hexaferrites) and soft (manganites) magnets, magnetic materials (with high magnetic parameters) and biocompatible (for ex. Hydroxyapatite or other) magnetic and ferroelectric materials. When combined in a single system as BP, the hard magnetic properties of the hexaferrites and the tunability of the manganites lead to the potential for novel or dual-functional devices such as an all-oxide magnetic tunnel junction.
CS MNP consists of an inner core which made of a one material coated with another material as an external shell. So, in the case of CS MNP it is possible to combine materials with a high magnetic moment (for ex. Iron or others) as core and a shell (for ex. iron oxide or others) with good biocompatibility. Such structural features allow the possibility of combining specific properties of varied materials.
In review shown that 57Fe Mössbauer spectroscopy is an important tool to extract information about the relationship between the structure and magnetic properties of materials, and provides evidence for changes due to substitution effects in magnetic materials.

Poster Session A

Poster A

P-A.023

Synthesis and characterization of DMSA stabilized superparamagnetic iron oxide nanoparticles

I. Sharifi

Text Magnetic nanoparticles have attracted due to their potential applications in many biomedical fields, such as magnetic fluid hyperthermia and MRI contrast enhancement. These applications need that the magnetic nanoparticles have narrow particle size distribution, high magnetization behavior with unchanging physical and chemical properties. In this study, iron oxide nanoparticles have been synthesized by thermal decomposition method. After that nanoparticles coated by DMSA as a stabilizer in the water-based colloidal system. The XRD patterns showed single-phase spinels without any impurities. Also, TEM displays a good distribution of 8±2 nm particles. FTIR Spectroscopy confirmed single-phase spinel in nake and coated magnetic nanoparticles. The IR spectra of the sample shown that high-frequency bands v1 and v2 are at 580 cm-1 and 377 cm-1, respectively. These bands indicate tetrahedral and octahedral sub-lattice in the spinel structure. As well, FTIR analysis shows that DMSA coated nanoparticles have small changes in spinel bands due to the effect of coating on the length of the Fe-O bond. The magnetic measurement showed about 2Oe coercivity in the samples. That can be shown the superparamagnetic behavior of the nanoparticles. Additionally, saturation magnetization was measured for the naked sample 41.16 emu/g. with respect the magnetic and structural analysis, DMSA coated nanoparticles can be a good candidate for biomedical applications.

Poster Session A

Poster A

P-A.24

Advantageous performance of carbon-coated superparamagnetic nanoflowers for paper-based immunoassays

A. Moyano, M. Salvador, J. Martínez-García, M. Blanco-López, M. Gónzalez-Gómez, Z. Vargas Osorio, Y. Piñeiro, J. Rivas, M. Rivas

Text Lateral flow immunoassay (LFI) is a rapid, simple and cost-effective test, widely used as a point-of-care biomedical diagnostic tool.1 Its most popular example is the pregnancy test. It is a paper-based platform for detection of biomarkers consisting mainly of three parts: a nitrocellulose membrane, with an absorbent pad at one end, and a conjugate pad at the other end (see Figure 1). The liquid sample flows along the membrane by capillarity and the biomolecule under test gets caught on a line (the test line) by a specific antibody. To make the line visible, the biomarker is previously and specifically labelled by nanoparticles.

Traditionally, as the technique relies on a visual signal, it is a positive/negative test meant to verify the presence/absence of the biomolecule under test. Adding the quantifying ability is a challenge for which we have used superparamagnetic nanoparticles (instead of the traditional gold or latex labels) combined with a magnetic reader.2 Moreover, if the particles display strong colour intensity, we can profit from both, optical and magnetic measurements.

In this work we explore two strategies to improve the magnetic lateral immunoassays: (i) Substituting the monodisperse nanoparticles by nanoflowers, and (ii) Coating the nanoflowers with carbon instead of a polymer3 (we previously used polyacrylic acid.)
To test the performance of the carbon coated nanoflowers Fe3O4@C as LFI labels we have chosen a model system by conjugating the particles to neutravidin and testing them against biotin printed across the membrane. At the biotin line they were retained due to the strong, specific and non-covalent interaction between biotin and neutravidin, forming the test line (see Figure 2.)

For the bioconjugation of nanoparticles, carbodiimide crosslinker chemistry and direct conjugation were tested. This was the first advantage obtained compared to polymer-coated particles: the crosslinker was found to be unnecessary as the bioconjugation took place optimally by direct conjugation with the carbon coating, which enormously simplifies the complexity of the process, and reduces the cost.

The colour intensity of the Fe3O4@C on the test line was even larger than that of Au nanoparticles, as can be seen by naked eye on Figure 2. Finally, the magnetic signal (obtained with an electromagnetic sensor sensitive to the particles' stray fields2) is substantially larger than that of monodisperse magnetite particles, and more sensitive and precise that the optical signal (obtained with a commercial strip reader ESE-Quant LR3 lateral flow system, QIAGEN.)

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Poster Session A

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Poster Session A

Poster A

P-A.025

Carrier doping effect of magnetic and transport properties on the geometrically frustrated iridate $Ca_5Ir_3O_{12}$

S. Haneta, Y. Yasukuni, C. Oka, M. Wakeshima, Y. Hinatsu, K. Matsuhira

Text $Ca_5Ir_3O_{12}$ has a hexagonal structure with space group of *P*-62m. In the crystal structure, it should be noted that one-dimensional chains of the edge-sharing IrO_6 form triangular lattices. $Ca_5Ir_3O_{12}$ has a mixed valance state of Ir^{4+} and Ir^{5+} and the averaged valence of Ir ions is +4.67 [1]. It is reported that $Ca_5Ir_3O_{12}$ shows a semiconducting conductivity and an antiferromagnetic (AFM) ordering below T_N =7.5 K [1]. In addition, $Ca_5Ir_3O_{12}$ indicates a second order of phase transition at 105 K, where the electrical resistivity shows a sharp bending; the origin of phase transition at 105 K is not clear at the present [1-3]. Recently, we reveals that $Ca_5Ir_3O_{12}$ shows nonlinear conductivity [4].
In this presentation, we will show the carrier doping effect of magnetic and transport properties. The carrier doping is done by substitution of Ca^{2+} by Na^{+}, La^{3+} and Bi^{3+}; Na substitution is hole doping, and La or Bi substitution is electron doping. The electrical resistivity decreases by the hole or electron doping. Although the AFM Curie Weiss temperature increases to 30 K by the Bi10% doping, that is 3 times larger in comparison with $Ca_5Ir_3O_{12}$, T_N decrease down to 5.0 K. The magnetic frustration becomes stronger by the electron doping.

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Poster Session A

Poster A

P-A.026

Co Induced Modification in Magnetic Properties of NdMn1-xCoxO3 (0.2 ≤ x ≤ 0.3)

F. H. Bhat, G. Anjum, V. Kumar, R. Dogra, I. Shvets, R. Kumar, M. A. Malik

Text We present here the magnetic properties of NdMn1-xCoxO3 (0.2 ≤ x ≤ 0.3) samples prepared by solid state reaction method. X-ray diffraction measurements at room temperature reveal its single phase orthorhombic structure. In magnetization vs temperature studies done at field strength of 0.1 T the field cooled (FC) and zero field cooled (ZFC) magnetization curves for both x = 0.2 and 0.3 samples diverge at 300 K with a separation which goes on increasing as the temperature decreases. This bifurcation may represent the magnetically disordered state or spin-glass like behaviour resulting from the existence of an inhomogeneous mixture of a ferromagnetic and antiferromagnetic state. The separation between FC and ZFC curves decreases with increase in field strength (0.5 & 1T) along with sharp increase in both FC and ZFC magnetization at low temperature. This clearly indicates that at low temperature the AFM ordering is broken and the system behaves like a FM. The magnetization measurements versus magnetic field were done upto 0.5T at different temperatures of 10, 100 & 250 K for the samples with x = 0.2-0.3.The shape of hysteresis indicates the presence of a ferromagnetic component in both the samples. At a given temperature the magnetization decreases with increase in Co concentration and at low temperature unsaturated FM state is established which complements the results of magnetization vs temperature study.

Poster Session A

Poster A

P-A.027

Collective Relaxation Phenomena in Dipole-Coupled Molecular Magnetic Solids

A. Garg

Text Low-temperature relaxation in solids of SMM's such as Fe_8 is a novel time-dependent phenomenon with strong inhomogeneity in the magnetic field, wherein the role of the dipolar coupling is central[1]. Each spin can flip only if the total field acting on it is less than a scale W set by the spin's nuclear spin environment. The dipolar field, H_{dip}, by contrast is $\sim 10^6 W$. This generates a very slow, complex, collective dynamics, highly non-exponential in time. Each spin waits until its local field < W. It then has some chance of flipping. A flip changes the field on $H_{dip}/W \sim 10^6$ neighboring spins, which in turn can flip and influence other spins. The critical issue is to understand how the disorder or distribution of H_{dip} evolves in time.

We have studied this problem using Monte Carlo and numerical solutions of kinetic equations of motion for demagnetization and Landau-Zener-St\"uckelberg protocols [2]. The results agree well with experiments. The *magnetization* protocol, on the other hand, is far more challenging, as one must now follow energy relaxation also. It appears that as M relaxes, the energy is held in the dipolar field. One must extend previous work to include correlations between H_{dip} and the spin on a site.

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Poster Session A

Poster A

P-A.028

Comparison of magnetic properties of nanocomposite and bulk rare earth titanates Ho2Ti2O7 and Yb2Ti2O7

A. Rinkevich, O. Nemytova, D. Perov

Text Detailed comparison of magnetic properties of nanocomposite and bulk samples of frustrated magnets is carried out. Classical spin ice material Ho2Ti2O7 and candidate of quantum spin ice material Yb2Ti2O7 are chosen as the objects of investigation. Nanocomposite samples contain titanate particles with the dimension less than 50 nm located in the inter-spherical voids of opal matrices. Bulk titanates Ho2Ti2O7 and Yb2Ti2O7 do not have a hysteresis loop at the temperature range from 2 to 50 K. The magnetization curves measured at the different temperatures are approximated by the Brillouin function. Nanocomposite titanates have a hysteresis loop. The magnetization values for the bulk and nanocomposite titanates in the equal fields are different. Moreover, the differences are not in proportion to the volume fraction of titanate in nanocomposite samples but several times larger. This fact indicates a high defectiveness and stoichiometry violation of nanocomposite titanates. For bulk titanates Ho2Ti2O7 and Yb2Ti2O7 at the temperature range from 2 to 50 K the Curie law approximately holds. For nanocomposite titanates the Curie-Weiss law does not hold at all and there is a difference of temperature dependencies of susceptibility measured under the cooling and heating.

Poster Session A

Poster A

P-A.030

Critical properties of the two-dimensional spin-pseudospin model on a square lattice

V. Ulitko, Y. Panov, D. Yasinskaya, A. Moskvin

Text To describe the antiferromagnetic and charge ordering competition in cuprates, we consider static spin-pseudospin model. The three components of the S=1 pseudospin triplet are associated with the three different valence charge states of the CuO4 center of CuO2 plane in cuprate and one component has the conventional spin s=1/2. This model generalizes the site-diluted Ising model on a square lattice by an accounting of the on-site and inter-site correlation energy for charged nonmagnetic impurities. The phase diagram of the model contains several pseudospin-ordered (charge-ordered) and spin-ordered phases. Here we explore the critical properties of the system by classical Monte-Carlo simulation. In order to determine the critical temperature, we used the method of fourth-order Binder cumulants. The static critical exponents of the heat capacity, the susceptibility, the ordering parameter, and the correlation length are calculated by means of the finite-size scaling theory.

Poster Session A

Poster A

P-A.031

ESR and magnetic phase diagram of the weakly ordered spin-1/2 chain system Sr_2CuO_3

E. Sergeicheva, S. Sosin, D. Gorbunov, S. Zherlitsyn, G. Gu, I. Zaliznyak

Text We report on the results of magnetic resonance and ultrasonic experiments in a weakly ordered antiferromagnet
Sr_2CuO_3 known as one of the best realizations of a spin-1/2 chain Heisenberg system with extremely small inter- to intra-chain exchange constants ratio $J'/J \sim 10^{-4}$ (J=2800 K). The proximity to a Luttinger-liquid state reveals itself in a very low ordering temperature T_N=5.4 K << J and unusually small value of an order parameter $0.06\mu_B$ [1].

Our electron-spin resonance studies [2] uncovered two different types of magnetic excitations in an ordered phase of Sr_2CuO_3. Apart from conventional Goldstone modes with small gaps induced by weak biaxial anisotropy, we observed a novel resonance branch arising below T_N which is supposedly related to a specific gapped longitudinal mode predicted to exist in the proximity to a critical point [3]. This gap decreases linearly with magnetic field and softens at a field $\mu_0 H_c \sim 9$ T indicating quantum phase transition.

In addition, a magnetic phase diagram is established using high sensitive phase-locked loop ultrasonic measurements. The presence of the field-induced phase transition is confirmed, with the nature of a high field phase still remaining unclear. Considerable increase of T_N in magnetic field up to 20% at $\mu_0 H \sim 10$ T is also observed. Both findings challenge further theoretical studies of the system.

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Poster Session A

Poster A

P-A.034

Effects of nonstoichiometry and substitution on frustrated magnetism of ferrite spinel $ZnFe_2O_4$

Y. Fujita, Y. Sugaya, T. Kusada, B. Nakagawa, H. Yamada, T. Watanabe

Text Ferrite spinel $ZnFe_2O_4$ is considered to be a geometrically-frustrated magnet, where magnetic Fe^{3+} ($3d^5$) ions with spin S = 5/2 form the sublattice of corner sharing tetrahedra (pyrochlore lattice). The magnetic susceptibility in this compound exhibits an antiferromagnetic-transition-like anomaly at ~ 13 K, while the ferromagnetic Weiss temperature θ_w ~ +120 K. However, the neutron scattering experiments in $ZnFe_2O_4$ revealed the absence of long-range magnetic order at low temperature of ~ 1.5 K, which implies that the frustration survives down to low temperatures in this compound.
We study effects of nonstoichiometry and substitution on the frustrated magnetism of $ZnFe_2O_4$ by investigating structural and magnetic properties of polycrystalline $Zn_{1-x}Fe_{2+x}O_4$, $Zn(Fe_{1-x}Mn_x)_2O_4$ and $Zn(Fe_{1-x}Co_x)_2O_4$. The magnetic susceptibility measurements in Fe-rich $Zn_{1-x}Fe_{2+x}O_4$ ($x > 0$) reveal that the magnitude of the antiferromagnetic Weiss temperature $\theta_w < 0$ is strengthened with increasing the Fe-rich nonstoichiometry x. Additionally, the magnetic susceptibility in the Fe-rich $Zn_{1-x}Fe_{2+x}O_4$ ($x > 0$) exhibits the appearance of spin-glass-like behavior at low temperatures below T_f ~ 11 K. Taking into account that $|\theta_w/T_f|$ in the Fe-rich $Zn_{1-x}Fe_{2+x}O_4$ ($x > 0$) increases with increasing x, the present study reveals that the frustration of $ZnFe_2O_4$ is enhanced by introducing the Fe-rich nonstoichiometry.

Poster Session A

Poster A

P-A.036

Frustrated optical lattice: from topological excitations to deconfined phase transition

X. Zhang, Y.-C. He, S. Hu, A. Pelster, R. Moessner, F. Pollmann, S. Eggert

Text We analyzed the repulsive particles in the frustrated optical lattice. For the anisotropic triangular lattice, we find the bosonic domain walls are excited. Such topological defects can continuously change the crystal structure, so that the exotic incommensurate supersolid is observed. Similar phenomena can also be found in the kagome optical lattice. When choosing cylindrical boundary condition, we found a novel edge liquid phase with fractional charges (spinons) linked by quantum strings (effective gauge field). In the strong coupling limit, we obtained the effective lattice gauge field theory which shows easy-plane NCCP1 form. And it hints the phase transition from valence bond solid to superfluid can be continuous one which is beyond Ginzburg-Landau symmetry breaking diagram. Recently, such topological phase transition is verified by utilizing large scale quantum Monte Carlo simulations.

Poster Session A

Poster A

P-A.037

Frustrated quantum Heisenberg antiferromagnets: around the localized-magnon paradigm

O. Krupnitska

Text There is a class of frustrated Heisenberg antiferromagnets (flat-magnon-band Heisenberg antiferromagnets) the properties of which can be described within the frames of localized-magnon paradigm [1]. On the other hand, there are several compounds which may show localized-magnon physics. One example is a natural mineral azurite the low-temperature magnetic properties of which can be explained using the spin-1/2 Heisenberg antiferromagnetic model on a frustrated diamond-chain lattice with a set of parameters which are close to the localized-magnon point [1, 2]. Another almost perfect realization of the frustrated square-lattice bilayer spin-1/2 Heisenberg antiferromagnet is a magnetic compound Ba2CoSi2O6Cl2 [3]. Using the localized-magnon picture, we have elaborated an effective low-energy theory which allows to explain the low-temperature high-field thermodynamics of frustrated quantum Heisenberg antiferromagnets with almost localized magnons (i.e., almost flat magnon band). We have applied this theory for explanation of experimental data for azurite [4, 5] and for magnetic compound Ba2CoSi2O6Cl2 [6].

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Poster Session A

Poster A

P-A.038

Ga substitution effect in the geometrically frustrated multiferroic delafossite CuCrO2: a Monte Carlo and ab initio approach

D. Ledue, A. Albaalbaky, Y. Kvashnin, R. Patte

Text In CuCrO2, an incommensurate magnetic configuration, close to the 120° spin configuration expected for a perfect planar triangular antiferromagnet, has been reported below its Néel temperature TN ≈ 24 – 26 K. This incommensurate magnetic state is due to magnetic frustration and lattice distortion. Few years ago, it was shown that doping CuCrO2 by Ga3+ (S = 0) in the Cr3+ sites (S = 3/2) results in a material that may combine the good performances from both semiconductors CuCrO2 and CuGaO2. In this work, we investigate the effect of Ga substitution on the magnetic and ferroelectric properties of CuCrO2 by Monte Carlo simulations using exchange interactions extracted of density functional theory calculations. Our simulations show that CuCr1−xGaxO2 (x ≤ 0.15) still possess antiferromagnetic ordering where TN decreases as the fraction of Ga3+ increases, while it turns to become disordered states for x ≥ 0.2. We also found that the spins in CuCr1−xGaxO2 for x ≤ 0.2 lie in a unique spiral plane while that for x = 0.3 go out of the spiral plane and randomly oriented in all directions. Thus spin-glass-like behavior appears for x = 0.3 due to the loss in the long range magnetic ordering. On the other hand, we find that CuCr1−xGaxO2 preserves its ferroelectric properties up to x = 0.2 where clear hystereses are seen upon spiral ordering takes place but with a decrease in the saturation polarization.

Poster Session A

Poster A

P-A.039

Influence of disorder on the nonequilibrium critical behavior of 3D and 2D Ising models

V. V. Prudnikov, P. V. Prudnikov, P. N. Malyarenko

Text Such features of nonequilibrium behavior as aging and violation of the fluctuation–dissipation theorem are observed in systems that experience second-order phase transitions [1]. In presented work the effect of structural defects and different initial values m_0 of magnetization on the nonequilibrium critical behavior of the 3D and 2D Ising models have been analyzed numerically using the Monte Carlo. Analysis of the two-time dependences of the autocorrelation function and dynamic susceptibility has revealed a superaging effect which associated with the domain wall pinning at structural defects.

Calculations of the limiting fluctuation-dissipation ratio (FDR) show that for the initial states with $0.25 \le m_0 \le 1$ the values of the FDR become equal to zero and are determined by the dynamics of domains in the long-term regime. For initial states with $0.02 \le m_0 \le 0.1$, the domain structure dynamics is not manifested in the long-term regime. As a result, the FDR values correspond to different universality classes for the pure as well as for disordered Ising models. Influence of disorder on the nonequilibrium critical behavior of 2D Ising model is developed through crossover effects of percolation threshold influence [2].

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Poster Session A

Poster A

P-A.041

Magnetic Properties of Quasi-Two-Dimensional Oxyborates Ni5Sn(BO5)2 with Ludwigite Structure

S. Sofronova, E. Eremin, A. Bovina

Text At present, the study of physical properties of magnetic quasi-low-dimensional compounds intensively developed. Oxyborates with ludwigites structure are the members of such type of compounds due to the presence of quasi-two-dimensional elements in their structure. The unit cell of ludwigites includes 4 non-equivalent positions which can be occupied by magnetic cations.
In this work, powder Ni5Sn(BO5)2 with ludwigites structures were synthesized by flux method, using the fluxes based on bismuth trimolybdat with addition of sodium carbonate. Magnetic characterization of the samples was carried out. Magnetic transition occurs at the temperature of 72 K. The temperature dependencies of ac-magnetization have two features at 15 and 72 K.
Indirect exchange interactions calculation was held for the compound Ni2MnBO5 in frameworks of the Anderson-Zavadskiy indirect exchange interactions model. Calculation results showed that exchange interactions are weak and frustrated between plane, but quite strong inside the plane, and that ferromagnetic and atiferromagnetic interaction competition presents between ions in plane and ions connected planes.

Poster Session A

Poster A

P-A.042

Magnetic excitations and transport properties in frustrated ferromagnetic chain

H. Onishi

Text In ordinary magnetic insulators, elementary excitation from a magnetic ordered state is described by a magnon, which is a quantized spin wave. Magnons carry spin current and thermal current. In contrast, frustrated quantum magnets frequently exhibit non-trivial ground states and elementary excitations. Thus we expect that novel types of carriers would contribute to spin and thermal transport phenomena. Here we focus on a spin nematic state in a spin-1/2 frustrated ferromagnetic chain. In the spin nematic state, low-energy excitations are governed by bound magnons, so that bound magnons carry spin current and thermal current. Regarding magnetic excitations, we find gapless longitudinal and gapped transverse spin excitation spectra, in accordance with quasi-long-range longitudinal and short-range transverse spin correlations, respectively, while we observe gapless quadrupole excitations, signaling quasi-long-range quadrupole correlations. In the present work, we investigate spin and thermal transport properties by exploiting numerical methods, such as exact diagonalization and density-matrix renormalization group. We will discuss the effects of bound magnon propagation in spin and thermal transport, based on detailed analyses of current-current correlation functions in the spin nematic ground state, and temperature and field dependencies of the spin Drude weight and the thermal Drude weight.

Poster Session A

Poster A

P-A.043

Magnetic ordering process and phase diagram of a honeycomb lattice compound InCu2/3V1/3O3 via magnetoresonance technique study

E. Vavilova, M. Iakovleva, H.-J. Grafe, A. Möller, T. Taetz, B. Büchner, V. Kataev

Text The S=1/2 Heisenberg frustrated antiferromagnet InCu(2/3)V(1/3)O3 appears to be a rare model of a honeycomb lattice compound with very weak interlayer magnetic couplings. Such a weak coupling and the spin frustration should prevented from the development of the long-range AFM order (peak is not shown by heat capacity measurements). However our previous studies on this compound have revealed signatures of an AFM transition at T*=38K [1]. In present study, we used Nuclear Quadrupolar Resonance and Nuclear Magnetic Resonance and high-field ESR techniques to investigate the local magnetic properties of InCu(2/3)V(1/3)O3 in combination with static magnetization data. The 115_In NMR as well as NQR spectra show a line splitting at T<T* which is a signature of the development of local magnetic fields in the vicinity of a magnetic phase transition. The T-dependence of the longitudinal relaxation rate shows a characteristic sharp peak upon approaching T*=38 K. These facts together with some features of ESR spectra indicate the establishment of 2D order, most likely of short-range type. Remarkably, with further decreasing temperature a second peak of NMR and NQR relaxation develops at T**=18 K. It is accompanied by the development of AF modes in ESR spectra and spin-flop transition in magnetization that can be an evidence of 3D long-range order. We discuss the possible scenario of magnetic ordering process in InCu(2/3)V(1/3)O3

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Poster Session A

Poster A

P-A.044

Magnetic properties of Cu/Co/Cu antidots with different pore size

H. Garad, F. Fettar, L. Cagnon, D. Barral, P. David, S. Usmani, D. Testemale, A. Rosa, O. Mathon, S. Pascarelli, D. Mannix

Text By reducing the size of magnetic material, fascinating physical properties might be induced. As example, nonmagnetic holes separating a continuous magnetic film is currently studied. Indeed the lateral size (**d**) and the separation from center to center (p) of holes controllably tune the magnetic properties. By defining the separation from edge to edge of antidots, namely **λ**=p-**d**, the major published results report either a variation of coercive field H_C as the form $H_C \approx \boldsymbol{\lambda}^{-1}$ or the appearance of a maximum. In addition, by focusing on the hysteresis loop, (one or two)-step magnetization reversal is often observed. These 2 last features are not completely understood. Magnetic properties of sputtered Cu/Co/Cu antidots with different **d** values [in the (15-80) nm range] are studied at 300K and at 5K using SQUID, where p=100nm. This leads to **λ**=(15-85)nm. For planar magnetic field, an $H_C \approx \boldsymbol{\lambda}^{-1}$ law is recorded for both temperatures. A two-step magnetization reversal is only observed for intermediate λ values [(40-60)nm]. For perpendicular magnetic field, a unique magnetic reversal is observed, and $H_C(\boldsymbol{\lambda})$ presents a maximum for λ≈30nm at 5K and 300K. Similar behaviors of exchange bias fields $H_E(\boldsymbol{\lambda})$ are also detected at 5K. Indeed, Co oxidation are favored, as revealed from X-Ray Absorption measurements. These magnetic properties will be analysed in light of structural and topological results.

Poster Session A

Poster A

P-A.045

Magnetic properties of ludwigites

R. Eremina, T. Gavrilova, I. Gilmutdinov, A. Kiiamov, E. Moshkina, S. Sofronova

Text Here we present the investigations of structural and magnetic properties of Cu-based compounds of the ludwigite family: Cu_2GaBO_5 and Cu_2AlBO_5. The important peculiarity of the presenting here type of ludwigite is the presence of Jahn-Teller cation in the structure. Because of the strong distortions of the nearest surroundings Cu ions the original magnetic structure is expected.
The Cu_2GaBO_5 and Cu_2AlBO_5 single crystals (the max. size: 4x10x3 mm3) were synthesized by the flux method in the form of orthogonal prisms. The synthesized samples have a monoclinic symmetry and belong to the P21/c space group. Curie temperatures were determined from the temperature dependencies of magnetic susceptibility, $T_C \approx$-85K for Cu_2AlBO_5 and -70K for Cu_2GaBO_5, respectively. Antiferromagnetic order transition was observed in Cu_2GaBO_5 monocrystal at 4K. We described the specific heat temperature dependence at 0, 1, 3 and 9T. To analyze the magnetic structures and estimate the superexchange interactions in Cu_2GaBO_5 crystal, we used a simple indirect coupling model32 based on the theory of the super-exchange interaction.
This work was supported by the RFBR no 17-02-00953.

Poster Session A

Poster A

P-A.046

Magnetic properties of novel iron oxoselenite $Fe_2O(SeO_3)_2$: ferrimagnetic sawtooth chain

E. Kozlyakova, E. Kuznetsova, A. Akhrorov, P. Berdonosov, A. Sobolev, I. Presniakov, A. Tsirlin, O. Volkova, A. Vasiliev

Text The sawtooth or delta chain is a spin chain of vertex-sharing triangles, that can be considered as a segment of highly frustrated kagomé lattice. In isotropic antiferromagnetic case of quantum spins, S = ½, this network attracts attention as a candidate for a spin liquid ground state. The distortion of a triangle partially relieves the frustration which results in ferrimagnetic arrangement of the magnetic moments within delta chain.

In this work, we first time investigated thermodynamic properties of the iron oxoselenite, $Fe_2O(SeO_3)_2$, which hosts unique tilted sawtooth chains formed by Fe^{3+} ions, in mixed octahedral/tetrahedral coordination. Single crystals and powders were synthesized by gas transport reaction and hydrothermal technique, respectively, and studied in measurements of magnetization, specific heat and Mössbauer spectroscopy. Prediction of exchange interaction order was made by DFT calculations.

We suggest ferrimagnetic tilted sawtooth chain model to describe the whole set of experimental data. In our case there is hierarchy of numerous exchange interactions, that influence the observed magnetic response of the compound. Our suggestions have to be verified in future neutron scattering measurements.

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Poster Session A

Poster A

P-A.048

Magnetization Dynamics of Thermally Active Square Artificial Spin Ice

M. Pohlit, G. Muscas, A. Ciuciulkaite, H. Stopfel, E. Östman, P. Jönsson, B. Hjörvarsson, V. Kapaklis

Text Over the last decades, the collective behaviour in ensembles of strongly interacting single-domain magnetic nanoparticles has been a matter of considerable interest. Artificial Spin Ice (ASI), i.e. arrays of dipolar coupled ferromagnetic islands – mesospins – fabricated by nanolithography, exhibit similar collective phenomena, while the interaction strength between the islands and their geometric arrangement can be tailored at will. Furthermore, ASI, properly designed to support thermal fluctuations, can serve as an ideal platform to study thermal dynamics and thermodynamic phase transitions, which can mimic the dynamical properties of frustrated, naturally occurring magnetic spin systems. Here, we adapt the temperature dependent AC susceptibility method based on the Magneto-Optical Kerr effect, a technique well known for probing relaxation dynamics in magnetic particle ensembles and spin glasses, to explore the magnetization dynamics of square ASI. A broad frequency dependent peak in the real part of the susceptibility is observed, when the corresponding observation time window matches the relaxation time of the system, indicating mesospin dynamics at a temperature lower than the Curie temperature of the material. These dynamics originate from the interplay between intrinsic mesospin dynamics and dipolar interactions in the ASI lattice. We set out to disentangle these contributions to the switching field distribution of the ensemble using First Order Reversal Curves (FORC).

Poster Session A

Poster A

P-A.050

Measurement of symmetric and asymmetric magnetization curve by Lock-in Amplifier

T. Shirane, Y. Shouji

Text The measurement of linear (χ_0) and nonlinear (χ_n : n >0) susceptibilities have been recognized an effective method of studying magnetic response at temperatures near the Curie point T_C [1]. The most common method of measuring χ_n makes use of a mutual inductance bridge. A magnetic sample is placed in a core of a transformer whose secondary coil is a first-order gradiometer. The χ_0 and χ_n are measured by detecting $n\omega$ components of an induced voltage using a lock-in amplifier. Many experimental results of χ_n at temperatures near T_C have shown that magnetic loss and nonlinearity of magnetization significantly increase in the critical region below T_C [2]. These imply a magnetization curve has a complicated hysteretic behavior even in very low field. However, the measurement of a magnetizaton curve in such a very low field is difficult to be performed by a usual technique. In previous paper, we proposed a new method to measure hysteretic magnetization curves by using a lock-in amplifier with a harmonic-detection function [3]. The drawback of this method has been not to be able to measure asymmetric magnetization curve. In this work, we report a measuring method of asymmetric magnetization curves. The detailed experimental method and results will be shown in the full paper.

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Poster Session A

Poster A

P-A.051

Non-Fermi liquid behavior realized in doped pyrochlore $Y_2Ir_2O_7$

T. Taniguchi, H. Nomura, J. Angel, R. Asih, I. Watanabe, K. Matsuhira

Text $Y_2Ir_2O_7$ is a J_{eff}=1/2 Mott insulator, showing AFM transition at 165 K [1,2]. The AFM state with Ir moments with "all-in/all-out" configuration which is observed in metal-insulator transition of $Nd_2Ir_2O_7$ is theoretically predicted [1,3]. Theoretical study for pyrochlore iridates predicts a new quantum critical phenomena (QCP) around the disappearance of AFM with "all-in/all-out" configuration by chemical doping [4]. We have investigated the effect of chemical carrier doping for pyrochlore iridates in order to reveal the theoretically predicted QCP and novel phase.

In this presentation, we will show the effect of hole doping for $Y_2Ir_2O_7$. The present hole doping was carried out by fixing 5% of Cu substitution and increasing the amount of Ca substitution; a small amount of substitution of Cu improves a reactivity. We have performed the resistivity, thermoelectric power, specific heat, magnetic susceptibility, and □SR measurements. By this hole doping, AFM ordering is rapidly suppressed, and the conductivity becomes metallic behavior; AFM disappears at Cu5% and Ca20%. Then, the resistivity at Cu5% and Ca20% shows $T^{0.67}$ dependence below 40 K down to 0.35 K, that is clearly deviated from T^2 dependence expected in Fermi liquid.

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Poster Session A

Poster A

P-A.052

Nonequilibrium critical dynamics of low-dimensional frustrated magnets and multilayer structures

P. V. Prudnikov, V. V. Prudnikov, I. S. Popov, M. V. Mamonova, V. O. Borzilov

Text Magnetic multilayers and low-dimensional magnets demonstrates the slow critical evolution from a nonequilibrium initial state. Aging, coarsening and memory effects are nontrivial features in the non-equilibrium behavior of such systems with slow dynamics [1]. This study includes the Monte Carlo simulation of the nonequilibrium critical evolution from different initial states of frustrated low-dimensional magnetics [1] and multilayers based on anisotropic Heisenberg films [2].

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Poster Session A

Poster A

P-A.053

Phase diagrams of a 2D Ising spin-pseudospin model

Y. Panov, V. Ulitko, K. Budrin, A. Chikov, A. Moskvin

Text To consider the competition of magnetic and charge ordering in high-T_c cuprates, a simplified static 2D spin-pseudospin model was earlier proposed. This model is equivalent to the 2D dilute antiferromagnetic (AFM) Ising model with charged impurities. In a mean-field approximation (MFA), five phases are realized in the ground state, depending on the concentration of charged impurities and the ratio between the exchange and the inter-site charge interaction constants and the on-site correlation parameter. It is shown that the cases of strong exchange and strong charge correlation differ qualitatively. For a strong exchange, the spin AFM phase is unstable with respect to the phase separation into the charge and spin subsystems, which behave like immiscible quantum liquids. The temperature dependence of the specific heat exhibits two successive phase transitions: first, AFM ordering in the spin subsystem diluted by randomly distributed charged impurities, and second, the condensation of impurities in the charge droplets. The temperature of condensation of impurities in the charge droplets is given by singularity of the spin-pseudospin correlator. In the case of strong charge correlation, one has a frustration in the charge-ordered ground state of the system. For numerical simulation, a high-performance parallel computing program was implemented using the classical Monte-Carlo method. The calculated temperature phase diagrams of the system are compared with the MFA results.

Poster Session A

Poster A

P-A.054

Pressure Effect to the Resistivity of a Heavy-Fermion Amorphous Alloy $Ce_{80}Ru_{20}$

Y. Amakai, K. Ishihara, H. Hitotsukabuto, S. Ito, Y. Kawamura, T. Nakano, S. Murayama, N. Momono, H. Takano

Text Amorphous (*a*-)$Ce_{80}Ru_{20}$ alloy exhibits a large electronic specific heat coefficient γ (> 200 mJ/molK^2, x = 80) and the T^2 dependence of resistivity with the large coefficient A is observed at low-temperature. These behaviors suggest that this alloy forms a heavy-fermion (HF) state even in the amorphous structure. In this work, in order to investigate the pressure effect to the HF state for *a*-$Ce_{80}Ru_{20}$ alloy, we have measured resistivity under pressure.
The amorphous $Ce_{80}Ru_{20}$ was prepared by a DC high-rate sputtering method from the arc-melted ingot onto water-cooled Cu substrate. The electrical resistivity ρ was measured by using a standard four-probe method (Quantum Design PPMS) from 2 to 300 K. Resistivity under hydrostatic pressure up to 1.3 GPa was measured by using a CuBe piston-cylinder cell set up in the PPMS.
The ρ at the ambient pressure for *a*-$Ce_{80}Ru_{20}$ decreases with decreasing temperature, and we found a shoulder of the ρ at T_{sh} ~ 10 K. The T_{sh} increases rapidly with applying pressure, and becomes 240 K at 0.8 GPa. The coefficient A of the T^2-dependence at low-temperature ρ decreases rapidly with increasing pressure, and is smaller by one order of magnitude than the value of the ambient pressure at more than 1 GPa. The large enhancement of the T_{sh} and the decrement of the A-value by applying pressure imply the increase of the Kondo temperature T_K. Therefore, the HF state in the *a*-$Ce_{80}Ru_{20}$ alloy is considered to be suppressed by the applying of slight pressure.

Poster Session A

Poster A

P-A.055

Pressure-dependent x-ray diffraction of multiferroic RMn_2O_5

W. Peng, V. Balédent, M.-B. Lepetit, M. Greenblatt, P. Foury-Leylekian

Text Multiferroics have attracted enormous attention, due to their fascinating physics and potential applications. The report of remarkable magnetoelectric coupling in $TbMn_2O_5$, exhibiting reversible and reproducible variation of the electric polarization by applying a magnetic field makes the RMn_2O_5 (R= rare earth, Bi, and Y) family exceptional. As small variations of the interatomic distances directly modify the superexchange integrals of this complex system, it is crucial to elucidate the multiferroic properties of RMn_2O_5 under external parameters, such as external magnetic field and pressure.

Recently, enhanced polarization has been observed in RMn2O5 (R=Tb, Ho and Y) compounds under pressure, as well as the apparition of a new magnetic phase. It is thus urgent to study accurately the structural properties of the RMn_2O_5 compounds under pressure. In this work, we have systemically studied the structure and properties of RMn_2O_5 (R=Pr, Nd, Sm, Gd, Tb and Dy) under pressure at room temperature by using powder x-ray diffraction. We evidence the anisotropic contraction of the unit cell parameters, under pressure, *a* presents a greater contraction than *b* and *c*. We also show that theR^{3+}, Mn^{3+} and Mn^{4+} atomic displacements present different behavior according to the nature of R. In addition, the position of R^{3+}, Mn^{3+} and Mn^{4+} do not involve linearly with
the pressure. These results will help to understand the influence of the pressure on the multiferroic properties of this series.

Poster Session A

Poster A

P-A.056

Quantization of gapped Z_2 spin liquid low-energy thermal excitations in $SmMnO_{3+\delta}$

F. Bukhanko, A. Bukhanko

Text In the given work have been investigated features of the temperature dependences of $SmMnO_{3+\delta}$ samples magnetization M(T) in the range of temperatures $4.2 \leq T \leq 20$ K, received in dc fields H=100 Oe, 1 kOe and 3.5 kOe in FC - mode of measurements. According to the conventional models of a gapped Z_2 quantum spin liquid, asymmetric double-humped peak feature of M(T) close to T_{spinon}= 8 K founded at H=100 Oe corresponds to a continuous spectrum of low-energy magnetic thermal excitations in a kind of a 2D spinon gas with S = 1/2, smeared in the range of temperatures 6 – 10 K. With growth of intensity of a magnetic field to value H = 1 kOe asymmetric double-humped peak feature M(T) with the centre close 8 K is transformed to the symmetric peak smeared in more wider interval of temperatures 4.2-12 K with top near to temperature T_{spinon}. It is supposed that expanded peak feature of M(T) in $SmMnO_{3+\delta}$ in intermediate field H=1 kOe corresponds to a continuous spectrum of low-energy magnetic excitations of a gapped Z_2 quantum spin liquid in the form of 2D spinon gas with high density, induced by growth of an internal gauging "magnetic" field. At the further growth of an dc external field to H = 3.5 kOe, a continuous spectrum of spinon excitations in the form of expanded peak feature of a magnetization near 8 K is transformed to a discrete spectrum of the low-energy thermal excitations of a gapped Z_2 quantum spin liquid in the form of quantum oscillations of M(T).

Poster Session A

Poster A

P-A.057

Quantum spin dynamics of weakly coupled Ising spin chains in an exotic spin-density wave phase.

S. Nikitin, L. Wu, Z. Wang, C. D. Batista, L. Vasylechko, G. Ehlers, M. Lumsden, M. Brando, A. Podlesnyak

Text Quantum phase transitions are a matter of special interest in condensed matter physics for last decades from both experimental and theoretical points of view and among all quantum critical materials, one-dimensional (1D) quantum spin systems attract a considerable attention due to strong quantum fluctuations.
In this work, we have investigated novel Yb-based quasi-1D compound, $YbAlO_3$ perovskite. We observed that Yb moments have extremely strong Ising-like anisotropy and form weakly coupled antiferromagnetic spin chains, running along the *c*-axis with very weak magnetic interactions within the *ab*-plane, despite the 3D perovskite structure. We followed the evolution of the ground state with applying of magnetic field along easy-axis using magnetization, specific heat, single crystal neutron diffraction and inelastic neutron scattering (INS) measurements. At temperature below 150 mK and field range between H = 0.32 T and H = 1.1 T we found an elusive quantum incommensurate phase, similar to the longitudinal spin-density phase, previously observed in Ising-like spin ½ quasi-1D antiferromagnet $BaCo_2V_2O_8$. Our INS measurements shed the light on the unconventional gapless spin excitations within this phase.

Poster Session A

Poster A

P-A.058

Reentrant spin-glass state formation in polycrystalline Er2NiSi3

S. Pakhira, C. Mazumdar, R. Ranganathan, M. Avdeev

Text Magnetically frustrated systems are of great interest and one of the most adorable topics for the researcher of condensed matter physics, due to their various interesting properties, viz. ground state degeneracy, finite entropy at zero temperature, lowering of ordering temperature, etc. Ternary intermetallics with the composition RE2TX3 (RE = rare-earth element, T= d electron transition metal and X= p electron element) crystallize in hexagonal AlB2 type crystal structure (space group P6/mmm). In a hexagonal crystal structure with antiferromagnetic interaction between the moments, the center moment is geometrically frustrated. Magnetic frustration along with disorder arrangements of non magnetic ions are the building blocks for metastable spin-glass ground state formation for most of the compounds of this stoichiometry. The newly synthesized compound Er2NiSi3 compound forms in single phase in AlB2 type structure with space group P6/mmm. The compound orders antiferromagnetically below 5.4 K and spin freezing of the frustrated magnetic moments occurs below 3 K for the compound. The compound shows magnetic relaxation behavior and magnetic memory effect below its freezing temperature. Neutron diffraction patterns for temperatures below the spin freezing temperature have been analyzed using FULLPROF software package. Diffuse magnetic scattering at low temperatures yields spin glass state formation for the compound.

Poster Session A

Poster A

P-A.059

Relaxation of spin excitations in strong-leg spin ladder with non-magnetic doping

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Text We have studied relaxation in spin ladder magnet called DIMPY $(C_7H_{10}N)_2Cu_{(1-x)}Zn_xBr_4$. DIMPY is unique compound described by strong-leg spin ladder model [1]. Non-magnetic Zn doping in DIMPY results in the formation of bonded clusters near dopant called “spin islands” [2]. In our case clusters are strongly correlated.
The earlier study of pure DIMPY revealed the presence of uniform Dzyaloshinskii-Moriya interaction [3]. Because of the gap, ESR absorption signal in pure DIMPY is freezing out on cooling. In doped DIMPY ESR signal follows the same route above 4K, but does not vanish at low temperatures down to 450mK. Thus, we could highlight two regimes of spin dynamics in doped DIMPY: triplets-dominated (T>4K) and clusters-dominated (T<1K). Scaled angular dependencies in the triplets-dominated regime for different concentrations of Zn (x=0-6%) are the same, it means that type of the relaxation also is the same. However, we observed narrowing of ESR line in both regimes. The decrease of ESR linewidth in triplets-dominated regime indicates suppression of some relaxation channels with doping. Tentatively this can be interpreted as a reduction of DM vector mean length. The linewidth decrease in clusters-dominated regime indicates clusters interaction and increasing of the lifetime of the triplets excitations.
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Poster Session A

Poster A

P-A.061

Spin Glass transition in AuFe, CuMn, AuMn, AgMn and AuCr systems

A. da Silva Jr, A. Martins, M. de Campos

Text The transition from ferromagnet to spin glass was investigated in the systems AuFe, CuMn, AuMn, AgMn and AuCr.
The used method was a Simulated Annealing Monte Carlo.
The evaluated Hamiltonian has two contributions,
one considering the exchange energy and other taking into account the external applied magnetic field.
In the simulation, it was compared the Heisenberg Hamiltonian with the long-range RKKY Hamiltonian.
It is found that the RKKY Hamiltonian is able to predict with great accuracy the experimentally observed transition temperatures in the evaluated systems.
However, it is essential that the complete RKKY Hamiltonian be considered. In other words, this means that distant next neighbors need to be taken into account in the calculations.

Poster Session A

Poster A

P-A.062

Spinon magnetic resonance in a quasi-1D spin-1/2 antiferromagnet with a weak exchange interaction

T. Soldatov, A. Smirnov, K. Povarov, M. Hälg, W. Lorenz, A. Zheludev

Text A quasi-one-dimensional spin-1/2 antiferromagnet $K_2CuSO_4Cl_2$ is a rare example of a model spin-chain compound with Dzyaloshinsky-Moriya (DM) interaction of the uniform type. According to theory, e.g. [1], for quantum spin-1/2 chain, exhibiting a two-spinon continuum of excitations, the uniform DM interaction modifies excitation spectrum by a shift in momentum space. Besides, an unusual spin gap opens at the center of the Brillouin zone. The fine structure in the form of an ESR doublet should occur in a magnetic field **H** || **D** (**D** is DM vector). The gap is about DM energy *D*, see [1].
In this paper we check the formation of the spinon gap in $K_2CuSO_4Cl_2$, which has much lower values of *D* (still unknown) and exchange integral *J* = 3 K, compared to Cs_2CuCl_4 and $K_2CuSO_4Br_2$, previously studied. The measurements were done in the frequency range 0.7 - 50 GHz. Upon cooling from 10 to 0.4 K the single ESR line shifts to higher fields at **H** || **D** and to lower fields at **H** $\perp$ **D**. This is in accordance with the predicted behavior of low-frequency component of the doublet at **H** || **D** and with the shift of single gapped spinon mode at **H** $\perp$ **D**. Below 1 GHz the ESR line broadens significantly, probably indicating sub-gap regime with a gap of 1 - 2 GHz.
Thus, the observed behavior of ESR in $K_2CuSO_4Cl_2$ is in a correspondence with the scenario of modification of spinon continuum, despite we have failed to discover the pronounced doublet.

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Poster Session A

Poster A

P-A.064

Substitution effects on frustrated magnetism of chromite spinel ACr_2O_4 (A = Zn and Cd)

Y. Koga, R. Okada, S. Kobayashi, H. Yamada, T. Watanabe

Text Cubic spinel chromites $ZnCr_2O_4$ and $CdCr_2O_4$ are considered to be typical spin-frustrated magnets, where magnetic ions of Cr^{3+} ($3d^3$) with spin S = 3/2 form the sublattice of corner sharing tetrahedra (pyrochlore lattice). While Weiss temperatures of $ZnCr_2O_4$ and $CdCr_2O_4$ are $\theta_W \sim$ -390 K and $\theta_W \sim$ -70 K, respectively, an antiferromagnetic transition occurs at low temperature of $T_N \sim$ 12 K for $ZnCr_2O_4$ and $T_N \sim$ 7.8 K for $CdCr_2O_4$.

We study the Cr-site substitution effects on the frustrated magnetism of $ZnCr_2O_4$ and $CdCr_2O_4$ by investigating structural and magnetic properties of mixed crystals $Zn(Cr_{1-x}Fe_x)_2O_4$ and $Cd(Cr_{1-x}Fe_x)_2O_4$. In these mixed crystals, orbital-inactive Fe^{3+} ($3d^5$) with spin S = 5/2 is substituted for orbital-inactive Cr^{3+} ($3d^3$) with spin S = 3/2. The X-ray diffraction experiments at room temperature confirm that $Zn(Cr_{1-x}Fe_x)_2O_4$ and $Cd(Cr_{1-x}Fe_x)_2O_4$ form the spinel-type cubic crystal structure in all the Fe concentration range of x = 0 ~ 1. The magnetic susceptibility measurements in $Zn(Cr_{1-x}Fe_x)_2O_4$ and $Cd(Cr_{1-x}Fe_x)_2O_4$ reveal that, with increasing the Fe concentration x, the Weiss temperature θ_W changes from negative to positive values at $x \sim$ 0.3, indicating the competition of antiferromagnetic and ferromagnetic interactions. Additionally, the present study reveals that $Zn(Cr_{1-x}Fe_x)_2O_4$ and $Cd(Cr_{1-x}Fe_x)_2O_4$ with $x \sim$ 0.3 exhibit anomalous spin-glass-like behavior, which might be a result of the introduction of bond frustration into the geometrically-frustrated system.

Poster Session A

Poster A

P-A.065

Substitution effects on magnetism of Laves phase compounds $TiFe_2$ and $NbFe_2$

Y. Fukushima, H. Ishii, Y. Takei, S. Enomoto, M. Ogawa, M. Saito, T. Watanabe

Text Laves-phase compounds $TiFe_2$ and $NbFe_2$ have C14-type hexagonal crystal structure, which contains Kagome lattice sheets of the Fe atoms. $TiFe_2$ and $NbFe_2$ respectively exhibit an antiferromagnetic transition at $T_N \sim 290$ K and a spin-density-wave (SDW) transition at $T_{SDW} \sim 10$ K. The magnetic orders of these compounds are very sensitive to nonstoichiometry. For $TiFe_2$, the Fe-rich nonstoichiometric $Ti_{1-x}Fe_{2+x}$ ($x > 0$) exhibits a ferromagnetic transition at $T_c \sim 350$ K, while the Ti-rich nonstoichiometric $Ti_{1-x}Fe_{2+x}$ ($x < 0$) exhibits an antiferromagnetic transition at $T_N \sim 290$ K. For $NbFe_2$, the SDW transition temperature T_{SDW} in the Fe-rich nonstoichiometric $Nb_{1-x}Fe_{2+x}$ ($x > 0$) is enhanced with increasing the Fe-rich nonstoichiometry, and a ferromagnetic order appears at $x > 0.01$. On the other hand, for the Nb-rich nonstoichiometric $Nb_{1-x}Fe_{2+x}$ ($x < 0$), the SDW transition temperature T_{SDW} is suppressed with increasing the Nb-rich nonstoichiometry, and a ferromagnetic order appears at $x < -0.02$. Recently, $NbFe_2$ has attracted much interest due to the possible emergence of quantum criticality in the nonstoichiometric $Nb_{1-x}Fe_{2+x}$, which can be tuned by the amount of nonstoichiometry x at around $x_c \sim -0.015$. We study the element substitution effects on the itinerant-electron magnetism of $TiFe_2$ and $NbFe_2$ by investigating structural, electrical, and magnetic properties of polycrystalline $Ti(Fe_{1-x}M_x)_2$ and $Nb(Fe_{1-x}M_x)_2$ (M = Co and Mn).

Poster Session A

Poster A

P-A.066

Supercrystals of magnetic nanoparticles as promising candidates for the superferromagnetic state.

V. Russier, J. Richardi, I. Lisiecki, A.-T. Ngo, C. Salzemann, M. Konczykowski, C. Raepsaet, V. Mosser, S. Nakamae

Text Single domain nanocrystals (MNC) coated by a non-magnetic layer and fixed in a solid matrix interact through dipolar interactions (DDI) which, combined with the intrinsic magnetocrystalline anisotropy (MAE) lead to complex magnetic phases as the superspin glass (SSG) [1]. For long-range-ordered MNC supercrystals with fcc or bcc structure a super ferromagnetic (SFM) phase is expected for small values of the MAE to DDI strengths ratio, λ_u, although their experimental realization is still debated.
We focus on the numerical modelisation of the onset of the SFM phase and on the experimental realization of such 3D MNC assemblies made with Co [2] or γ -Fe_2O_3 MNC. The latter present a weaker anisotropy, which decreases λ_u and thus favor the creation of SFM phase. To unambiguously detect the SPM/SFM or SPM/SSG transition in supercrystal samples, we are developing a local magnetometry using micro-Hall probes. Using Monte Carlo simulations in the framework of the finite size scaling for fcc lattices of spherical MNC [3], we determine the threshold value of λ_u beyond which the SFM order disappears due to the MAE induced disorder.

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Poster Session A

Poster A

P-A.068

3D Reconstruction of Magnetization using Soft X-ray Transmission Tomography

A. Hierro Rodriguez, D. Gürsoy, C. Phatak, C. Quiros, A. Sorrentino, L. M. Alvarez-Prado, M. Velez, J. I. Martin, J. M. Alameda, E. Pereiro, S. Ferrer

Text Novel devices and structures such as 3D nanomagnets can present high level of complexity[1]. Their study needs the development of novel characterization techniques. This work introduces a new method to obtain 3D magnetic reconstructions of arbitrary systems by using dichroism and soft X-ray tomography[2]. Recently, the volume resolved magnetic reconstruction has been experimentally demonstrated by C.Donnelly et al.[3] using hard X-rays. Our approach exploits the high dichroic contrast of magnetic elements in the soft X-ray range to acquire high quality data from reduced number of images without compromising reconstruction accuracy compared with the hard X-rays approach. The proposed method uses two orthogonal tilt series acquired with both positive and negative dichroism. These tomograms are jointly processed using a modified Algebraic Reconstruction Technique for obtaining the 3D magnetization of the sample. The method has been applied to two simulated magnetic particles: a nanodisc and a heterostructure. The obtained 3D magnetization configurations have been compared with the original ones. The results are in agreement with the ground truth and can be quantitative. This suggests that our method has great potential to characterize highly complex magnetic systems, 3D nanomagnets and novel spintronic devices.

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Poster Session A

Poster A

P-A.069

A new mixed magnetic state in ferromagnetic CoFeB ring structures

A. Kovács, A. Kákay, J. Caron, J. Fassbender, R. Dunin-Borkowski

Text It is generally accepted that a thin ferromagnetic ring structure can adopt either a flux-closed vortex state or an 'onion' state, in which the two arms of the ring are magnetized parallel to each other. Here, we use quantitative off-axis electron holography to reveal new magnetic states in hexagonal CoFeB ring structures. Samples were prepared by using magnetron sputtering to deposit 30-nm-thick CoFeB onto hexagonal GaAs nanowires with diameters of between 80 and 120 nm. Thin ring-shaped structures were prepared by slicing individual nanowires using focused ion beam milling. Remanent magnetic states in the rings were studied using off-axis electron holography in magnetic-field-free conditions in an aberration-corrected transmission electron microscope operated at 300 kV. The magnetic moments in the two halves of the rings were found to be parallel to each other, but separated by vortices with opposite senses. The experimental results were compared with finite element micromagnetic simulations performed for rings of different thickness revealing the limiting factors for the different magnetic states.
The authors are grateful to J. Arbiol, D. Grundler, D. Meertens, A. Fontcuberta i Morral and R. R. Zamani for the provision of samples and ongoing collaborations. This work was supported by EU's 7th Framework Programme/ER-C Grant Agreement No. 320832.

Poster Session A

Poster A

P-A.070

Actinide Spintronics

E. R. Gilroy, C. Bell, R. Springell

Text Large spin-orbit coupling in metals , such as platinum and palladium, is promising for producing highly spin polarised currents for spintronics via the spin Hall effect. However, the presence of induced magnetic moments in heavy elements at interfaces with ferromagnets is known to occur, but the effect on spin transport across the interface is an unresolved question. Naively, due to its large mass, uranium is another interesting candidate for studying spin-orbit coupling and spintronics. Notably, it has been shown using x-ray circular dichroism (XMCD) that a significant induced moment occurs in Fe/U multilayers but not in Ni/U or Co/U. These results motivate magnetotransport studies of FM/U bilayer thin films, where FM = Fe, Ni or Co, to disentangle the role of spin-orbit coupling from that of induced moment. In the first instance, we focus on room temperature magnetometry and magnetoresistance measurements for various U thicknesses. We will discuss our preliminary studies which show potential oscillations of in-plane anisotropy with increasing U thickness. These results may be reminiscent of the XMCD work.

Poster Session A

Poster A

P-A.071

Bi-metal nanostructures within nanostructured silicon with respect to permanent nanomagnets

K. Rumpf, P. Granitzer, R. Gonzalez-Rodrigues, J. Coffer, P. Poelt, H. Michor

Text The purpose of this work is to fabricate nanostructured silicon with two different materials of embedded magnetic nanostructures to exploit the magnetic properties of both metals and gain control of the exchange coupling between the two metals especially with respect to their volume ratio. Furthermore a variation of the structure size and the proximity of the metal deposits modify the exchange coupling and thus the energy product. The final goal is to achieve nanocomposits with an energy product as high as possible to give rise to on-chip applications using permanent nanomagnets, especially arranged in arrays.
Two different templates, porous silicon and porous silicon nanotubes are utilized to achieve such nanocomposites. The morphology (pore diameter, tube diameter) of the two systems is comparable. In the case of the utilization of porous silicon templates the oriented and separated pores are filled with two different metals, namely Ni and Co which are deposited alternatingly by electrodeposition. A further approach is the chemical growth of Co nanoparticles within porous silicon nanotubes (SiNTs) and the additional deposition of a Ni layer on the outer surface of the tubes. Since the silicon wall of the tubes offers a porous structure the Co particles, which are localized near the pore surface on the wall of a given nanotube, can touch the Ni layer and thus exchange coupling between them is enabled.

Poster Session A

Poster A

P-A.072

Changes in the micromagnetic structure of ferrite-garnet films in external electric fields

V. Koronovskyy

Text Changes in the domain structure (DS) of ferrite-garnet films under joint action of DC and AC electric fields were investigated by the method of optical dark field microscopy with the direct visual observations [1]. This paper is a continuation of our earlier researches [2,3]. We revealed the magnetoelectric (ME) activity effect of vertical Bloch lines (VBL) of the films in E-fields in our experimental conditions which is visually manifested as a broadening of the regions of VBL localization. This broadening can be interpreted as the effect of additional amplification by the external spatially homogeneous E-field of the initially existing micro-slope of the domain wall (DW) region in the vicinity of the VBL. Moreover a complex influence on the film by two channels is manifested not only the above-described effect of the ME activity in the region of VBL, but also ME "activity" effect of the DW's is visualized. Results of our investigations show that in ferrite-garnet films have a transformation of the inhomogeneous magnetic structure caused by the ME interaction due to the E-fields influences on distribution of the magnetization in these films. Reaction of the DS to influence of E-fields was caused by changing the magnetic anisotropy parameters of the films in E-field.

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Poster Session A

Poster A

P-A.073

Co/Pd-based synthetic antiferromagnetic multi-stacks on Au/Resist underlayer: towards biomedical applications

G. Varvaro, S. Laureti, D. Peddis, G. Barucca, D. Nissen, O. Lik, M. Albrecht

Text Mesoscale magnetic particles are a major class of materials with the potential to revolutionize current clinical diagnostic and therapeutic techniques. They are commonly fabricated by bottom-up chemical methods; however, recent studies have demonstrated that top-down approaches based on techniques developed for micro/nano electronics can be used to fabricate monodisperse magnetic micro/nanoparticles with a complex structure and shape that are hard to obtain by chemical routes. In this work, we exploited the possibility to use thin film stacks consisting on multiple repeats ($1 < M < 8$) of single [Co/Pd]N/Ru/[Co/Pd]N ($N = 4, 5, 6$) units with antiferromagnetic coupling and perpendicular anisotropy, as a potential starting material to fabricate free-standing synthetic antiferromagnetic micro/nano-disks by the subsequent micro/nano-fabrication processes. For this purpose, films were directly grown on a sacrificial resist layer spinned on a Si substrate, which would serve to obtain free-standing micro/nano-disks after its dissolution. The multi-stack fulfills all the key criteria required for biomedical applications up to $M = 6$, together with the ability to vary the total magnetic moment (by changing M) without significantly affecting any other features. Moreover, the samples show a strong perpendicular uniaxial magnetic anisotropy that is desired for all the applications relying on the transduction of a mechanical force via the micro/nanodisks in an applied field.

Poster Session A

Poster A

P-A.074

Co2FeIn Heusler nanowires prepared by electrochemical deposition

L. Galdun, V. Vega, Z. Vargova, E. Barriga-Castro, C. Luna, R. Varga, V. Prida

Text Heusler alloys, one of the fascinating group of materials face a new challenge because of the accessing the nanoscale regime. The evolution of nanotechnology offers the opportunity to incorporate new materials into the products of industrial companies such as data storage devices or disk read/write heads. This give rise to the large interest in the preparation of metallic nanowires such as Fe-Co-Ni, prepared by electrochemical deposition into the anodic aluminum oxide (AAO) membranes [1].
Half-metallic character of Co2-based Heusler alloys offers great advantage due to their potential application as a highly spin-polarized current source in the field of spintronic devices [2].
Here, we report on structural, morphological and magnetic properties of Co2FeIn nanowires prepared via electrochemical deposition in the AAO membranes. The diameter of the single nanowire is of about 180 nm with additional 10 nm SiO2 protective layer and averaged chemical composition of Co46.8 ±0.5 Fe25.4 ±1 In27.8 ±1 and A2 disordered polycrystalline structure. Magnetic measurements revealed that the easy magnetization axis is very close to the nanowire axis.

This work has been supported by NanoCEXmat ITMS 26220120035, VEGA 1/0060/13, APVV-0027-11, APVV 16-0079 and Spanish MINECO research funds under project Nº MAT2013-48054-C2-2-R.

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Poster Session A

Poster A

P-A.075

Compensation points in GdFeCo thin films

E. Kunitsyna, O. Koplak, R. Morgunov

Text Magnetic properties of the Ta(3nm)/Pt(5nm)/Gd21.6Fe67.8Co10.5(20nm)/IrMn(7nm)/Pt(3nm) heterostructures with perpendicular magnetization were measured in 2 – 300 K temperature range. These structures attract interest of specialists as good platform for development of the optically controlled magnetic records provided by new physical effect which is All Optical Switching (AOS) of the local magnetization under femtosecond laser impulse [1]. Unusual temperature dependence of the hysteresis loop was found. Decrease of the temperature down to 100 K leads to diminishing of the saturation magnetization till zero. Following cooling below 50 K causes increase of MS. Coercive field monotonically increases with temperature decrease. Compensation point at 100 K is strongly shifted in comparison with 150 K observed in GdFeCo films of similar composition [1]. Compensation of the magnetizations of the FeCo and Gd sublattices will be considered in single layered as well as in double layered GdFeCo structures. The temperature dependence of the magnetic anisotropy will be discussed in the work.

Authors are thankful to S.Mangin for the samples presented in our disposal. This work was financially supported by Ministry of Education and Science of Russian Federation grant 3.1992.2017/4.6.

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Poster Session A

Poster A

P-A.076

Competing effects of dipolar interactions and surface anisotropy in assemblies of magnetic nanoparticles : impact on physical observables

F. Vernay, J.-L. Déjardin, H. Kachkachi

Text We present a general analytical framework for computing the physical observables of interacting nanomagnets assemblies. In the dilute case, it is possible to derive explicit and useful formulae for a direct interpretation of the FMR [1] or AC susceptibility shift [2], on the basis of microscopic physical parameters such as anisotropy and dipolar coupling. We show that, depending on the particle's material and shape, intrinsic surface anisotropy and inter-particle dipolar interaction may compete and eventually lead to a mutual compensation of their effects with a zero frequency shift.
Our results agree with earlier works on dipolar interactions only [3,4]. Here, we further extend the study to more realistic situations by taking into account surface effects which are of critical importance in nanomagnets. We think that the analytical expressions we have obtained for the FMR frequency shift and AC susceptibility could help set up a qualitative analysis of future experiments on various arrays of nanoelements. In particular, our work contributes to a better understanding of the effect of dipolar interactions that is necessary for optimizing the specific absorption rate in view of practical applications such as magnetic hyperthermia [5].
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Poster Session A

Poster A

P-A.077

Description of ion irradiation driven changes of magnetic anisotropy in ultrathin Co films with Pt and Au surroundings

Z. Kurant, P. Mazalski, W. Dobrogowski, J. Fassbender, A. Wawro, A. Maziewski

Text We propose a convincig method to tune magnetic anisotropy by Ga^+ ion irradiation in ultrathin epitaxial Pt/Co(d_{Co})/Pt films [1]. Two-dimensional (cobalt thickness d_{Co}, Ga ion fluence F) diagrams of coercivity and magnetic anisotropy fields have been derived from local magnetooptical polar Kerr effect (PMOKE) based measurements. The out-of-plane magnetization regions in the shape of two branches are distinct on the 2D (d_{Co}, F) diagrams. However, the similar irradiation of ultrathin cobalt layers with other covers – like Au/Co(d_{Co})/Pt, Pt/Co(d_{Co})/Au or Au/Co(d_{Co})/Au – results in different modifications of magnetic properties e.g. lack of two out-of-plane magnetization branches in Au/Co/Pt films [2]. Here we explain observed non-monotonic character of the magnetic anisotropy changes in 2D (d_{Co}, F) representation. Proposed model allows estimating the surface and volume contributions of the anisotropy in the specific regions. Presence and position of the Au layer in the films influence both the surface and volume contributions. The film with Au cap layer exhibits higher surface and smaller volume contributions than those with Pt cap layer. Obtained results are discussed in the context of processes occurring at the interfaces.
Supported by the NCN FUGA project (DEC-2015/16/S/ST3/00450).
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Poster Session A

Poster A

P-A.078

Development of a New Soft X-ray Ptychography Spectro-Microscope at the Swiss Light Source (SLS)

M. Langer, C. A. F. Vaz, S. Chiriotti Alvarez, A. Bergamaschi, M. Guizar-Sicairos, A. Kleibert, J. Raabe

Text Avoiding the use of X-ray optics, several diffractive imaging techniques were recently developed with the possibility to map the phase and the amplitude contrast while pushing the resolution limit towards the wavelength of the incident light.
We are currently developing a new soft X-ray ptychography spectro-microscope with the goal to provide wavelength-limited images of a broad variety of materials. The instrument will particularly be suited for magnetic imaging, since the 3d transition metal absorption edges are within this energy range enabling imaging at a high X-ray magnetic circular dicroism (XMCD) contrast. This contribution will provide the current status, the technical conception and the future design of this instrument.
The microscope will receive the high coherent flux supplied by two apple undulators with full polarization control. As a unique characteristic, a low-noise hybrid detector will be incorporated in the setup. Moreover, the instrument is designed to operate in ptychography and scanning transmission electron microscopy (STXM) mode.
In summary, the development of a new soft X-ray spectro-microscope for diffraction-limited imaging is presented. With this instrument we are aiming to advance the mapping of the spectroscopic and magnetic response of many materials systems, such as spin textures and nanodevices.
This work is supported by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 701647.

Poster Session A

Poster A

P-A.079

Development of magnetic anisotropy in CoO/Fe(001) by bottom-up interface engineering

A. Brambilla, A. Picone, D. Giannotti, A. Calloni, H. Hedayat, E. Carpene, C. Dallera, G. Vinai, P. Torelli, M. Foerster, L. Aballe, M. Finazzi, L. Duò, F. Ciccacci

Text Intriguing magnetic properties can be obtained in systems containing antiferromagnetic (AF) transition metal (TM) oxides (O) both by low-dimensionality and by proximity to ferromagnetic (F) layers. So far, we have investigated both chemical [1] and magnetic [2] properties of a variety of Fe/AF (NiO, CoO) layered structures. One of the most critical issues concerning reactive TMO/TM interfaces is the high degree of chemical mixing [1]. Exploiting a metastable Co buffer layer, we have succeeded in obtaining a CoO/Fe interface free of any Fe oxide that, intriguingly, is also characterized by a dislocation-driven nanostructuration of CoO [3]. Such an interface engineering leads to the development of a significant uniaxial magnetic anisotropy, induced by tiny amounts of deposited CoO [4]. The corresponding magnetic behavior and the physical mechanisms that drives it were investigated by standard (magneto-optical Kerr effect, MOKE) and element specific (X-ray Magnetic Circular Dichroism, XMCD) hysteresis loops, by magnetization-induced second harmonic generation (MSHG), and by XMCD-Photoelectron Emission Microscopy (XPEEM) revealing that the source of the magnetic anisotropy resides indeed at the very interface of the system.

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Poster Session A

Poster A

P-A.080

Dy1Ag2/Ag111 surface alloy - a potential 2d ferromagnetic substrate for metal organic interfaces

J. Seidel, S. Mousavion, E. Walther, K. Medjanik, D. Vasilyev, S. Babenkov, M. Ellguth, H.-J. Elmers, G. Schönhense, B. Stadtmüller, M. Aeschlimann

Text On the way to functionalize metal-organic hybrid interfaces, metallic surface alloys have emerged as highly interesting tunable substrates with intriguing spin-structures. For the field of spinterface science, these surface alloys have recently attracted considerable attention due to the likely existence of a ferromagnetic phase at low sample temperature [1]. Here, we present our recent studies on the lanthanide-noble metal surface alloy Dy1Ag2/Ag(111). Using low energy electron diffraction (LEED) and scanning tunneling microscopy (STM), we characterized first in detail the lateral structure. Subsequently, we investigated the spin-dependent electronic valence band structure in the full momentum and energy space by spin resolved momentum microscopy. We are able to identify Dy-Ag hybrid states and present a detailed analysis of its spin and momentum distribution.

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Poster Session A

Poster A

P-A.081

Dynamical behavior of hard magnetic 2D strontium hexaferrite nanoparticles in colloidal solutions

V. Korolev, L. Trusov, E. Anokhin, A. Eliseev, P. Kazin

Text Strontium hexaferrite is a hard magnetic M-type hexaferrite with high magnetocrystalline anisotropy. Such materials are well-known and widely used for the production of ceramic magnets, magnetic tapes and microwave devices. High coercetivity leads to remanence in hexaferrite nanoparticles. Combined with anisotropic form of these nanoparticles it gives rise of particularly interesting phenomenon — colloidal magneto-optical effect.

In the present work we studied the complex dynamic behavior of strontium hexaferrite nanoplatelets in various viscous media under application of AC and DC external magnetic field using optical, magnetic and rheological methods. Nanoparticles were synthesized by glass-ceramic route using borate matrix. According to the TEM data the diameter and thickness of the particles are 50 nm and 5 nm respectively. Stable colloids in aqueous, ethanol, glycerol and ethylene glycol media were prepared.

We show that dynamics of the hexaferrite nanoprartices are highly depended of viscous properties of surrounding media. The magnetooptical response of aqueous colloids can be observed in weak AC magnetic fields (20 Oe) with frequency of 2000 Hz. High viscosity of the media significantly slows down the rotation of nanoparticles. Glycerol colloids lose response to the AC fields with frequency as high as 100 Hz. The work is supported by the RFBR grant 16-03-01052.

Poster Session A

Poster A

P-A.082

Dynamics of the magnetic relaxation of surface inhomogeneity induced by femtosecond laser impulse in Ta/Pt/GdFeCo/IrMn/Pt film

O. Koplak, A. Bezverhny, I. Shashkov, E. Kunitsyna, V. Gornakov, R. Morgunov

Text The effect of laser irradiation and spin-polarized current on magnetization of ferromagnetic films is promising in new optically controlled technologies of the information storage/recording. The magnetization switching in the perpendicular ferromagnetic multilayered film of the GdFeCo alloy can be performed by single circularly polarized femtosecond laser pulses. This work was aimed to structural and magnetic studying of ferromagnetic films Ta/Pt/Gd21.6Fe67.8Co10.5/IrMn/Pt surface around the laser burned spots and to the analysis of the magnetic relaxation of the laser irradiated area in external magnetic field (up to 0.2 T). Single laser pulse of 8.9 mJ/cm2 fluency, 632 nm wavelength and 50 fs duration was used. Surface profile around laser magnetized area of Ta/Pt/GdFeCo/IrMn/Pt structure was scanned. The spot of the 6-8 um diameter was found by MFM, MOKE, SEM and AFM techniques. Magnetization reversal was studied as function of the magnetic field. Aftereffect of the external magnetic field in different areas of the sample was observed. Comparison of magnetic properties of optically switched area with the non irradiated surface was performed. The microscopic images of the MFM are in good agreement with the MOKE images of the reversal nucleus.

Authors thank to S.Mangin and T.Fache for GdFeCo film irradiated by femtosecond laser. This work was financially supported by Ministry of Education and Science of Russian Federation grant 3.1992.2017/4.6.

Poster Session A

Poster A

P-A.083

Effect of artificial grain boundary phases on magnetic properties for Nd-Fe-B thin films

G. Saito, M. Doi, T. Shima

Text Nd-Fe-B sintered magnets show the large magnetocrystalline anisotropy among all permanent magnets. However, the mechanism of the coercivity is not yet fully understood. Recent studies revealed the enhancement of coercivity is realized by deposition of several cap layers such as Al and Fe-Ga alloy on micro-fabricated Nd-Fe-B thin film with grid patterns. In this study, in order to investigate the effect of cap layer materials on the magnetic properties for Nd-Fe-B alloys, the grid and dot patterns of Nd-Fe-B thin films have been fabricated by micro-fabrication. The sample were prepared by using an ultra-high vacuum (UHV) magnetron sputtering system. The substrate temperature was kept at 500 ºC during the deposition of Mo buffer layer and Nd-Fe-B layer. Then, Mo oxidation protective layer was deposited. The samples were annealed at 575 ºC for 30 min. Nd-Fe-B square or disk patterns were micro-fabricated through the use of electron beam (EB) lithography followed by Ar ion etching. The line width between Nd-Fe-B square patterns was varied from 30 to 100 nm and the diameter of Nd-Fe-B disk patterns was varied from 1.0 to 2.0 µm. After the micro-fabrication process, Nd-Fe-Ga cap layer of 10 nm and MgO oxidation protective layer of 10 nm was deposited. It is confirmed that the value of coercivity Hc was improved from 10.5 kOe for Nd-Fe-B continuous film to 14.4 kOe for Nd-Fe-B grid patterns of d = 30 nm with $Nd_6Fe_{12}Ga_2$ cap layer.

Poster Session A

Poster A

P-A.084

Effect of composition on epitaxial growth and magnetic properties of Mn-Ge films on Ir/Cr buffered MgO(001)

S. Dash, B. Schleicher, S. Schwabe, L. Reichel, R. Heller, S. Fähler, V. Neu, A. K. Patra

Text Mn-Ge based compounds with perpendicular magnetic anisotropy at room temperature have attracted considerable interest for their potential applications in nanoscale spintronics devices. To exploit functional properties of Mn_3Ge as memory cell in magnetic tunnel junction a detailed analysis of epitaxial growth and magnetic properties with different buffer layer architecture is essential. The effect of composition on phase formation, texture and magnetic properties of Mn-Ge films prepared by DC magnetron sputtering on Ir/Cr buffered MgO(001) is examined. These films grow epitaxially having *c*-axis of the tetragonal ($D0_{22}$) unit cell pointing out of the film plane with an epitaxial relation of $D0_{22}$ Mn-Ge[100](001) ll Ir[100](001) ll Cr[110](001) ll MgO[100](001). The composition has a drastic impact on the magnetic properties of these films. $Mn_{77.5}Ge_{22.5}$ films close to stoichiometric Mn_3Ge exhibit perpendicular magnetic anisotropy with good magnetic texture (0.04) and squareness (0.87). However, two extreme compositions show high coercivity but very low magnetization. The reason for low magnetization can be ascribed to the substitution of excess Mn into Ge sites and formation of secondary nonmagnetic phases for films with high and low Mn content, respectively. Nevrtheless, at room temperature the measured values of saturation magnetization, coercivity and anisotropy field for the epitaxial $Mn_{77.5}Ge_{22.5}$ films are 90 emu/cc, 2.86 T and 9.6 T, respectively.

Poster Session A

Poster A

P-A.085

Effect of composition on the magnetic properties for Mn-Ga-N thin films

K. Ohwada, M. Doi, T. Shima

Text Rare earth magnets exhibit the highest maximum energy products among all permanent magnets, so they have been used for wide variety of applications. A lot of efforts have been done to find another permanent magnet materials excluding heavy rare earth elements. One of candidate materials is Mn-based alloy. The binary $D0_{22}$-Mn_xGa (x =1~3) compounds have attracted much attention due to its high Curie temperature and high magnetic anisotropy. However it demonstrates a low saturation magnetization with ferrimagnetic nature. It is proposed that the addition of nitrogen might be increase the lattice constant of the MnGa alloy in the c-axis direction, and consequently it is expected to enhance the magnetocrystalline anisotropy and the saturation magnetization. In this study, in order to investigate the effect of nitrogen on the magnetic properties and crystal structure, Mn-Ga-N ternary alloy thin films have been prepared and the effect of additive elements on the structure and magnetic properties have also been investigated. The samples were prepared by using an ultra-high vacuum sputtering system. A 70 nm thick Mn-Ga-N layer was deposited on the MgO (100) substrate. The crystal structure was characterized by XRD. Magnetic properties were measured using SQUID magnetometer. From XRD patterns, $D0_{22}$-MnGa (002), (004), (006) peaks have been clearly observed for all samples. Saturation magnetization (Ms) of 219 emu/ cm^3 was obtained for the film with $Mn_{63.8}Ga_{32.8}N_{3.4}$ (at. %) thin films.

Poster Session A

Poster A

P-A.086

Effect of iron impurities on magnetic properties of nanosized CeO2 and Ce-based compounds

Y. Jiraskova, J. Bursik, P. Janos, J. Lunacek, O. Zivotsky

Text Existing studies of magnetic behaviour of nonmagnetic oxides such as CeO_2, Al_2O_3, or ZnO in their nanosized form exhibit large differences in obtained magnetic moments. These moments are ascribed mainly to oxygen vacancies at which localized electron spin moments are formed. In the case of CeO_2, also other reasons for its ferromagnetism have been considered, such as, e.g., effects of Ce^{3+} ions on the nanoparticle surfaces which carry their own magnetic moments contrary to diamagnetic Ce^{4+} ions, or recently detected magnetic iron-based impurities. Their small amount in units of ppm was detected in nanosized CeO2 prepared by precipitation/calcinations' procedure and in input chemicals. This was confirmed by ^{57}Fe Mössbauer spectrometry and it is responsible for small magnetization in thousandths of Am^2kg^{-1} measured by SQUID magnetometer at 300 K and 2 K. These findings call for other investigation clarifying the true origin of the magnetism of CeO2 and similar nanomaterials.
The present contribution summarizes the results obtained for nanosized CeO_2 prepared by different procedures and from different chemicals. The samples were analyzed by means of Inductively Coupled Plasma Atomic Emission Spectroscopy, X-ray photoelectron spectroscopy, scanning and transmission electron microscopy, ^{57}Fe Mössbauer spectrometry, and SQUID magnetometry with the aim to estimate quantitatively the portion of iron-based impurities.

Poster Session A

Poster A

P-A.087

Electronic state of Sr_2FeMoO_6 thin film surfaces before and after *ex-situ* post-annealing.

I. Angervo, M. Saloaro, S. Granroth, H. Huhtinen, P. Paturi

Text We investigate the effects of *ex-situ* temperature post-annealing on a set of identically pulsed laser deposited Sr_2FeMoO_6 (SFMO) thin films where, based on our preliminary structural and magnetic characterizations, the insignificant film-to-film variation has been observed. Since the SFMO is a highly regarded candidate for future spintronic applications, we focus our analysis on the results obtained with X-ray photoelectron spectroscopy (XPS). XPS is a surface sensitive measurement technique, which provides us with information on the effects of *ex-situ* treatment to electronic states, which do not show up in the bulk measurements. The ex-situ temperature annealing was conducted in high vacuum varying the post-annealing temperature between 200 °C and 600 °C . The post-annealing chamber is directly linked to a XPS-setup and therefore this enables us to prevent the contamination of films by ambient atmosphere between the preliminary and the following XPS-measurements before and after the annealing treatment. More specifically, the effects of annealing treatment are studied by analyzing the detailed oxygen 1s spectrum along with changes in the carbon contamination. Successful ex-situ treatment will provide a more optimal interface section between the SFMO and ex-situ deposited secondary layers in multilayer spin-valve structures.

Poster Session A

Poster A

P-A.088

Emergent Exotic States in 1D and 2D Magnet-Superconductor Hybrid Systems with Atomic-Level Control

R. Wiesendanger

Text Majorana states in nano-scale magnet-superconductor hybrid systems have recently attracted great interest for topological quantum computation [1,2].
Here, we will focus on artificially fabricated 1D atomic Fe chains on a superconducting Re(0001) substrate using STM-based atom-manipulation. Spin-polarized STM measurements [3] reveal the presence of non-collinear spin textures, stabilized by interfacial Dzyaloshinskii-Moriya interactions [4]. Tunneling spectra measured spatially resolved reveal the evolution of the local density of states as well as the emergence of zero-energy bound states at the chain ends above a critical chain length. Based on the exact knowledge of the geometrical, electronic and spin structure of our hybrid system, the experimental results can be compared rigorously with ab-initio and tight-binding calculations supporting the interpretation of the spectroscopic signatures at the ends of the chains as Majorana bound states [5].
Based on this model-type platform, the design of more complex network structures for Majorana state manipulation will be discussed. Moreover, we will also address recent studies of Majorana edge modes in model-type 2D magnetic islands on elemental superconductors.

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Poster Session A

Poster A

P-A.089

Enhanced Magneto-Optical Response Of Permalloy-Based Magnetoplasmonic Crystals

N. Perova, V. Belyaev, A. Fedyanin, V. Rodionova

Text The magneto-optical (MO) effects are interesting due to a possibility to control properties of light by application of magnetic field. These effects can be used as logic elements for optical circuits and sensors. The main restriction is small values of MO effects, that can be enhanced by using magnetoplasmonic crystals (MPlCs) - nanostructures of noble and ferromagnetic metal. In MPlCs MO effects can be enhanced due to exciting surface plasmon polaritons (SPPs). [1]
The MPlCs studied were fabricated by magnetron sputtering of metals and dielectrics on subwavelength gratings with periods of 320, 740 and 1440 nm. To obtain maximal efficiency, magnetoplasmonic nanostructures for both plasmon effects and for obtaining a high magnetization in weak fields were covered with layers of noble metal and ferromagnetic metal that were obtained [2-3].Transparent dielectric layer of silica nitride was used to prevent the oxidation of permalloy layer.
Fabricated MPlCs was attested by atomic force microscopy. Magnetic properties of fabricated samples were investigated by Kerr magnetometry. Optical and MO properties at were studied by spectroscopy of reflectivity coefficient technique.

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Poster Session A

Poster A

P-A.090

Enhancement of high frequency reflection loss of strontium ferrite dot arrays on MWCNTs

A. Ghasemi, A. Ashrafizadeh

Text Substituted strontium ferrites with composition of SrFe12-xGdx/2Tbx/2O19 (x=0-0.5 in a step of 0.1) were decorated as dot arrays on the outer surface of multiwalled carbon nanotubes without subsequent annealing. Mössbauer spectroscopy results display that the crystallography site occupancy of substituted cations was 4f1 and 2b in hexagonal structure. Magnetic dynamics was studied by the measurement of ac magnetic susceptibility versus temperature at different frequencies. The phenomenological Vogel–Fulcher models were confirmed the existence of strong interaction between dot array. The formation of uniform distribution of magnetic dot array on the carbon nanotubes was also displayed into the micrographs. With adding substituted cation the coercivity enhances due to the increasing of first anisotropy constant, while the saturation of magnetization decreased. Rectangular waveguide with TE10 mode was used for measuring the scattering parameters. It was found that with an increase in substitution contents, the value of reflection loss along with bandwidth were enhanced up to x=0.4. Reflection loss was also measured at different thickness of absorber (1.5-2.2mm in a step of 0.1) and volume percentage of carbon nanotubes (5-60% in a step of 5%). The optimized parameters were 1.7mm and 45%, respectively. The nanocomposites were suitable candidates for utilizing in electromagnetic wave absorbing technology.

Poster Session A

Poster A

P-A.091

Evaluation of dead layers in Bi-substituted magnetic garnet thin films prepared by metal organic decomposition method

T. Kaito, N. Masami, A. Hironori, I. Takayuki

Text It is reported from the experiment of the spin-seebeck effect using $Nd_{3-x}Bi_xFe_{5-y}Ga_yO_{12}$ prepared in this laboratory that its effect saturates when Bi substitution amount exceeds 1. The reason for this is is assumed that the transport of spins at the interface was hindered by the dead layers formed on the outermost surface of the garnet thin film. In this report, we report the results of evaluating dead layers on the surface of samples with different Bi substitution amount.
$Nd_{3-x}Bi_xFe_5Ga_1O_{12}$ (Bi x, Ga 1 : NIG, x =1, 2) and $Nd_{0.5}Bi_{2.5}Fe_5O_{12}$ (Bi 2.5 : NIG) thin films were prepared on $Gd_3Ga_5O_{12}$ (111) and glass substrate by metal organic decomposition (MOD) method. Thereafter, etching was carried out with nitric acid for 30 sec. Cross section observation by TEM and magneto-optical effect measurement, simulation using virtual optical constant method, XPS and GD-OES mesurement were carried out for charactarization of thin films.
As a result of the Kerr rotation angle spectra of the Bi 2: NIG thin film, the period of the peak due to optical interference becomes narrower after etched than as grown, and the Kerr rotation angle becomes large. On the other hand, Faraday rotation angle shows almost no change in rotation angle during as grown and after etched. From the above results, it is considered that a dead layer existing on the thin film surface and having a small magneto-optical effect was etched.

Poster Session A

Poster A

P-A.092

Evolution of magnetic properties of sputtered Ni/Cu multilayers with different thicknesses

A. Karpuz, S. Colmekci, H. Kockar

Text Ni/Cu multilayers with different thicknesses were sputtered on the commercial acetate substrates and the changes in their magnetic properties were reported. The investigated films were designed for three different total thicknesses values (120 nm, 240 nm and 280 nm) as x[Ni(10nm)/Cu(30nm)], x=3, 6, 7. The films with thicknesses of 120 nm, 240 nm and 280 nm contain 48 %, 51 % and 52 % Ni atoms, respectively. The rest of films are Cu atoms. The X-ray diffraction (XRD) analysis showed that the all films crystallized in the face centered cubic phase with (111) preferential orientation. The average crystallite sizes were also calculated by using the XRD data. It was shown that the crystallite sizes are in agreement with the grain sizes observed on the multilayer surfaces by using a scanning electron microscope. The magnetic measurements were revealed by using a vibrating sample magnetometer. The saturation magnetization, M_s values were calculated as 590 emu/cm^3, 605 emu/cm^3, 615 emu/cm^3 and remanence, M_r values were also found as 396 emu/cm^3, 371 emu/cm^3 and 204 emu/cm^3 for the films with thicknesses of 120 nm, 240 nm and 280 nm, respectively. The increase in the total film thickness resulted in an increase in the M_s value and a decrease in the M_r value. Coercivity values were 116 Oe, 104 Oe and 89 Oe for the multilayers with thicknesses of 120 nm, 240 nm, 280 nm, respectively. It was found that the multilayers became magnetically softer when their total thickness increased.

Poster Session A

Poster A

P-A.093

Exchange bias due to different antiferromagnetic phases of NiMn in NiMn/FeNi thin films

M. Moskalev, V. Vas'kovskiy, V. Lepalovskij, A. Svalov, K. Balymov, N. Kulesh

Text Although NiMn is extensively used in spintronics, its antiferromagnetic phases and the mechanisms of their formation in thin films have not been properly explained. This work elucidates how different antiferromagnetic phases of NiMn form and affect exchange bias.
Two series of magnetron-sputtered films were studied: 1 - glass/Ta/FeNi/Ni_xMn_{100-x}/FeNi/Ta;
2 - glass/Ta/Ni_xMn_{100-x}/FeNi/Ta. The Ni content in the NiMn layer *x* ranged in 15÷70at.%. Magnetic properties at room temperature and their temperature dependences were studied by MOKE and a VSM, respectively. Crystal structure was investigated by XRD analysis.
As-deposited series 1 films exhibited exchange bias within *x*=20÷35at.%. The presence of the antiferromagnetic γ-Mn phase was indicated by XRD patterns and blocking temperature (=450K). None of as-deposited series 2 films exhibited exchange bias. XRD analysis revealed the absence of any ordered phases of NiMn in such films. The antiferromagnetic θ-NiMn phase, characterized by higher blocking temperature (=700K), was obtained by annealing in both series of films and confirmed by XRD analysis. Exchange bias of NiMn/FeNi films is established to be due to either the antiferromagnetic *A*1 γ-Mn or $L1_0$ θ-NiMn. The metastable γ-Mn forms through epitaxial growth on the buffer cubic FeNi layer. θ-NiMn forms after annealing at temperatures above 300°C by either decomposition of γ-Mn or emergence from the X-ray amorphous state in the case of the films without the buffer FeNi layer.

Poster Session A

Poster A

P-A.094

Exchange-Biased Magnetic and Magnetoresistive Properties of Co/Pt-IrMn Nanopatterned Multilayered Media

J. Kasiuk, A. Maximenko, J. Fedotova, W.-B. Wu, D. Mitin, M. Albrecht, O. Kupreeva, S. Lazarouk

Text Nanopatterned Co/Pt multilayered thin films (MLs) possessing perpendicular magnetic anisotropy (PMA) offer great opportunity for various applications such as magnetic sensors, logic devices, media for high-density recording. Exchange bias (EB) effect induced in the films normal direction by adding antiferromagnetic (AFM) IrMn layer is expected to increase magnetic hardness of MLs and their PMA because of exchange coupling at FM-AFM interface. Additionally, EB-effect available up to room temperature expands application of the materials in magnetoelectronics for designing tunnel junctions and spin-valve structures.
In the present study, Co/Pt-IrMn MLs are deposited on porous TiO2 templates with flattened surface and homogeneously distributed pores (40-60 nm in diameter). Significant EB-shift of magnetization loops μ(H) up to 740 Oe accompanied by perfect curves squareness is achieved for continuous films in their normal direction. Simultaneously, nonsymmetric field dependences of magnetoresistance MR(H) are characteristic for these films, hysteresis and shift of MR(H) curves being comparable with corresponding parameters of μ(H) loops. Exchange coupling between FM and AFM layers is diversified by pinning effects in the similar porous films that increases effectively coercive field HC, saving high PMA and EB with full shift of μ(H) loop to the negative field region. The EB-field and HC are tailored successfully by varying surface morphology of templates and stacking order of MLs.

Poster Session A

Poster A

P-A.095

Exciton- and Plasmon-Exciton-assisted TMOKE in the Magnetic Semiconductor Nanostructures

O. Borovkova, F. Spitzer, V. I. Belotelov, I. A. Akimov, A. N. Poddubny, V. F. Sapega, M. Wiater, T. Wojtowicz, G. Karczewski, A. K. Zvezdin, D. R. Yakovlev, L. Litvin, R. Jede, M. Bayer, I. Savochkin

Text Excitation of the electromagnetic modes or quantum states in the magnetic materials could resonantly enhance the magneto-optical effects in them. Especially, this is important for the materials with the weak magneto-optical response. In this work we address an influence of the excitonic and hybrid plasmon-excitonic modes to the transverse magneto-optical Kerr effect (TMOKE). We examine the reflection and TMOKE spectra of the semiconductor nanostructures covered with plasmonic gratings when the external magnetic field is directed along the quantum well (QW) plane. 10nm-thick CdMnTe QW is sandwiched between non-magnetic CdMgTe barriers. In the QW the energy structure of excitons is defined by the quantization of the carriers in the direction perpendicular to the sample plane. Gold grating on top of the semiconductor nanostructure supports the SPP modes. A frequency of the plasmonic SPP mode is angular-dependent, thus, we can excite surface plasmon polariton and excitonic state at the same spectral position and observe a hybrid mode. These hybridized plasmon-exciton modes encourage the enhancement of TMOKE in the semiconductor nanostructures and lead to the hybridization of the TMOKE spectrum. Particularly, we observe a change of the TMOKE sign when excitonic resonance is crossed by the plasmonic one.

This study was supported by RFBR (proj. no. 16-32-60135 mol_a_dk), Foundation for the advancement of theoretical physics BASIS, and Deutsche Forschungsgemeinschaft via ICRC TRR 160.

Poster Session A

Poster A

P-A.096

Exploring the static and dynamical behaviour of spherical exchange-biased Janus particles as a new tool for microfluidic biointeraction screening.

R. Huhnstock, M. Reginka, A. Tomiţa, D. Holzinger, A. Ehresmann

Text In recent years a lot of attention has been drawn towards the engineering of magnetic Janus particles (JPs) and the investigation of their dynamical properties when subjected to a temporally shaped external magnetic field in a liquid environment. While showing a significant potential for the application in microfluidic devices previous works have mainly focused on either softmagnetic or perpendicular to plane magnetized caps regarding JPs for catalytic self-propulsion in non-biocompatible media, e.g. H_20_2. In this work, we introduce an exchange bias (EB) thin film system for the JP's magnetic cap for preferential alignment of the magnetic moments parallel to the cap surface as a result of the unidirectional anisotropy induced by the EB.

The JP's magnetic properties were experimentally studied by magnetic force microscopy and MOKE magnetometry to reveal the anisotropic magnetic behaviour and the formation of uncompensated magnetic net charges within the opposing equatorial regions along the anisotropy axis. These experimental results were corroborated by micromagnetic simulations, in which further tailoring of the JPs magnetic properties with respect to the strength of the EB and the uniaxial anisotropy of the cap's ferromagnetic material was analysed. Exposing the JPs to a spatially and temporally shaped magnetic stray field landscape results in a superposition of controlled translations and rotations which emphasizes their potential use for biomolecular interaction analysis.

Poster Session A

Poster A

P-A.097

FORC based interaction strength investigations in permalloy micro arrays

F. Groß, J. Gräfe, S. Ilse, E. Goering

Text First-order reversal-curves (FORCs) are a powerful tool to distinguish between microscopic interaction and coercivity contributions without the need for lateral resolution. However, most real systems violate Mayergoyz' criteria which hinders the interpretation of the FORC density as Preisach distribution, thus, limiting FORC to a ‘fingerprint’ of this specific material. Hence, understanding additional features in such complex FORC diagrams is crucial for the applicability of the method.
Here, we extend the interpretability of FORCs diagrams. We artificially design permalloy stripe systems of alternating width which violate the before mentioned criteria in order to systematically investigate resulting features in the FORC density and link them to their micromagnetic origin. Using a NanoMOKE3 we directly measure the low field spatially resolved switching field distribution (SFD), and the FORC density. Comparing two independent approaches for the SFD with the FORC density, we can decode additional features and assign them to be a consequence of interaction between hard and soft magnetic components. We find this interaction peak intensity to be a quantitative measure for the interaction strength in the system and can correlate its volume to the actual interactions within the system. This is a thorough step into a more quantitative interpretation of FORC diagrams.

Poster Session A

Poster A

P-A.098

Fabrication of soft amorphous ferromagnetic material and tuning of curie temperature by interfacial proximity effects

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Text B. Pal1, Heikki Palonen and B. Hjorvarsson
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Amorphous ferromagnetic(A-FM) materials are of significant interest for various quality assets, like, soft magnetism, tunable magnetic anisotropy, structural homogeneity, large proximity effects and high magnetoresistance ratio in magnetic tunnel junctions. Here we investigate on TM(Fe, Co, Ni), Zr, AlZr based A-FM materials grown by ultra-high vacuum(1x10-10 mbar) DC magnetron sputtering. We also study the interfacial proximity effects and magnetic interactions on ultrathin heterostructures and multilayer structures. X-ray reflectivity (XRR) demonstrates the controlled layering and the intended thickness of the layers, further confirmed by cross-section high-resolution transmission electron microscopy (HRTEM). X-ray diffraction (XRD) shows no crystalline enclosures in the magnetic layers or at the interfaces. Magnetic measurements are performed by different MOKE setups and SQUID magnetometer. We observe that coercivity and ordering temperature change significantly with variation of composition and interfacial couplings. Also, the Curie temperature can be tuned using the large interfacial proximity effects in FM-FM [Fe1-x(AlZr)x – Ni1-x(AlZr)x] or FM-NM [Ni1-xZrx – Al1-xZrx)] multilayers. This magnetic proximity effects in low-dimensional heterostructures can be used to obtain new functionality in spintronic devices.

Poster Session A

Poster A

P-A.099

Ferromagnetic/Antiferromagnetic phase coexistence and local magnetic profiles in compositionally graded manganite surfaces

S. J. Carreira, M. H. Aguirre, J. Briático, E. Weschke, L. B. Steren

Text The electronic and magnetic reconstruction arisen at manganite surfaces are still under intense research and gives rise to a wide variety of functional properties [1]. In compositionally graded manganites with the general formula $La_{1-x}Sr_xMnO_3$ (LS_XMO), the Sr-doping and the structural strain can be tune artificially within a few unit cells near the surface, with the potential advantage of controlling at will their properties. In doing so, bilayers ($LS_{0.33}MO$ (25 nm)/LS_XMO (0 nm < t < 6 nm)) with 0<X<0.1 were grown on STO (001), in order to change in a controlled manner the evolution of the valence states and the structural strain along the c-axis. STEM-HAADF, EELS and Synchrotron radiation studies with surface sensitivity allowed us to discern between ferromagnetic (FM) and antiferromagnetic (AFM) profiles, charge asymmetries, valence profiles and local anisotropy changes in the exchange interactions. These profiles emerge mainly from the competition between structural deformations and the spatial distribution of the Sr-content throughout the interfaces. Enlightened by these results, we constructed a phase diagram of the FM and AFM phases in terms of the structural strain and the doping level. Moreover, our results provide a successful strategy to finely tune the spin-polarization at manganites surfaces by the proper choice of an oxide capping layer [2].

[1] Di Yi et al 2017 *J. Phys.: Condens. Matter* **29** 443004.
[2] Santiago J. Carreira et al 2018 *Appl. Phys. Lett.* **112** 032401.

Poster Session A

Poster A

P-A.100

Field-free spin orbit torque switching in Co/Pt/Co multilayer

S. Łazarski, W. Skowroński, S. Ziętek, J. Kanak, K. Grochot, T. Stobiecki, M. Schmidt, J. Aleksiejew, F. Stobiecki

Text Magnetization switching in thin multilayers is used for the writing process of contemporary magnetic random access memories. In spin-orbit torque, spin polarized current is generated in material possessing large spin-orbit coupling, typically heavy metals such as W, Ta or Pt. Avoiding the necessity of external field during the switching process can be achieved by coupling two ferromagnets with different anisotropies [1] or using two metals with different spin orbit coupling sign [2].
Here, we take advantage of Pt heavy metal, which is both a source of the spin current and a spacer that induces ferromagnetic coupling between two Co layers. Full multilayer stack: Ti(2)/Co(3)/Pt(0-4)/Co(1)/MgO(2)/Ti(2) (thickness in nm) together with bottom Ti(2)/Co(3)/Pt(4) and the top Pt(4)/Co(1)/MgO(2)/Ti(2) parts were investigated, exhibiting perpendicular (in-plane) anisotropy in thinner (thicker) Co layers. Current induced magnetization switching were measured in the Hall bars using anomalous Hall effect. By varying the thickness of Pt spacer we tune the coupling between two Co layers. As the result, for the Hall bar with Pt thickness corresponding to an intermediate ferromagnetic coupling, the magnetization switching is induced solely by in-plane current.

Project supported by National Science Centre, Poland, Grants No. 2015/17/D/ST3/00500 and No. 2016/23/B/ST3/01430.

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[2] S. Li et al. Sci. Rep. 7, 972 (2017)

Poster Session A

Poster A

P-A.101

Fine-tuned perpendicular magnetic anisotropy of Co-doped Mn_3Ga thin films

W. Yoo, H.-W. Bang, C. Kim, Y. H. Lee, K. Lee, M.-H. Jung

Text Mn_3Ga has been proposed as a promising material for possible applications of spintronics because of high perpendicular magnetic anisotropy (K_U ~ 1.0 MJ/m^3), low saturation magnetization (M_S ~ 0.1 MA/m), high Curie temperature ($T_C \geq$ 700 K), and high spin polarization (P ~ 88 %). To increase the prospect for the application, however, there are challenging issues to reduce its high coercivity (H_C ~ 19 kOe) and solve the problem related with lattice mismatch (~ 6%) between Mn_3Ga film and MgO substrate. Recently, transition metal doped Mn_3Ga has been investigated for tuning the electronic and magnetic properties while retaining their advantages. Among them, we focus on Co-doped Mn_3Ga ($Mn_{3-x}Co_xGa$) thin films showing a crystal structure transition from tetragonal to cubic and simultaneously a magnetic change from ferrimagnetism with perpendicular magnetic anisotropy (PMA) to ferromagnetism with in-plane magnetic anisotropy (IMA). As finely tuning x, we could adjust the H_C and MS values. At the critical composition of structural and magnetic transition, H_C is abruptly reduced to 1.2 kOe while retaining PMA and the lattice mismatch is lowered about 4.7%. These results are attributed to the decreasing ratio of Mn-Mn antiparallel coupling and the increasing ratio of Mn-Co parallel coupling, leading to a slight increment of saturation magnetization.

Poster Session A

Poster A

P-A.102

Flexible (Co,Ru)Fe_2O_4 epitaxial thin films for Spintronics Applications

P. Monalisha, Y. Bitla, P. S. Anil Kumar

Text Room temperature magnetic semiconductors have drawn significant attention due to their potential spintronic device applications. Inverse spinel Cobalt Ferrite with large magnetocrystalline anisotropy & magnetostriction coefficient is an alternative candidate for such applications. However, its insulating nature restricts the realization of spin polarized carriers at room temperature. Ruthenium doping in cobalt ferrite essentially increases the conductivity while retains the magnetic properties. Ru^{4+} doped cobalt ferrite can be a tunable magnetic semiconductor.

Epitaxial thin films of (Co,Ru) Fe_2O_4 –[CRFO] were grown on Mica(001) substrate using Pulsed laser deposition technique. The 2D nature of flexible mica substrate allows growth of free-standing like film via van der Waal's heteroepitaxy minimizing substrate clamping effect. The structural characterization revealed the epitaxial nature of (*lll*) oriented CRFO film with a high degree of crystallinity(FWHM-0.45 degree).The surface topography probed by atomic force microscopy displayed a very smooth surface having roughness of 0.3 nm. The electrical conductivity of CRFO films were enhanced compared to parent $CoFe_2O_4$.The CRFO films showed room temperature ferrimagnetic behavior with a saturation magnetization of 140 emu/cc and coercivity of 1000 Oe comparable to those reported for CFO/Mica.

Poster Session A

Poster A

P-A.103

Forming of ε-Fe2O3-phase in the xerogel matrix, magnetic and dielectric properties.

A. Dubrovskiy, S. Yakushkin, D. Balaev, S. Semenov, Y. Knyazev, V. Kirillov, O. Martyanov

Text Magnetic metamaterials are widely used as magnetic recording media and magneto-optical devices. In this study we draw our attention to epsilon-iron oxide (ε-Fe2O3). ε-Fe2O3 is known to be unique among other iron oxide polymorphs due to its extremely high coercive field and high frequency millimeter wave adsorption. ε-Fe2O3 is a metastable phase, it can be obtained only in the form of particles with the size less than a particular nanometer threshold. Therefore to obtain the ε-Fe2O3 nanoparticles without admixture of other iron oxide polymorphs, one has to control the particle size and prevent the agglomeration process.
In the present work we report a novel synthesis method, to obtain a silica-gel material with combination of sol-gel and impregnation method. Using this technique we have succeeded creating ε-Fe2O3 nanoparticles in silica matrix with high iron oxide content, without admixture of other iron oxide polymorphs and with nanoparticles narrow size distribution.
Using the shape of the samples obtained we prepared well polished capacitors for the measurement of permittivity of the samples. Magnetodielectric effect with magnetic ordering of the iron oxide ε-Fe2O3 makes this material attractive; an eventual coupling of these properties could find a widespread range of applications.
The work was supported by the Russian Science Foundation grant № 17-12-01111.

Poster Session A

Poster A

P-A.104

Growth and spin orbit effects in insulating magnetic garnets with perpendicular magnetic anisotropy

S. Ding, A. Ross, S. Becker, J. Cramer, M. Kläui, J. Yang, G. Jakob

Text Insulating rare earth iron garnets (RIG) have drawn great interest in recent years due to their excellent performance in the field of spintronics with low Gilbert damping and long spin diffusion lengths. Heterostructures of in-plane magnetized RIG with heavy metals have been widely used to study spin Hall magnetoresistance (SMR) and the spin Seebeck effect (SSE), phenomena which are mainly induced by spin current interactions at the interface.[1] One of the attractive possibilities using spin currents, is the current induced control of magnetization in RIG. In particular using RIGs with perpendicular magnetic anisotropy (PMA), spin orbit torque (SOT) effects have been shown to switch them efficiently.[2] We present our results of the successful growth of high quality thulium iron garnet (TmIG) and gadolinium iron garnet (GIG)[3] films by pulsed laser deposition. Over a range of thicknesses, PMA is observed, tailored by lattice strain between film and substrate, allowing for the robust investigation of spin orbit effects in insulating PMA-RIGs. Utilizing the (inverse) spin Hall effect in a neighboring heavy metal layer, detection and control of the magnetic state is successfully achieved for low current densities.

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Poster Session A

Poster A

P-A.105

High temperature superparamagnetic transition at zinc doped cobalt ferrite nanostructures

M. B. Kaynar, S. Ozcan

Text In this work, we present the effect of zinc edition to the magnetic properties of cobalt ferrite fine particles. Cobalt ferrite fine structures are synthesized by wet-milling. Rietveld analysis showed that all structures have a mean particle size of 100 nm. Magnetic characterizations of the samples are carried on with a high-temperature vibrating sample magnetometer. Room temperature magnetization measurements show a ferrimagnetic hysteresis loop for all the samples with an increasing saturation magnetization by increasing the zinc amount in the samples. This is a known property of the inverse spinel structure. Room temperature magnetization measurements also show a decrease at the coercivity of the samples by increasing the zinc amount because of the lower spin-orbital interaction of the zinc than cobalt. ZFC measurements revealed a blocking temperature higher than room temperature for all the samples which indicates a superparamagnetic transition above the 600 K.

Poster Session A

Poster A

P-A.106

High-coercive MnBi thin films with tunable particulate and continuous microstructures

M. Villanueva, C. Navío, J. Rial, E. Céspedes, F. J. Mompeán, M. García-Hernández, J. Camarero, A. Bollero

Text Mn-based ferromagnetic alloys show interesting permanent magnet (PM) properties provided development of the ferromagnetic phases and an adequate microstructure. In particular, the MnBi low temperature phase (LTP) is attracting increasing attention nowadays regarding its large uniaxial magnetocrystalline anisotropy, a theoretical (BH)max=17MGOe, a Curie temperature of 628 K and a positive temperature coefficient of the coercivity. This latter characteristic makes the coercivity of the LTP to increase with temperature [1].
MnBi films, with nominal thickness raging between 50 and 200 nm, have been prepared by sequential DC magnetron sputtering of Bi and Mn layers onto glass substrates, with in-situ annealing. By maintaining constant the atomic ratio and modifying substrate temperature and post-annealing temperature, a variety of singular morphologies are reported here, from quasi-isotropic isolated MnBi micro-particles to larger platelet-like individual ones up to highly coalesced textured film-like areas.
High LTP-MnBi purity showing large coercivities has been achieved, reaching 16.2 and 22 kOe at 300 and 350 K, respectively [2]. The maximum of 29 kOe at 500 K is among the largest reported ones for the MnBi system.

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Poster Session A

Poster A

P-A.107

Mapping of magnetic fields in strained La0.67Sr0.33MnO3 thin films using off-axis electron holography

Q. Lan, A. Kovács, C. Wang, L. Jin, X. Zhong, R. E. Dunin-Borkowski

Text The high spatial resolution analysis of the magnetic properties of perovskite magnetic oxide thin films is important both for providing a fundamental understanding of magnetism and for the development of novel spintronic devices. $La_{0.67}Sr_{0.33}MnO_3$ (LSMO) is an important conductive ferromagnetic oxide, whose magnetic properties are sensitive to the presence of structural defects (e.g., grain boundary, oxygen vacancies and 'dead layers' at interfaces). Here, we use off-axis electron holography to measure the magnetic field in a cross-sectional epitaxial LSMO thin film on a Nb-doped $SrTiO_3$ substrate with high spatial resolution. We aim to study the correlation between magnetic properties and structural defects. The magnetic field measurements are performed both at room temperature and at cryogenic temperature in an aberration-corrected transmission electron microscope operated in Lorentz mode. Particular emphasis is devoted to the impact of oxygen-vacancy-ordering-induced structural phase evolution on magnetic functionality as a function of temperature. The correlation between magnetic domain structure and the presence of 'dead layers' at interfaces is also investigated. Such high-resolution mapping of magnetic fields in LSMO thin film promises to provide direct experimental correlations between local microstructure and magnetism.

Poster Session A

Poster A

P-A.109

In situ Thin Film Growth for Polarized Neutron Reflectometry

W. Kreuzpaintner, S. Mayr, J. Ye, B. Wiedemann, A. Book, Z. Inanloo-Maranloo, T. Mairoser, A. Schmehl, A. Herrnberger, J. Stahn, J.-F. Moulin, P. Korelis, M. Haese, M. Pomm, M. Heigl, P. Böni, J. Mannhart, M. Albrecht

Text Magnetic films and heterostructures thereof are the basic building blocks of a large number of magneto-electronic devices. Their performance relies on the magnetic properties of the layers they consist of. These are functions of the layers' morphology and microstructure and of the coupling between them. Since these parameters can change during the process of growth, it is highly desirable to analyse the development of the magnetic properties of heterostructures during the growth process and to correlate them with the structural parameters of the sample.
While the structural characterisation of thin films during growth by various techniques is common practice (as e.g. commonly done by RHEED/LEED, STM or synchrotron radiation), the in situ measurement of the magnetic properties of films using (polarised) neutron reflectometry is a challenging task.

Within a collaboration of TU München, University Augsburg and MPI Stuttgart, we have built and operate a mobile sputtering facility for the growth and in situ monitoring of magnetic multilayers, which can be installed at suitable neutron beamlines. The current state in development will be shown, including unpolarized and polarized measurements on thin films carried out at the reflectometer REFSANS at the FRM II and fast in situ PNR measurements at the AMOR beamline at PSI. For the latter, the “Selene” neutron optical concept, based on elliptic neutron mirrors is essential. An overview over the latest developments will also be given.

Poster Session A

Poster A

P-A.110

In-situ spin-polarized time-of-flight momentum microscopy of the Heusler compound Co2MnGa(001)

S. Chernov, C. Lidig, O. Fedchenko, K. Medjanik, D. Vasilyev, S. Babenkov, M. Jourdan, G. Schönhense, H.-J. Elmers

Text Half-metallic ferromagnets represent an important class of materials because their completely spin polarized conduction electrons enhance the functionality of spintronic devices. Heusler alloys are of particular interest due to their high Curie temperature. Although first-principles calculations predicted a number of Heusler alloys to be half-metallic, this property could experimentally only be verified for a few compounds. Some of the theoretical studies indicate that local electron correlations in Heusler compounds are often significant and surface states play a dominant role. We have measured the spin polarized electronic dispersion relations in the valence band region from the Fermi energy to 1 eV binding energy using spin polarized time-of-flight momentum microscopy. For exciting photoelectrons we have used the fourth harmonic of the fundamental mode of a Ti-sapphire laser (6 eV). Using this very efficient experimental method, we overcome the challenging high surface reactivity of Heusler compounds. Our experimental results are in agreement with recent spin-integrated results
and allow for a thorough test of theoretical models, indicating that one has to extend the single parameter approach for including electronic many-body effects.

Poster Session A

Poster A

P-A.111

Influence of Deposition Rate on Properties of FeCrNi Alloy Thin Films Produced by a DC Sputtering Technique

N. Kaplan, A. Karpuz, H. Kockar

Text The effect of different deposition rates (DRs) on structural and magnetic properties of FeCrNi thin films was investigated. The films were deposited on flexible polymer substrates by using a DC sputtering technique. The thickness of films was 50 nm. The film contents were found by using a energy dispersive X-ray spectroscopy. The crystal structure determined by using an X-ray diffraction detected that all films have a bcc structure. And, the peak intensities changed depending on the film content which was varied by DRs. The morphological analysis of the surfaces performed by a scanning electron microscope displayed that the grain size on surfaces increases with the increase of DRs. Further measurements carried out by an atomic force microscopy disclosed an increase in the film surface roughness with increasing DRs. As to magnetic analysis, the increase of ferromagnetic content resulted in an increase in saturation magnetization measured with a vibrating sample magnetometer. Also, coercivity values firstly remained almost stable (131-135 Oe) for deposition rates of 0.04 and 0.06 nm/s, and then decreased from 135 Oe to 68 Oe when the deposition rate increased from 0.08 to 0.12 nm/s. The possible reason for the changes in the magnetic properties is the changes in the micro-structural properties caused by different DRs. It is seen that the magnetic properties of the FeCrNi films can be easily controlled by changing production parameters for possible industrial applications.

Poster Session A

Poster A

P-A.112

Influence of epitaxial strain on electronic transitions in La2/3Sr1/3MnO3 ultrathin films

M. Zahradník, T. Maleček, T. Maroutian, G. Kurij, G. Agnus, P. Lecoeur, L. Beran, M. Veis

Text Ultrathin films of La2/3Sr1/3MnO3 (LSMO) attract interest for applications in spintronics due to their unique physical properties (colossal magnetoresistance, metallic conductivity, high Curie temperature, high degree of spin polarization). Their ferromagnetism was first explained by double-exchange (DE) interaction [1], which is strongly influenced by Mn-O-Mn geometry. Therefore one of the main factors responsible for change of their magnetic properties is epitaxial strain.
Using pulsed laser deposition, we prepared LSMO films on four different substrate materials, providing a large variety of strains. The exact strain states of the films were determined by X-ray diffraction. Spectroscopic ellipsometry and magneto-optical (MO) spectroscopy was used to characterize the optical and MO properties. Spectra of the off-diagonal permittivity tensor elements reveal presence of previously reported electronic transitions around 2.5 eV [2] and 3.5 eV [3]. Another transition around 4.3 eV is observed only in spectra of films deposited under compressive strain. We show that this transition is likely to originate from lowering of the crystal symmetry as a consequence of the epitaxial strain. It is a manifestation of the key role of strain in controlling the magnetic properties of ultrathin perovskite layers.

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Poster Session A

Poster A

P-A.113

Influence of sputtering conditions on $LaSrCoO_3$ thin films properties

M. Sanchez-Perez, O. J. Dura, J. P. Andres, R. Lopez Anton, J. A. Gonzalez, M. A. Lopez de la Torre

Text Perovskite oxides have received considerable attention due to both fundamental and technological aspects. They show a large variety of interesting phenomena as superconductivity, ferroelectricity or ferromagnetism. From a technological point of view, they emerge as excellent materials for Solid Oxid Fuel Cells or spintronic devices. Among perovskite oxides, cobaltites show remarkable magnetic properties as spin-state transitions or an unusual glassy ferromagnetic behavior. $La_{(1-x)}Sr_xCoO_3$ (LSCO) is one of the most widely studied example.For LSCO, it is possible to induce a transition from an insulator-non magnetic state to a metallic-ferromagnetic state through temperature or Sr dopping. Moreover, there is a great motivation for the study of LSCO in thin film form. The dimensional confinement of the magneto-electronic phase separation, the oxygen stoichiometry or the strain effects provide the possibility to tune properties and potential applications of LSCO.
In this work, we present a physical characterization of $La_{0.5}Sr_{0.5}CoO_3$ thin films. For this purpose, a family of samples with different structure and thickness was deposited by reactive RF magnetron sputtering from LSCO compound target. The influence of deposition parameters as temperature, time, oxygen partial pressure and substrate composition, was checked by structural, electric and magnetic characterization. It has been observed a clear dependence of the electric and magnetic behavior on only some of these parameters.

Poster Session A

Poster A

P-A.114

Inhomogeneous magnetic field influence on magnetic properties of NiFe and IrMn based thin film structures with exchange bias

C. Gritsenko, V. Rodionova, B. Anton, G. Babaytsev, I. Dzhun, N. Chechenin

Text We have studied NiFe and IrMn based thin film structures with exchange bias for their using in spintronics and magnetic recording, where, from the applied point of view, magnetic properties of materials play crucial role. The main idea of our investigations is to control magnetic properties of samples by inhomogeneous magnetic field that was applied during thin film deposition. For this, we have used two permanent magnets with curved shape to create the external magnetic field in deposition camera of magnetron sputtering machine. The silicon (100) substrate was put between these two magnets and the magnetic field was applied in-plane to the substrate. Thus, there were realized variable magnitude and configuration of magnetic field along all the substrate. As a result, we show how configuration and magnitude of this magnetic field influence on shape of bilayered NiFe/IrMn, IrMn/NiFe and trilayered NiFe/IrMn/NiFe thin film magnetic properties (hysteresis loops shape, coercivity and exchange bias) and structure. For the mentioned experiment, we made six samples with different IrMn layer thicknesses, 2,4,6,8, 10 and 20 nm. Significantly, we showed that for the bilayered NiFe(10nm)/IrMn(20nm) it is possible to create stepwise hysteresis loop.

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P-A.115

Interface charge/spin transfer between a half-metal ferronagnet and a semiconductor

I.-O. Pana, L. Soran, C. Leostean, M. Stefan, A. Popa, D. Toloman, S. Gutoiu, A. Stegarescu

Text At the interface between a metal and a semiconductor the work functions should be equalized. This is done by charge transfer across the interface. In case of a half-metal (HM) ferromagnet (FM) interfaced with a semiconductor, at nanoscale, this process is spin polarized. A common HM-semiconductor Bloch wave, with coherent spin polarization, is formed. Depending on the HM Fermi level position, the charge/spin transfer may go either form the HM into the semiconductor or in the reverse way. In the former case localized states should be available in the semiconductor band gap. This process generates de-coherence of ordered states on the HM side and reduces its magnetization. In the second case the charge transfer goes into unoccupied CB states above the Fermi level of the HM. It should be done in accordance to the spin polarization required here. This process induces, via indirect exchange, a carrier-mediated ferromagnetism on the semiconductor side. RKKY calculations indicate a FM coupling of defects here. Additionally, when the HM is a hard FM its coercivity is reduced by the exchange coupling with the magnetic semiconductor. The process may be understood within (non)cooperative magnetization switching model of Preisach and its improvements. For exemplification the case of FePt($L1_0$) nanoparticles covered with Poly(3-hexylthiophene) semiconductor is analyzed. Also the cases of superparamagnetic HM Fe_3O_4 nanoparticles covered with either SnO_2 or TiO_2 shells will be discussed.

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P-A.116

Bistability in a nonlinear multiferroic composite resonator

L. Fetisov, D. Burdin, A. Berzin, N. Ekonomov, Y. Fetisov, P. Hayes

Text Bistability in resonance systems manifests itself in the existence of two stable states, differing in the level of transmitted or reflected power, for the same level of excitation power. In this paper, the bistability was detected and investigated in a magnetoelectric layered resonator.
The resonator contained a substrate of borosilicate glass of dimensions 30x2x0.15 mm3, amorphous ferromagnetic film, 2 μm thick, and a film of piezoelectric AlN, 2 μm thick. Bias magnetic field H was applied along the structure. The resonator was excited by an alternating voltage and changes in the magnetization of the structure caused by the converse ME effect were recorded.
The dependence of the ME voltage u on the frequency f of the excitation voltage for different excitation amplitudes U was measured. With increasing U, the resonance line is distorted, the frequency of the maximum fm shifts first downwards and then upwards. The bistability regions appear on the low-frequency and high-frequency slopes of the line with increasing and decreasing frequency. The bistability was also observed in the dependences of the output voltage u on the excitation voltage U.
A theoretical model for bistability in multiferroic resonator is proposed. It is shown, that bistability in multiferroic resonator arises due to nonlinearity of the magnetic layer of the structure.
The research was supported by the Russian Science Foundation, project 17-12-01435.

Poster Session A

Poster A

P-A.117

Effect of Si doping on magnetic and magnetocaloric properties of Ni-Co-Mn-Sn alloys

S. Ghosh, P. Sen, K. Mandal

Text Ni-Mn based Heusler alloys were found to show a large inverse magnetocaloric effect (IMCE) across their first order magneto-structural transition (FOMST). Addition of a few amount of Co replacing Ni in these alloys enhances the magnetic entropy change (ΔS_M) but the appearance of field induced hysteresis across the FOMST reduces the net relative cooling power (RCP) of that material in higher doping concentrations.[1] Therefore to improve IMCE properties of Hesuler alloys, we have to reduce the hysteresis loss significantly for their commercial use as refrigerant material.
Herein, the magnetic and MCE properties of polycrystalline $Ni_{48}Co_{1.5}Mn_{35}Sn_{15.5-x}Si_x$ (x = 1, 2, 4) Heusler alloys, prepared by arc melting furnace, have been investigated by magnetic measurements. All these alloys are found to undergo a FOMST from martensite to austenite structure along with a second order magnetic ferro to para transition. M-T curve reveals that the structural transition temperature shifts to lower temperature with Si substitution in place of Sn. Magnetic entropy change (ΔS_M) and net RCP are found to 10.86, 5.46, 2.42 $Jkg^{-1}K^{-1}$ and 122.7, 144.5, 63 J/kg for x = 1, 2 and 4 alloys due to a field change of 50 kOe respectively. Interestingly, with increasing Si substitution the average hysteresis loss reduces significantly from 52.1 J/kg (x = 1) to 8.62 J/kg (x = 4).

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P-A.118

Effects of Ti and Gd for Ga substitution on microstructure, magnetic and mechanical properties of polycrystalline Ni-Mn-Ga magnetic shape memory alloy

A. Łaszcz, M. Hasiak, J. Kaleta

Text Alloying elements have substantial influence on microstructure and magneto-mechanical properties of NiMnGa-based MSMAs. Considering that fact, this paper presents a systematic study of effects of Ti and Gd addition to NiMnGa system. Materials with composition of $Ni_{50}Mn_{25}Ga_{20-x}Y_x$ (x=0 or 5, Y=Gd, Ti) were produced and annealed for 5 h at 1173 K. Microstructure investigations performed by SEM and AFM show that $Ni_{50}Mn_{25}Ga_{25}$ and Ti-doped alloys, both in the as-cast and annealed state, are single phase materials, whereas Gd-doped sample reveals dual-phase structure. Thermomagnetic measurements confirm reversible martensitic transition in the $Ni_{50}Mn_{25}Ga_{25}$ and Ti-doped alloy. Ti addition reduces the temperature of phase transformation, which equals to M_s=169.4 K for Ti-doped alloy and 183.4 K for reference alloy. On the other hand, the $Ni_{50}Mn_{25}Ga_{20}Gd_5$ alloy, both in as-cast and annealed state, does not experience fully phase transition. Similar trend is also observed for Curie point, which does not depend on heat treatment, but varies with chemical composition (Tc=366.8 K, 352.3 K and 305.8 K for reference, Gd- and Ti-doped alloy, respectively). Mechanical properties of materials were investigated by using planar distributions of nanohardness. This approach allows to estimate physical properties of studied alloys and separate hardness of each individual phase in Gd-doped sample. It is notable that Ti or Gd addition to NiMnGa system leads to increase in hardness of this material.

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P-A.119

FeCo Soft Magnetic, Electrically Insulated Nanopowders

M. M. Codescu, E. Chitanu, W. Kappel, D. Patroi, E. Manta, J. Pintea

Text The concept of more electrical aircraft architecture requires new magnetic materials, with improved magnetic and electrical properties. The paper investigates the soft magnetic materials based on $FeCo/Al_2O_3$ core-shell nanoparticles, synthesized by sol-gel technique. These nanomaterials combines the high saturation magnetisation of FeCo compound with the increased resistivity of Al_2O_3 and allow the decreasing of magnetic losses for the bulk sized components, compared with the currently available Fe-Si alloys, used as metallic punched sheets for the building of the magnetic cores in electrical machines. The main physical characteristics of the $FeCo/Al_2O_3$ prepared nanomaterials are: saturation magnetisation in the range of 100 - 200 emu/g, coercivity around 14.35 kA/m and, for sintered materials, resistivities of order of 10^{14} Ω •m.

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P-A.120

Influence of disorder on elastic, magnetic and electronic properties of Co2CrAl Heusler alloy

M. Zagrebin, V. Sokolovskiy, T. Pershukova, V. Buchelnikov

Text At present, the Co_2CrAl alloy has attracted a strong interest from both experimental and theoretical points of view due to the complex half-metallic ferromagnetic (FM), ferrimagnetic and antiferromagnetic behaviors. Co_2CrAl crystallizes in the $L2_1$ structure [1]. On the one hand, the experimental studies of magnetic and structural properties of Co_2CrAl depending on the mechanical alloying have shown that the structural disorder leads to the disappearance of FM order [1-3]. On the other hand, the influence of plastic deformation on the structural disorder does not change sufficiently the magnetic and electronic properties of Co_2CrAl [2]. The similar study of Co_2CrAl thin films showed that a decrease in the Curie temperature and saturation magnetization is observed with an increase in the structural disorder [4]. In this work, we using density functional theory implemented into VASP package [5,6] have studied the influence of disorder of on elastic, magnetic and electronic properties of the Co2CrAl alloy. Supercells of $L2_1$, B2, A2 structures have been used. The total energies, elastic modulus, and DOS have been calculated for these structures.

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P-A.121

Investigation of electronic, magnetic and structural properties of the $Fe_{1-x}Mn_xRh$.

O. Pavlukhina, V. Buchelnikov, V. Sokolovskiy, M. Zagrebin

Text Fe-Rh-based alloys have attracted a lot of attention because of their possible application in magnetic cooling, thermally assisted magnetic recording and spintronic devices. It well known, that the magnetic order in Fe-Rh compounds depends strongly on the concentration of elements. Therefore, it is important to study the effect of adding a third element on the magnetic and structural properties of the material. In this work, we present theoretical investigations of the structural, electronic and magnetic properties $Fe_{1-x}Mn_xRh$ (x = 0, 0.125, 0.25, 0.5, 0.625, 0.75, 0.875, 1) alloys. The properties of Mn-doped Fe-Rh alloys are investigated by the VASP and SPR-KKR packages. In the present work we calculated the total energies for different spin configurations as functions of the lattice parameter. It is shown that the calculated optimized lattice parameter for Fe-Rh alloy is in a good agreement with experimental and other theoretical values. The total and partial DOS curves for Fe1-xMnxRh alloy was calculated. The total energy differences between the tetragonal distorted and cubic phases for $Fe_{1-x}Mn_xRh$ compositions with the energetically favorable spin configuration as functions of c/a ratio was obtained. It is shown that at some additions of Mn atoms the martensitic transitions can exist.

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P-A.122

Low-power cw optical control over MgO-based tunneling spintronics

K. Katcko, U. Halisdemir, F. Schleicher, L. Kandpal, B. Leconte, N. Beyer, A. Boulard, J. Arabski, F. Montaigne, E. Beaurepaire, W. Weber, S. Boukari, M. Hehn, D. Lacour, M. Bowen

Text Magnetic tunnel junctions (MTJ) have been extensively studied in the past 20 years due to their potential in both present-day (read heads in hard disk drives) and foreseen (STT-MRAM, robust memristors for bio-inspired computing) storage capacities. This potential societal impact rests upon the ability, within these devices, to combin both high spintronic performance (high tunneling magnetoresistance, or TMR), and high current densities that enable, through spin transfer torque physics, an electric control over the device's spintronic state. This combination is enabled by the presence of double oxygen vacancies within the MTJ's MgO tunnel barrier, which promote very low barrier heights while maintaining spintronic performance.
Most efforts to optically control the MTJ's spintronic state have focused on ultra-short, intense laser pulses of circularly-polarized light to flip a ferromagnetic electrode's magnetization. In contrast, we have investigated how the optical activity of the MgO barrier's oxygen vacancies can promote a similar functionality. While our initial efforts were marred by heating issues, we have completed carefully crafted experiments that unequivocally show that it is possible to optically alter the spintronic performance of MgO-based MTJs using the optical activity of oxygen vacancies. We achieved this demonstration using low-power, continuous wave (cw) laser light, which opens a viable path toward industrial applications.

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P-A.123

Magnetic anisotropy and stress-magnetoimpedance (S-MI) in current-annealed Co-rich glass-coated microwires with positive magnetostriction

M. Nematov, L. Panina, A. Adam, N. Yudanov, A. Dzhumazoda, A. Morchenko, D. Makhnovskiy

Text Amorphous alloys have low magnetocrystalline anisotropy but can exhibit various kinds of induced anisotropy. In the case of a low magnetostriction, the magneto-elastic anisotropy is reduced by relaxing the internal stresses at annealing. In such alloys the magnetic properties can be controlled by uniaxial anisotropy induced during the heat treatment in the presence of a magnetic field or a mechanical stress. The induced anisotropy is of huge practical relevance making it possible to tailor the magnetization behaviour according to practical demands.
In this work, effects of a dc current annealing, in terms of magnitude and inflow time, on magnetic hysteresis properties, magnetoimpedance (MI) and stress-magnetoimpedance (S-MI) in glass-coated amorphous $Co_{71}Fe_5B_{11}Si_{10}Cr_3$ microwires with a small positive magnetostriction were investigated. The annealing process leads to the creation of a specific magnetic anisotropy of a helical or circular type, and consequently, was helpful to control the MI and S-MI behaviours making them more suitable for particular sensing applications. After annealing, the magnetoimpedance plots transformed from a bell-shape typical of an axial easy anisotropy to a shape with two symmetrical peaks, the magnitude and position of which are controlled with the annealing current parameters. Applying a tensile stress to the annealed wires changes the easy anisotropy direction which creates the condition for highly sensitive S-MI without use of dc bias fields.

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P-A.124

Magnetic properties of Fe-Ni-Co-Al alloys

A. Mashirov, I. Musabirov, A. Kamantsev, E. Dilmieva, A. Koshelev, V. Kalashnikov, V. Koledov, V. Shavrov

Text Recently, it has been proved that the addition of Ta and B elements in the Fe-Ni-Co-Al system alloy alters the non-thermoelastic martensitic transformation by thermoelastic and leads to a "giant" superelasticity up to 13.5% in the $Fe_{40.95}Ni_{28}Co_{17}Al_{11.5}Ta_{2.5}B_{0.05}$ alloy [1]. Methods of induction and arc melting, followed by homogenizing annealing and quenching, produced ingots of Fe-Ni-Co-Al and Fe-Ni-Co-Al-Ta-B alloys, and then manufactured alloy plates and investigated magnetic properties. When measuring the dependent of magnetization, a typical path for ferromagnets was found, which, with a decrease in temperature from 335 K to 4 K, is replaced by ambiguous hysteresis behavior. The coefficient of the sensitivity of the magnetostructural transition to the magnetic field is determined. The obtained data can be explained by a combination of states of the spin and deformation glass [2].

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P-A.125

Magnetic properties of stainless steels under corrosive action of choline chloride based ionic liquids

V. Dziamidzenka, A. Zhyvulka, K. Yanushkevich, A. Galias, V. Constantin, E. I. Neacsu, C. Donath, A. M. Popescu

Text An influence of corrosion action based on choline chloride ionic liquids on magnetic properties of various grades of stainless steels is studied. Corrosion resistance studies were carried out on OL44, OL52, ST4571, Monel and Uranus B6 stainless steels were investigated by potentiodynamic method after exposure with solutions of ChCl – Oxalic Acid (1:0,5)M and ChCl – Malonic Acid (1:2)M at 80ºC during 1 month. Analysis of Tafel polarization curves for all samples had been performed, and corrosion electrochemical parameters were calculated. The temperature dependences of the specific magnetization before and after corrosion action were studied by ponderomotive method in 0.86 T magnetic field in the temperature range of 77 – 1000 K. Comparative analysis of temperature dependences of specific magnetization before and after ionic liquids exposure confirms a high corrosion resistance of magnetic characteristics of the investigated stainless steels under conditions of long-term contact with based on choline chloride ionic liquids at 80°C. Images obtained with an electron microscope show a surface of the steel in the initial state contains defects which become centres of pointed corrosion. Corrosion resistance of stainless steels in contact with based on choline chloride ionic liquids solutions at moderate temperatures is satisfactory for the practical application of these materials.

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P-A.126

Magnetism of Magnetic Shape Memory Films: Recent developments

V. Chernenko, V. L'vov, V. Golub, J. M. Barandiaran

Text Heusler magnetic shape memory alloys (MSMAs) are characterised by competing ferromagnetic (FM) and antiferromagnetic (AF) exchange interactions due to different Mn-Mn distances within the unit cell, drastically modified by martensitic transformation (MT). Nanotwinning of martensite strongly affects the magnetic order, but its role is not well understood. We present the results of recent FMR studies of NiMnGa and Ni(Co)MnSn MSMAs epitaxial films. (1) In the prototype Ni-Mn-Ga ferromagnetic thin films, we found a strong FM exchange coupling between the submicron twin components, which resulted in a reduced magnetic anisotropy. Due to FM exchange coupling, magnetic moments of the twins tend to align parallel to each other, and the magnetic domains spread across a large number of neighbouring twins. Magnenetoresistance and FMR studies of epitaxial films of Ni52.3Mn26.8Ga20.9 MSMA revealed the formation of a non-collinear magnetic structure due to the nanotwinning. The electron scattering on such a magnetic structure is an origin of the noticeable negative magnetoresistance in a broad temperature range. (2) FMR studies of epitaxial film of martensitic metamagetic Ni46.0Mn36.8Sn11.4Co5.8 MSMA revealed a presence of weak AF coupling between the FM ordered twin components. This coupling explains the exchange bias and magnetic resonance spectra of the films, in the same terms as in the case of artificial antiferromagnets, made of AF coupled multilayers.

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P-A.127

Magneto-mechanical Optimization and Analysis of a Magnetostrictive Cantilever Beam for Energy Harvesting

V. Apicella, C. S. Clemente, D. Davino, D. Leone, C. Visone

Text The requirement of self-powered stand-alone sensors attracted the interest of technological research in last years. Devices able to transform mechanical vibrations into electric power, known as Kinetic Energy Harvesters (KEH), are among the most studied. A solution is represented by the cantilever configuration exploiting magnetostrictive Fe-Ga alloys. Vibrations energy spectrums are complex and usually distributed over a quite large frequency range, while cantilever KEH work in a relatively narrow band. This requires both modelling and experimental effort to provide an “optimal” system tuning. In this paper, different configurations have been developed and tested to detect geometric and physical parameters affecting resonance frequency, bandwidth and converted power. The selected cantilever is made by bonding two Galfenol strips to an Aluminium foil, which guarantees a better mechanical resistance and provides a larger stiffness with an increasing resonance frequency. An optimized permanent magnet system has been developed to supply an effective magnetic bias to the active material with the aim to increase the converted power. Experimental tests were performed with an electrodynamic shaker in the 50-200 Hz frequency interval with acceleration in the 1-4 g amplitude range. The results seem quite encouraging, because a relatively high converted energy is obtained, in spite of the simple device structure.

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P-A.128

Magnetorheological fluids and foams for multiferroic applications

L. Makarova, Y. Alekhina, A. Omelyanchik, V. Rodionova, D. Peddis, V. Spiridonov, N. Perov

Text Recently new rheological multiferroic material based on elastic polymer, ferromagnetic and ferroelectric particles was proposed [1]. The magnetoelectric coupling between different types of particles depends on elastic properties of polymer matrix. It was supposed that the internal deformations in silicone porous structure were larger than those in elastic continuous medium. This should lead to an increase of the magnetoelectric transformation. In this work the investigation of mechanical and magnetic properties of magnetorheological foam based on silicone porous structure and magnetic fluid is presented.
The rheological foam based on silicone porous structure with ferroelectric particles was prepared as a base of multiferroic material. The magnetic fluid was prepared by ultra-sonication of glycerol with cobalt ferrite nanoparticles (10nm). The resulting colloid was stable and it was placed into the foam like in a sponge. The fluid does not pour out from the foam due to capillary effect.
Magnetic properties of the fluid and the foam which were investigated by VSM are similar. Unlike the fluid, the foam can take any shape and has the ability to deform in external magnetic field. This could be prospective for practical application and for development of multiferroic and multifunctional materials.
Financial Support of RFBR Grant No. 17-32-50183 is acknowledged.
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Poster Session A

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P-A.129

Magnetostriction of Fe100-xGax alloys from first principles calculations

M. Matyunina, M. Zagrebin, V. Sokolovskiy, V. Buchelnikov

Text Nowadays, the Fe-Ga alloys is a focus of interest due to a giant magnetostriction λ001 observed at room temperature in low magnetic fields [1]. The extraordinary values of λ001~395×10-6 and 350×10-6 near the concentration of Ga ~19% and ~27% [1], respectively, makes these alloys to become promising materials for applications in sensors and actuator technology [2].
This work presents the results of determination of tetragonal magnetostriction λ001 from first principles calculations for Fe-Ga alloys. The structural optimization of crystal lattices, calculations of magnetocrystalline anisotropy energy (MAE) and tetragonal shear modulus were done by the VASP package [3] with an account of supercell approach (32 atoms in supercell) for A2 (Im-3m), D03 (Fm-3m), and L12 (Pm-3m) phases of Fe100-xGax alloys (0≤x≤31.25). To estimate the MAE we deformed supercell along the z-axis for each structure for their optimized parameters with a constant volume of the supercell and for differently fixed magnetization directions [001] axis and [111] one. After this, the obtained MAE was used for calculation of magnetostriction [4]. It is shown that theoretical magnetostriction well agrees with experimental data.
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P-A.130

Modeling FORC Diagrams of Elastomers Containing Magnetically Hard Multigrain Particles

M. Vaganov, Y. Raikher

Text Magnetorheological elastomers (MRE) are smart materials consisting of a soft polymer matrix with embedded magnetic particles. Physical properties of these composites can be tuned by an applied magnetic field because of its interaction with magnetic moments of particles. Due to their prospect applications in the field-controlled devices, MREs are of considerable interest to researchers. It is crucial to model the magnetization processes of such materials and obtain the dependency of magnetic properties of MREs on the applied field. Experimentally available MREs with the spherical NdFeB particles with the mean radius of 50 micrometers experience lack of reliable physical models due to the relatively large size of particles exceeding the critical size of the single-domainess. In our study, a magnetic microparticle embedded in a soft matrix is represented as a cluster of single-domain grains described by the Stoner-Wohlfarth model. The cluster can rotate with respect to the surrounding matrix, but grains do not move relative to each other. Minimization of the total energy of such system yields orientation of the microparticle and magnetic moments of the grains. Using the model, the first-order reversal curve (FORC) diagrams were calculated for magnetically isotropic MRE samples at different elasticity of the polymer matrices. The modeled FORC diagrams reflect not only hysteretic properties of the magnetic filler but also contain information on elastic properties of the matrices.

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P-A.131

Modeling of Magneto-Optical Kerr Effect Spectra in (Ni,Fe)2MnGa alloy

J. Zemen, M. Zelený, L. Straka, M. Veis, O. Heczko

Text The martensitic transformation in magnetic shape memory alloys (MSMAs) between the high temperature austenitic (cubic) and low temperature martensitic (tetragonal) phases is intimately linked to the electronic structure of the material codetermined by its magnetic ordering. Magneto-optical Kerr spectroscopy reveals important details about the magnetic and electronic structure of materials including MSMAs with high sensitivity to the induced strain of the lattice. The available experimental spectra for Ni-Mn-Ga alloy [1,2] indicate that there are significant differences between the electronic structures of austenite and martensite.

In presented work we simulated magneto-optical (MO) spectra as a function of partial occupation of Ni sites by Fe atoms. This allows us to track the gradual change of the MO spectra from Ni_2MnGa to Fe_2MnGa alloy which does not exhibit a martensitic transformation. The Projector-Augmented Wave method (PAW) and linear response theory implemented in the VASP code [3] were used to obtain the frequency dependent dielectric matrix. Similarly to experimental observation we have found a strong dependence of the MO spectra on Fe concentration which corresponds to changes in electronic structure responsible for the stability of cubic phase.

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Poster Session A

Poster A

P-A.132

Multifunctional phenomena in substituted RCo2 compounds

G. Politova, T. Kaminskaya, A. Filimonov, I. Tereshina, A. Il'ushin

Text In this work the magnetocaloric and magnetostrictive properties of substituted RCo2 compounds with Laves phase structure are investigated and analyzed. The samples Tb0.2Dy0.8-xGdxCo1.9Al0.1 (x = 0-0.5) were obtained by arc melting using of high-purity rare-earth metals. The crystal structure of these compounds was monitored by X-ray diffraction; the surface topology of the synthesized samples was studied by atomic force microscopy. Surface topology features, temperature dependences of lattices parameters of these multicomponent alloys have been obtained and analyzed. The magnetostriction and the magnetocaloric effect (MCE) in external magnetic field up to 1.2 and 1.8T, respectively, were studied in wide temperature range.
The phase transitions temperatures were determined. It is shown that all compounds demonstrate magnetostructural phase transitions at the Curie temperature, where significant magnetostriction and MCE observed. The relationship between observed effects is shown; the universal curve of entropy under various magnetic field changes has been constructed by using a phenomenological procedure. In the low-temperature region, there is a sign-alternating field dependence of the magnetostriction, which indicates a distortion of the magnetic structure, a violation of the collinearity of the magnetic moments of the sublattices.
The work was performed within the scope of the state task of the FASO of Russia (007-00129-18-00), in part was supported by the RFBR (18-03-00798).

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P-A.133

Phonon spectra of Pd_2MnZ (Z = Ga, Ge, As) Heusler alloys

V. Buchelnikov, O. Miroshkina, A. Zayak

Text In this work, the phonon spectra of Pd_2MnZ (Z = Ga, Ge, As) Heusler alloys are studied. Nowadays there is very little information about these alloys in the literature. For the phonon properties of Pd2Mn-based compounds, data are not yet available.
The phonon calculations in pointed Pd_2Mn-based alloys were performed using the force-constant method, according to which the Hellmann-Feynman forces were computed in the 40-atoms supercells, which were elongated in $[110]_c$ direction in the conventional $L2_1$ cubic cell, which corresponds to the $[010]_t$ direction in the tetragonal cell.
PHONON program developed by K. Parlinski together with the Vienna ab initio simulation package (VASP) was used for these calculations [1-4]. The PHONON program allows calculating of the phonon frequencies for crystals from a set of forces provided as a file calculated with VASP.
As a result, phonon dispersion curves for Pd_2MnZ (Z = Ga, Ge, As) were calculated.
It was found that there are no peculiarities in the spectra of studied alloys in contrast to Ni_2MnGa for which negative frequencies of transverse acoustic mode TA_2 are observed [5].
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Poster Session A

Poster A

P-A.134

Spin current induced excitations in antiferromagnetic nanowire

V. Kuchkin, H. Gomonay

Text Magnetoelastic (ME) excitations in antiferromagnetic (AF) nanostructures attract increasing interest due to possible applications in spintronics [1,2]. This study aims dynamics of ME excitations induced in a cubic AF by spin current. Analysis of the potential energy of an AF is performed in approximation of the frozen lattice. Using the Lagrange approach we obtain the equations of motion for the Neel vector and the displacement vectors in presence of spin current with account of dissipation and ME coupling.We calculate the value of the threshold current at which the system is unstable with respect to autooscillations. Taken together, these findings highlight an important role of ME in AF spintronics on the way of minimization of computer components.

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Poster Session A

Poster A

P-A.135

Static and dynamic response of Griffiths phase in $Tb_{4.925}La_{0.075}Si_2Ge_2$ magnetocaloric compound

P. A. Algarabel, N. Marcano, L. Fernandez-Barquin, J. P. Araujo, A. M. Pereira, J. H. Belo, C. Magen, L. Morellon, R. Ibarra

Text The $R_5(Si_xGe_{1-x})_4$ (R = rare earth) compounds have been the subject of intensive research since the discovery of the giant magnetocaloric effect (GMCE) near the magnetostructural transition in $Gd_5Si_2Ge_2$. Their promising magnetoresponsive properties have triggered a plethora of studies in order to shed light on the nature of such intense effects. The complex layered crystalline structure, the competition between magnetic interactions and the strong relation between structure and magnetic properties lead to the observation of another exotic regime such as the Griffiths-like phase.

In this work, the static and dynamic response of the Griffiths phase in the magnetocaloric compound $Tb_{4.925}La_{0.075}Si_2Ge_2$ has been experimentally investigated by means of dc magnetization and linear and nonlinear ac susceptibility measurements in the frequency range 100 Hz – 10 kHz. The data show that a cluster-glass state is formed at a characteristic freezing temperature T_{G^*} within the Griffiths phase regime ($T_c < T < T_G$) below the characteristic Griffiths temperature T_G where the short-range ferromagnetic correlations set in. The data near the freezing temperature are fitted to a critical slowing down process characterized by the dynamic exponents $z\nu \sim 6$ and $\beta \sim 4$. The origin of the intermediate cluster-glass phase inside the Griffiths-like phase is analyzed in the framework of the complex competition between the interslab and intraslab magnetic interactions.

Poster Session A

Poster A

P-A.136

Structural and Magnetic Properties of FeNiCoAl-based Superelastic Ribbons

F. Borza, G. Ababei, G. Stoian, M. Grigoras, N. Lupu

Text In the attempt to reduce the steps involved in the thermo-mechanical processing of FeNiCoAlTaB SMAs a cost effective technique, rapid quenching from the melt, has been reported by our group for the fabrication of these magnetic superelastic materials as wire-shaped materials. In the present work we report up to 3% superelasticity in rapidly quenched FeNiCoAl-based ribbons subjected to various thermal treatments. $Fe_{43.5}Ni_{28}Co_{17}Al_{11.5}$ and $Fe_{40.95}Ni_{28}Co_{17}Al_{11.5}Ta_{2.5}B_{0.05}$ ribbons with the thickness of aprox. 30 micrometers and 1 mm in width have been prepared in inert athmosphere. X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) as well as thermomagnetic and magnetic investigations have been performed on as-cast samples and on thermally treated samples (600°C for 72 hours and 800°C for 1 hours). The structure of rapidly quenched specimens analysed, by XRD and SEM, confirmed the formation of γ' phase. The thermomagnetic and magnetic measurements, aiming to reveal magnetization dependence on both temperature and applied magnetic field, indicated an increase in T_c from 450°C to 650°C for the 600°C annealed ribbons and a decrease to 420°C for the 800°C annealed ribbons. The coercive field reaches 5 KA/m for the 600°C annealed ribbons. The highest superelastic effect was found to be approximately 3% for the 600°C FeNiCoAl annealed ribbons.
Acknowledgment – Work supported by Ministry of Research and Innovation, Romania, Nucleu Programme (PN 18 06 01 01).

Poster Session A

Poster A

P-A.137

Structural and magnetic characterization of glass-coated microwires of Ni2FeGa Heusler alloy

L. Froľová, T. Ryba, J. Kopeček, L. Fekete, T. Kmječ, O. Heczko, R. Varga

Text Ferromagnetic shape memory alloys (FSMAs) belong to the group of smart materials which combine the properties of sensors and actuators [1]. Heusler alloy based on Ni-Mn-Ga is a prototype of FSMAs owing to large magnetic field induced strain reaching up to 10% accompanied by large changes of magnetic properties. However, lack of ductility of this system and difficult preparation due to evaporation of Mn during melting can limit its potential applications.

Alternatively, Heusler alloy based on Ni-Fe-Ga with composition close to the stoichiometric 2:1:1 have been proposed as promising candidate of FSMAs with transformation characteristics quite similar to Ni2MnGa [2]. Heusler alloy Ni2FeGa for our study was prepared by Taylor – Ulitovsky method, which allows easy production of monocrystalline microwire. Structural transformation at about 220 K was studied by optical microscopy, magnetic measurement and X-ray diffraction. Mossbauer spectroscopy was used to evaluate the changes during transformation at the different temperatures. Magnetic properties were analyzed by MFM which shows influence of magnetic field on the size and direction of magnetic domains in the austenite.

This work was supported by the projects, Slovak VEGA grant No. 1/0164/16, APVV project APVV-16-0079 and GACR 16-00043S.

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Poster Session A

Poster A

P-A.138

Structural and magnetic properties of Al- and Si-substituted Mn-Ge alloys with $D0_{22}$-type structure

Y. Shoji, H. Okada

Text Mn-based alloys with tetragonal $D0_{22}$-type structure have attracted much attention because these alloys exhibit high magnetocrystalline anisotropy and high Curie temperature but have small magnetization due to a ferrimagnetic state [1]. It has been reported that $D0_{22}$-type Mn_3Ga and Mn_3Ge are obtained in Mn-poor composition $Mn_{3-x}Ga$ and Mn-rich composition $Mn_{3+y}Ge_{1-y}$, respectively. In this work, we have investigated structural and magnetic properties of off-stoichiometric $D0_{22}$-type Mn-Ge alloy with substitution of Ge by Al and Si to clarify the substitution effects.
Polycrystalline samples of $Mn_{3.03}Ge_{0.97-x}Al_x$ and $Mn_{3.09}Ge_{0.91-y}Si_y$ were prepared by arc-melting method. Structural and magnetic properties were investigated using a powder X-ray diffractometer and a vibrating sample magnetometer, respectively.
The single phase of the $D0_{22}$-type structure was obtained at $x \leq 0.3$ and $y \leq 0.5$. For $Mn_{3.09}Ge_{0.91-y}Si_y$, lattice parameters *a* and *c* linearly decrease with increasing Si content. In contrast, for $Mn_{3.03}Ge_{0.97-x}Al_x$, lattice parameter *a* increases with increasing Al content, whereas lattice parameter *c* decreases. Magnetization of $Mn_{3.09}Ge_{0.91-y}Si_y$ decreases slightly with increasing Si content. On the other hand, that of $Mn_{3.03}Ge_{0.97-x}Al_x$ increases with increasing Al content. There results imply that the difference of the Al and Si substitution effects is related to the number of the valence electron rather than the ionic radius.

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Poster Session A

Poster A

P-A.139

Transport properties of Mn_2CoSn Heusler alloy

M. Seredina, D. Karpenkov, M. Zhelezny, A. Risunkov, R. Chatterjee, R. Y. Umetsu, V. Khovaylo

Text Half-metallic ferrimagnets with high Curie temperature have been attracting growing attention in the field of spintronics. Mn_2CoSn is of particular interest among such Heusler alloys. However, transport properties of this alloy have not been studied so far. This motivated us to investigate electrical resistivity and Hall effect in polycrystalline samples of Mn_2CoSn.
Ingot of Mn_2CoSn (nominal composition) was prepared by an induction melting method. A part of ingots was annealed at 1073 K for 7 days and subsequently quenched in cold water. Real composition of the ingot was determined by energy dispersive X-ray spectroscopy to be $Mn_{1.99}Co_{1.03}Sn_{0.98}$. XRD analysis revealed that samples were mainly single phase (space group F-43m) with lattices parameter a = 0.6083 nm. Transport properties were investigated by CRYOTEL equipment in a temperature range from 80 to 800 K.
Measurement of electrical resistivity ρ revealed that Mn_2CoSn has semiconducting behavior of ρ in all temperature range. High values of electrical resistivity (420 μOhm•cm at T = 80 K) are sign of half-metals, but its strong dependence on temperature denies this fact. Curie temperature determined from ρ(T) curve was found to be ~603 K, which is in a good agreement with the literature data. Abnormal Hall coefficient (AHC) calculated from results of Hall resistivity is of order 10^{-1}. Mn_2CoSn changes conduction type from holes-like to electrons conduction at T = 137(±3) K.

Poster Session A

Poster A

P-A.140

Antiferromagnetic CuMnAs alloy: role of defects

F. Maca, J. Kudrnovsky, V. Drchal, K. Carva, P. Balaz, I. Turek

Text Electronic, magnetic, and transport properties of the antiferromagnetic (AFM) CuMnAs alloy with tetragonal structure, a promising material for the AFM spintronics, are studied from first principles using the total energy calculations. We estimate stability of different phases and calculate formation energies of possible defects in the alloy. Mn_{Cu} and Cu_{Mn} antisites and vacancies on Mn or Cu sublattices were identified as most probable defects in CuMnAs. We find that the interactions of the growing thin film with the substrate and with vacuum are important for the phase stability of real samples prepared as a thin film on the appropriate substrate. We estimated also in-plane resistivity of CuMnAs with defects of low formation energies. Our numerical simulations fitted experiment very well if we assumed concentrations 3.5-5% Mn_{Cu} antisites in the samples, much larger concentrations would be needed for Cu_{Mn} antisites or Mn-vacancies. Finally, we determine the exchange interactions and estimate the Néel temperature of the ideal and disordered AFM-CuMnAs alloy using the Monte Carlo approach. A good agreement of the calculated resistivity and Néel temperature with experimental data makes it possible to draw conclusions concerning the competing phases.

Poster Session A

Poster A

P-A.141

Antiferromagnetic spintronics with 3d transition metal oxides

A. Ross, R. Lebrun, S. Bender, J. Cramer, L. Baldrati, A. Qaiumzedah, R. Duine, A. Brataas, M. Kläui

Text The ubiquitous class of antiferromagnets (AF) benefits from unparalleled stability to applied external fields, magnetisation dynamics with THz frequencies and a lack of long range dipole-dipole interaction leading to possible high integration densities. Numerous theoretical studies have been undertaken, describing the mechanisms through which AFs could be integrated into current spintronic devices, even replacing the heavily researched and utilised ferro- and ferri-magnetic components. AF insulators have been shown to have low Gilbert damping which should allow for efficient switching mechanisms and long-range propagation of magnonic spin currents.
Here, we investigate the efficiency of spin-orbitronic mechanisms and spin transport properties in AF 3d transition metal oxides. Using an AF insulator with an adjacent heavy metal, we have undertaken spin Hall magnetoresistance (SMR) and thermally induced spin Seebeck measurements in local and non-local structures. We find that SMR is an efficient method to determine the direction of the Néel vector and allows us to detect switching in AFs induced by fields above the spin flop and spin-orbit torques.
We compare our measurements on thin film AF multilayer stacks with bulk single crystals in which we recently observed micrometers spin diffusion lengths. This allows us to reveal the underlying AF properties behind spin transport, highlighting some of the requirements for the development of real antiferromagnetic spintronic devices.

Poster Session A

Poster A

P-A.143

Cluster multipole theory and magneto-optical Kerr effect in antiferromagnets

T. Koretsune

Text Magneto-optical Kerr effect (MOKE) has been known as a powerful tool to investigate magnetic properties of materials. For example, the MOKE can be used to detect the magnetic moment in various situations. Sometimes, the net magnetic moment is considered to be crucial for the MOKE. In the recent experiment, however, a large Kerr rotation angle is detected in the antiferromagnet, Mn3Sn[1]. Such behavior is also expected theoretically in Mn3Ir[2]. These MOKE in antiferromagnets can be understood by the magnetic symmetry and such antiferromagnetic structures have been classified by the cluster multipole theory[3].

In this study, we show the calculated MOKE in weak ferromagnets, where Dzyaloshinskii-Moriya interaction induces canted ferromagnetic moment in antiferromagnets. It is found that a large MOKE appears, which comes from antiferromagnetic contribution as in Mn3Sn and Mn3Ir. We also discuss the difference between the MOKE in ferromagnets and antiferromagnets.

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Poster Session A

Poster A

P-A.144

Coalescence-driven, uncompensated antiferromagnetic order in Co doped ZnO

V. Ney, B. Henne, M. Buchner, F. Wilhelm, K. Ollefs, A. Rogalev, A. Ney

Text The evolution of the structural and magnetic properties of Co doped ZnO has been investigated over an unprecedented concentration range above the coalescence limit. We have grown Co:ZnO films with Co concentrations from 10% to 60% of the cationic sublattice by reactive magnetron sputtering. The samples have been measured using integral techniques like XRD and SQUID magnetometry as well as elementselective techniques based on XANES and the associated XLD and XMCD.
Co substitutes predominantly for Zn in the lattice, as measured by XLD. At low Co concentrations, the films which are devoid of metallic Co precipitations exhibit anisotropic paramagnetism [1]. With increasing Co content, the films become antiferromagnetically ordered with increasing order temperature [2]. Uncompensated spins, coupled to the antiferromagnetic dopant configurations, lead to a vertical exchange-bias-like effect [3], which increases with increasing Co concentration [2]. In parallel, the effective magnetic moment per Co atom and the single-ion anisotropy [2] is gradually reduced. We will present the resulting phase diagram of the magnetic order which significantly deviates from theoretical predictions of coalescence-induced magnetic order in Co doped ZnO [4].

[1] A. Ney et al., Phys. Rev. B 81, 054420 (2010)
[2] V. Ney et al., Phys. Rev. B 94, 224405 (2016)
[3] B. Henne et al., Phys. Rev. B 93, 144406 (2016)
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Poster Session A

Poster A

P-A.145

Electronic structure of tetragonal CuMnAs

K. Vyborny, J. Minar, M. Veis

Text The tetragonal phase of CuMnAs progressively appears as one of the key materials for antiferromagnetic spintronics due to efficient current-induced spin-torques whose existence can be directly inferred from crystal symmetry. Theoretical understanding of spintronic phenomena in this material, however, relies on the detailed knowledge of electronic structure (band structure and corresponding wave functions) and it is therefore highly desirable to test its accuracy. Several computational methods (LAPW, pseudopotentials, SPRKKR, QSGW) are critically compared and two spectral quantities (optical permittivity and photoelectron spectra) are shown to be in good agreement with experimental data [1]. It is argued that, on the DFT level, Hubbard term needs to be added in order to account for electron-electron correlations and relevant range of the values for the U parameter is given.

[1] M. Veis et al., Phys. Rev. B 97, 125109 (2018)

Poster Session A

Poster A

P-A.146

Enhancement of Spin Current in Metallic Antiferromagnets

Y. Wen, Y. Zhao, A. Manchon, X. Zhang

Text We report an enhancement of spin current in //Ta/IrMn/Cu/NiFe multilayer heterostructure, where a thin metallic antiferromagnets (AFM) IrMn can enhance the spin current from Ta to NiFe. The spin current enhancement with a pronounced maximum value around Neel temperature of the thin AFM layer was found. Through varying the measurement temperature, both electronic and magnonic spin current was evidenced. We found a larger spin current in samples with a thin IrMn layer compared with those without IrMn at low temperature, where the magnonic spin current is small. The pure electronic spin current should evanesce after passing through a very limited length (~1nm), which may suggest the dominating role of spin transmission at the interface of Ta/IrMn in the whole spin transport since the electronic spin current should fade with increasing thickness.

Poster Session A

Poster A

P-A.147

Evolution of magnetotransport properties in (Cr1-xMnx)2AlC MAX-phase with a small manganese impurity

K. Sobolev, M. Khajrullin, S. Granovsky, V. Rodionova, N. Perov

Text MAX-phases represent a relatively new class of ternary carbides and nitrides with a general formula Mn+1AXn which possess a unique set of properties, common both for metals and for ceramics. Although the major part of MAX-phases are non-magnetic, the (Cr1-xMnx)2AlC compound was recently confirmed to possess an AFM type of magnetic ordering which is competing with the FM one.
Samples of (Cr1-xMnx)2AlC with Mn concentration x = 0, 2.5%, 5% and 10% were synthesized using arc melting technique with further annealing. XRD and SEM-EDX analysis proved the high homogeneity of these samples (volume fraction of additional phases is less than 1%). Magnetic properties were investigated using SQUID magnetometry and the AFM type of magnetic ordering was also observed from the obtained results.
Temperature dependence of both Hall effect and magnetoresistance was investigated using the four-wire method of resistance measurements. The drastic change of the magnetotransport behavior was found with the increment of the manganese concentration. MR value raises three orders of magnitude for the (Cr0.9Mn0.1)2AlC sample compared with Cr2AlC one (it reaches the value of 3% in the field of 1 T) and also changes its sign which can be due to the change of the prime charge carriers. This suggestion was also confirmed with Hall effect measurement results. Such a big raise of MR effect makes the (Cr1-xMnx)2AlC MAX-phase a promising candidate for applications in an AFM spintronics.

Poster Session A

Poster A

P-A.148

Generation of Néel field in anti-ferromagnetic nanowire by a sloped electric field

K. Kubota, K. Yamada, Y. Nakatani

Text Recently, a magnetic domain wall (DW) motion in a magnetic nanowire has attracted attention as a novel technique for memory development [1]. Recently, it has reported that the DW motion velocity in Anti-ferromagnets (AFM) is much faster than that in ferromagnets [2-6] and, the DW motion in AFM has been gathering attentions. The DW in AFM with Dzyaloshinskii-Moriya interaction (DMI) can be moved by a spin-orbit transfer torque [4-5]. Whereas the DW in AFM without DMI can be moved by Néel field generated by Néel Spin Orbit Torque (NSOT) [7, 8]. In this study, we propose a method to generate Néel field by using a sloped electric field (SEF) and demonstrate the DW motion in AFM by micromagnetic simulations.

In the simulation, we assumed that Ku is decreased by the electric field, therefore Ku is decreased linearly from left edge to the right edge in the wire by SEF [9]. The reduction rate of Ku is defined as ΔKu (erg/cm^4) [9]. TIn the simulation results resultwith, at ΔKu = 3.0 Gerg/cm^4 shows that , the DW velocity increases rapidly to v = 10.8 m/s up to time t = 0.05 ns. The Néel field (HNéel) generated by the SEF can be obtained in the same method as [9];

$H_{Néel}^{eff}=1/(2Ms\ )\ (\partial\sigma/\partial x)$, (1)

where σ is AFM's DW energy. The simulation results agree very well with the DW velocity of $v_{Analy.}=\gamma\Delta/\alpha$ $H_{Néel}^{eff}$ (where ϒ, Δ and α are the gyromagnetic ratio, DW width and the Gilbert damping constant respectively) obtained by Eq. (1). It shows that Néel Field can be generated in AFM by SEF.

Poster Session A

Poster A

P-A.150

Half-metallic compensated ferrimagnetism in the Mn-Co-V-Al Heusler alloys

D. Benea, R. Gavrea, M. Coldea, O. Isnard, V. Pop

Text Detailed theoretical and experimental investigations on the electronic and magnetic properties of the $Mn_2Co_{1-x}V_xAl$ Heusler compounds are presented. The magnetization vs. temperature measurements on the $Mn_2Co_{1-x}V_xAl$ Heusler compounds show a decrease of the Curie temperature with V content, between 745 K (x = 0) and 671 K (x = 1). Ferrimagnetic near fully compensated behavior with the saturation magnetization of 0.29 μB /f.u. has been obtained for $Mn_2Co_{0.5}V_{0.5}Al$ alloy, in slight disagreement with Slater-Pauling rule. The electronic band structure calculations performed using the Korringa-Kohn-Rostoker (KKR) Green's function method for the $Mn_2Co_{0.5}V_{0.5}Al$ alloy show half-metallic almost compensated ferrimagnetic behavior with total magnetic moment of 0.3 μ_B /f.u.. The occupation of crystal sites with Mn, Co, V and Al atoms has been determined by total energy calculations. The fully compensated ferrimagnetic behavior is predicted theoretically for the compounds derived from $Mn_2Co_{0.5}V_{0.5}Al$ by slight variation on composition. For fully compensated ferrimagnetic compounds the half-metallic character is preserved, making them attractive for spintronic applications.

Poster Session A

Poster A

P-A.151

Increase of the orbital magnetic moment in uncompensated antiferromagnetic Co doped ZnO films

M. Buchner, B. Henne, V. Ney, J. Lumetzberger, F. Wilhelm, A. Rogalev, A. Hen, A. Ney

Text Density and pinning direction of uncompensated AFM moments in exchange bias systems play a crucial role in the understanding of exchange bias [1,2]. Recently it was revealed by XMCD studies on Co/FeMn that pinned Fe moments exhibit nearly pure orbital character [3].
In this contribution, we present that the orbital character of pinned magnetic moments is an intrinsic property of an uncompensated AFM by low-temperature XMCD spectra of Co doped ZnO films [4]. $Zn_{1-x}Co_xO$ (Co:ZnO) is an uncompensated AFM where the magnetism stems purely the Co dopant atoms. Uncompensated effective magnetic moments of Co are exchange coupled to compensated configurations of Co and O by an antiferromagnetic next neighbor cation exchange interaction. This results in a vertical exchange shift and an narrowly opened M(H) curve after field cooling [5].
Co K-edge XMCD spectra at different cooling field conditions were recorded to study uncompensated AFM moments with and without pinned Co moments. The spectra reveal a change at the main absorption energy, connected to the orbital moment. The signal obtained at the pre-edge, connected mainly to the spin systems, stays unaffected by the cooling conditions.
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[3] Audehm, P. et al., Sci. Rep 6, 25517 (2016).
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Poster Session A

Poster A

P-A.152

Interlayer Couplings Mediated by Antiferromagnetic Magnons

R. Cheng, D. Xiao, J. Zhu

Text Collinear antiferromagnets (AFs) support two degenerate magnon excitations carrying opposite spin polarizations, by which magnons can function as electrons in spin transport. We explore the interlayer coupling mediated by antiferromagnetic magnons in an insulating ferromagnet(F)/AF/F trilayer structure. The internal energy of the AF depends on the orientations of the two Fs, which manifests as effective interlayer interactions JS1.S2 and K(S1.S2)^2. Both coefficients J and K are functions of temperature and the AF thickness. In particular, J turns out to be antiferromagnetic at low temperatures and ferromagnetic at high temperatures. In the high-temperature regime, J is estimated to be much larger than the interlayer dipole-dipole interaction, allowing direct experimental verification.

Poster Session A

Poster A

P-A.153

Low temperature antiferromagnetic resonance study of quasy-2D magnet $Cu(en)(H_2O)_2SO_4$

V. Glazkov, Y. Krasnikova, I. Rodygina, R. Tarasenko, A. Orendáčová

Text Recently synthesized [1] antiferromagnet $Cu(en)(H_2O)_2SO_4$ orders at zero field at approximately 0.9 K. Magnetic ions Cu^{2+} are exchange coupled within (bc) plane of monoclinic crystal, in-plane couplings are $J/k_B \approx 3.5$ K and $J' \approx 0.35J$, interplane couplings are much smaller. Phase diagram of this compound was determined by magnetization and specific heat measurements and was discussed in contesxt of field-induced BKT transition [1].

We report results of low-temperature (down to 450mK) magnetic resonance study of this compound using multi-band ESR spectrometers operating from 4 to 40 GHz. As temperature approaches Neel point, ESR line broadens and below Neel temperature resonance absorption field shifts from paramagnetic resonance position. Obtained f(H) diagrams at the base temperature of 0.45...0.50 K are typical for the collinear antiferromagnet, it allows to identify b axis as the easy axis and shows that c* is very close to the hard axis of anisotropy. Zero-field magnon gaps are determined as well and are equal to 5.5 GHz and 13.5 GHz.

On cooling below approx. 600 mK (which is about 2/3 of T_N) splitting of the AFMR absorption line was observed. This splitting is presumably due to the interplane coupling, which splits resonance modes of coupled 2D systems, similarly to [2], and thus gives access to independent estimation of interplane coupling.

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Poster Session A

Poster A

P-A.155

Magnetic and transport properties of Mn_2FeGa melt-spun ribbons

V. Khovaylo, I. Gavrikov, M. Gorshenkov, Y. Anikin, R. Chatterjee

Text First principles calculations have suggested [1] that Mn_2FeZ (Z = Al, Ga, Si, Ge, Sb) Heusler alloys can be of interest for experimental studies due to their potential half-metallic properties. Experimental studies of the Heusler alloy with Z = Ga, Mn_2FeGa, have shown that crystal structure and magnetic properties of Mn_2FeGa strongly depend on annealing conditions [2,3]. To further explore physical properties of this alloy, we have prepared Mn_2FeGa in the form of melt-spun ribbons by a melt spinning technique. Properties of the ribbons were characterized by X-ray diffraction (XRD), magnetic and transport measurements. Room-temperature XRD diffraction revealed that the as-spun ribbons crystallize in a primitive cubic structure. Magnetic properties of the melt-spun ribbons turned out to resemble properties of antiferromagnetic compounds with Neel temperature above 300 K. Electrical resistivity measured in a temperature interval 80 – 360 K revealed that transport properties of melt-spun ribbons demonstrate behaviour of electrical resistivity typical for semiconductors.

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Poster Session A

Poster A

P-A.156

Magnetic anisotropy due to Rashba interaction in antiferromagnets

J. Ieda, S. E. Barnes, S. Maekawa

Text Magnetic anisotropy of an antiferromagnet (AFM) with the inversion symmetry breaking (ISB) is theoretically investigated. The magnetic anisotropy energy (MAE) resulting from the Rashba spin-orbit (RSO) and s-d type exchange interactions is determined for tight binding models of AFMs. We introduce two types of the Rashba interactions: The global ISB model, representing the effect of a surface, interface, or a gating electric field, results in an easy-plane magnetic anisotropy. In contrast, for a local ISB model, i.e., for a noncentrosymmetric AFM, a perpendicular magnetic anisotropy (PMA) arises. These MAE contributions have a key role in determining the direction of the Neel order parameter in AFM nanostructures and reflect the possibility of electrical-field control of the Nel vector.

Poster Session A

Poster A

P-A.157

Magnon spin transport through antiferromagnetic NiO

G. Hoogeboom, T. Kuschel, B. van Wees

Text Thus far, antiferromagnets(AFMs) played a passive role of pinning in giant magnetoresistance. AFMs hold promise of ultrafast and lossless AFM transport devices[1] when one is able to simultaneously generate and detect spin currents, while having control over the magnetic moment directions. AFMs have no stray fields so we made use of either the magnetic easy-plane character[2] or an attached ferromagnet to manipulate its magnetic moments. A charge current through Pt creates a spin accumulation and a thermally based magnon gradient.[3] Combining these characteristics enables the investigation of spin currents through NiO by the spin Hall magnetoresistance (SMR) and the spin Seebeck effect (SSE). Both SMR and SSE depend on the magnetic field direction and temperature and are detected in a local and a non-local configuration.

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[2] Hoogeboom et al., APL 111, 052409

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Poster A

P-A.158

Magnons and phonons exitation in nanosized NiO

N. Mironova-Ulmane, A. Kuzmin, L. Puust, I. Sildos, J. Grabis

Text The Raman spectra in nanosized antiferomagnetic NiO powders are rather similar to that in the single-crystal NiO. It consist of one-phonon (1P) band at ~570 cm^{-1} and two-phonon (2P) bands at ~730 cm^{-1}, ~906 cm^{-1} and ~1090 cm^{-1}. The 1P band becomes more pronounced in powders due to the presence of defects or surface effect, but the three 2P bands appear to be more broadened, especially the band at 906 cm^{-1}, which practically disappears. At the same time, the two-magnon (2M) band, observed in the single-crystal NiO at 1490 cm^{-1}, experiences dramatic decrease of intensity in nanopowders, becoming undetectable for <100 nm crystallites size at RT.
The temperature dependence (10-250 K) of the Raman signal in nanosized NiO powders shows two effects. First, the two-magnon peak is present in both samples, and its behavior follows the expected one for three-dimensional, cubic antiferromagnets: upon heating, the peak broadens, and its position shifts to lower energies. Second, the 1P band at 500 cm-1 remains unchanged for 1500 nm size powder at all temperatures, but in 100 nm size powder this band has a different shape and a sharp peak at 450 cm-1 grows up on top of the band upon cooling. In this work we also have performed temperature dependent Raman spectroscopy studies of single-crystal and polycrystalline NiO across the antiferromagnetic-to-paramagnetic phase transition.

Poster Session A

Poster A

P-A.159

Physical properties with metamagnetic-like behaviour in EuPd2Sn4

I. Čurlík, F. Gastaldo, M. Giovannini, M. Reiffers

Text In a systematic search for novel compounds in the Eu-Pd-Sn system, the intermetallic compound EuPd2Sn4 have been synthesized. EuPd2Sn4 was found to crystallize in the NdRh2Sn4-structure type (oP28) [1].
In this work we present the results of the physical properties of EuPd2Sn4. The temperature dependent magnetic susceptibility χ(T) is found to follow the Curie-Weiss law above 15 K. The evaluated effective magnetic moment is very close to the theoretical free-ion value for Eu2+. At lower temperatures, an antiferromagnetic transition was observed at 11 K. In addition, in EuPd2Sn4 a ferromagnetic type of interaction is induced by magnetic field. In fact, the M(B) dependence shows a metamagnetic-like behavior for values of the magnetic fields within 1 and 2 T. Above the metamagnetic transition at 8 T and 2 K the magnetization saturated at around 7 □B/Eu atom, which is the saturation value of the free Eu2+. The specific heat measurements show a λ-like anomaly reduced in both the temperature and the jump height as the magnetic field strength increases, confirming the antiferromagnetic transition.

[1] Acta Physica Polonica A, 131 (2017) 1003 - 1005

Poster Session A

Poster A

P-A.160

Piezospintronic effect in non-collinear magnetic antiperovskites

I. Samathrakis, H. K. Singh, H. Zhang

Text Antiferromagnets have recently become a hot research topic for spintronic applications. Unlike ferromagnets, they are robust against perturbations due to magnetic fields. Consequently, non-collinear magnets, being a special class of antiferromagnets, have also attracted a lot interest. The possibility of inducing magnetic moment as a response to mechanical strain, piezomagnetic effect, has already been investigated in the non-collinear antiferromagnetic antiperovskite Mn_3GaN. However, the piezospintronic effect (change of transport properties in response to applied strain) still remains unexplored. In this work, we investigate the piezospintronic effect of the aforementioned antiperovskite by analysing the symmetry and detailed density functional calculations. The anomalous Hall conductivity is calculated using the Wannier interpolation method for various magnetic configurations without and with strain. Moreover, high throughput screening in all compounds with chemical formula M_3XY with M=Mn, Fe, Ni, Cr, and Co, X=C and N and A unrestricted is performed to predict novel piezospintronic materials. Our results witness the presence of large anomalous Hall conductivity values, especially under compressive strain. Particularly, the piezospintronic effect highlights significant differences in the transport properties in almost energetically identical configurations, impelling the field of magnetisation control.

Poster Session A

Poster A

P-A.161

Propagation of spin waves through an interface between antiferromagnet and ferromagnet

O. Busel, O. Gorobets, Y. Gorobets

Text Boundary conditions for order parameters at an interface between antiferromagnet (AFM) and ferromagnet (FM) have been obtained in the continuous medium approximation taking into account the fact that the interface, as a composite material, has finite thickness which is much less than the length of the spin wave. Three order parameters have been considered inside an interface of finite thickness with magnetizations of both sublattices M1 and M2 of AFM, and magnetization M of FM. Using these boundary conditions, the excitation of a surface evanescent spin wave has been considered in FM when spin wave in AFM falls onto this interface. The uniform and nonuniform exchange between all order parameters have been taken into account in the interface energy as the typical functional dependencies of the constants in the energy on a coordinate in the interface. The coefficients of transmission and reflection of spin wave through the AFM/FM interface have been derived in cases of a compensated and noncompensated net magnetization of AFM at the AFM/FM interface layer.

Poster Session A

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P-A.162

Site-Specific Spin Reorientation in Antiferromagnetic State of $SeCuO_3$

N. Novosel, W. Lafargue-dit-Hauret, Z. Rapljenovic, M. Dragicevic, H. Berger, X. Rocquefelte, M. Herak

Text We report on magnetic field induced spin reorientation in antiferromagnetically (AFM) ordered state of low-dimensional magnet $SeCuO_3$ observed by torque magnetometry experiment.

Monoclinic $SeCuO_3$ was reported to be quasi-isolated linear spin tetramer system Cu2-Cu1-Cu1-Cu2 where strong Cu1-Cu1 interaction leads to spin singlet formation. Below T_N=8K AFM long-range order (LRO) sets in. The question arises whether spin singlet persists in LRO state or is broken allowing Cu1 spins to participate in the LRO state.

We performed extensive torque magnetometry measurements in AFM state of $SeCuO_3$. We employ simple phenomenological model using symmetry allowed magnetocrystalline anisotropy energy (MAE) to simulate spin reorientation and measured torque. This approach can quantitatively describe our data only under assumption of partial spin reorientation. Based on these results, we propose a model of magnetic order in H=0 and in $H>H_{SF}$. The microscopic origin of MAE in $SeCuO_3$ was also investigated using DFT+U calculations including spin-orbit coupling on an AFM model. It was evidenced inequivalent Cu sites impact differently the magnetic anisotropy of this system. Our results suggest that Cu1 singlets persist even in AFM LRO state, and only Cu2 spins reorient in finite magnetic field.

This work is fully supported by the Croatian Science Foundation (grant UIP-2014-09-9775) and by the COGITO project *Theoretical and experimental study of magnetic and multiferroic materials*.

Poster Session A

Poster A

P-A.164

Spin waves in coupled antiferromagnetic films

A. Sharaevskaya, E. Beginin, S. Nikitov, Y. Sharaevskii

Text Magnonics is fast-moving research area of magnetic micro- and nanostructures. Main carriers of signals used for information processing in such structures are magnons and, in particular, magnetostatic spin waves (MSW) [1-2]. In addition, antiferromagnetic (AFM) structures pay much attention for magnonic and spintronic devices taking into account their strong exchanged fields [3]. In this work we considered theoretical model of two coupled AFM layers separated by dielectric layer. We demonstrate results of calculating dispersion relation for such structure. We study spin-wave propagation through AFM layers and compare effect with ferromagnetic(FM) layers. We considered a two-sublattice model for describing spin wave propagation in single AFM layer. Using coupled mode approach we show how two modes (FM and AFM) split into symmetric and asymmetric waves compare with similar structure. One of main effects is splitting modes in AFM and FM crystals, that can be used for fabrication of the component base of spintronic logic and signal processing devices in THz range.

The support from RFBR (18-57-76001, 18-07-00509) and RSF (14-19-00760) is acknowledged.

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Poster Session A

Poster A

P-A.165

Spintronics with magnetoelectric antiferromagnetic thin films

D. Makarov

Text Thin film antiferromagnets (AF) have potential to revolutionize spintronics due to their inherently magnetic-field stable magnetic order and high-frequency operation. To explore their application potential, it is necessary to understand modifications of the magnetic properties and magnetoelectric responses of AF thin films with respect to their bulk counterparts. Considering grainy morphology of thin films, questions regarding the change of the intergranular exchange, criticality behavior and switching of the order parameter need to be addressed.
Our approach is based on the electron transport characterization of magnetic responses of thin film metallic (IrMn) and insulating (α-Cr2O3) antiferromagnets [1-3]. To access minute uncompensated surface magnetization, we rely on zero-offset Hall magnetometry [2]. To build a reliable description of the material properties, the analysis of the transport data is backed up by structural characterization and real space imaging of AF domain patterns using NV microscopy [2].
The fundamental understanding of the magnetic microstructure of magnetoelectric α-Cr2O3 thin films and the possibility to read-out its AF order parameter all-electrically allowed us to put forth a new recording concept where a magnetoelectric memory cell is addressed without using a ferromagnet [1].
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[3] R. Schlitz et al., Appl. Phys. Lett. 112, 132401 (2018).

Poster Session A

Poster A

P-A.166

Structural and magnetic properties of Mn_2FeAl

I. Gavrikov, A. Bogach, I. Shchetinin, D. Karpenkov, M. Zhelezniy, R. Chatterjee, V. Khovaylo

Text In order to check results of theoretical calculations which predict a high spin polarization and well-defined ferromagnetic properties in Mn_2FeAl, we prepared a polycrystalline ingot of Mn_2FeAl by an induction melting technique and studied its structural and magnetic properties.
Room-temperature XRD diffraction revealed that Mn_2FeAl crystallizes in a primitive cubic structure with space group $P4_132$ (prototype: β-Mn) with crystal lattice parameter a = 0.637 nm. Zero field cooling (ZFC) and field cooling (FC) curves were measured in a field of 1 kOe in a temperature interval from 5 to 400 K. ZFC curve demonstrates behavior typical for antiferromagnets. The maximum on this curve corresponds to Neel temperature T_N = 40 K below which the magnetization gradually decreases. It should be noted that a non-zero magnetization at $T >> T_N$ implies that magnetic interactions persist well above the Neel temperature. Along with this observation, the splitting of ZFC and FC curves below 40 K clearly points to a competing character of the magnetic interactions in Mn_2FeAl. Thus, our measurements revealed that experimentally measured magnetic properties are not in agreement with theoretical ones. This discrepancy can originate from the fact that in the first-principles calculation the crystal structure of Mn_2FeAl was assumed to be $L2_1$ while in the reality this compound crystallizes in a primitive cubic crystal structure.

Poster Session A

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P-A.167

Structural and magnetotransport properties of antiferromagnet-BiFeO3 epitaxial thin films obtained by Polymer Assisted Deposition

E. Otal, R. Ramos, M. Kim, F. Rivadulla, M. H. Aguirre

Text Bismuth ferrite (BiFeO3, BFO) has been widely studied for its unique magnetoelectric properties at room temperature, such as antiferromagnetism coupled with ferroelectricity. It has been also shown to display various novel phenomena, e.g., an increased conductivity at specific ferroelectric domain walls, photovoltaic properties, and new structural phases in thin films. Understanding microstructure and phase evolution in multiferroic BFO thin films is an important issue, because interesting physical properties with practical applications are related to the microstructure. This microstructure is also related with the synthesis/fabrication of the thin film. In this study, we address the polymer assisted deposition synthesis (PAD), a chemical technique of deposition with high control of thickness and stoichiometry. This method allows to produce a high quality epitaxial thin films of BiFeO3 on SrTiO3. We present a detailed investigation on the atomic structure, morphology and microstructre of BFO/STO thin films based on studied by various transmission and scanning transmission electron microscopy techniques (in particular, with a probe Cs - corrector for atomic resolution in the latter case). Magnetotransport properties of the epitaxial films are also presented.

Poster Session A

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P-A.168

Supermagnonic Dynamics of Domain Walls in an Antiferromagnet

R. Miguel Otxoa, P. Roy, K. Guslienko, J. Wunderlich

Text Magnetic domain wall dynamics in the layered antiferromagnet Mn2Au, driven by field-like current-induced spin-orbit torques, is investigated by analytical theory and atomistic spin dynamics simulations. Our findings unveil the inertial character of the moving domain wall when the driving mechanism is of field-like torque type. Additionally, spin waves emission only occur under rapid acceleration/deceleration. Once the domain wall reach state motion even though travelling at speeds of 98% of the maximum magnon group velocity no signature of spin-waves emission is observed. This means that the main reason for a given maximum steady-state velocity at a given excitation amplitude is here not due to dissipation via spin-waves. Instead, at these high speeds, the natural response of the system to release the exchange energy stored within the contracted domain wall is to nucleate a domain wall pair with trivial winding number preserving the overall topological charge. The impact of the new born domain wall pair is of great consequence onto the initially moving domain wall. We observe that, the system is able to sustain a moving domain wall at speeds higher than the maximum magnon group velocity revealing a super-magnonic regime of motion. Additionally, we provide a plausible scenario to explain this never before observed regime of motion based on the repulsive ferromagnetic exchange interaction among the neighbouring domain walls.

Poster Session A

Poster A

P-A.169

Synthesis and magnetic properties of the $Mn_{1-x}Co_xTe$ system solid solutions

A. Zhyvulka, V. Dziamidzenka, A. Galias, K. Yanuschkevich

Text The aim of this work is to study crystal structure and magnetic properties of $Mn_{1-x}Co_xTe$ ($0 \leq x \leq 0.5$) solid solutions. The samples were obtained by solid state reaction method from powders of base manganese telluride and cobalt telluride compounds. X-ray phase analysis of synthesized $Mn_{1-x}Co_xTe$ solid solutions was performed using CuKα–radiation in the point-by-point measurement mode in room temperature. The crystal structure of $Mn_{1-x}Co_xTe$ solid solutions is identified on the base of a hexagonal crystal cell $P6_3/mmc$ space group. Parameters a and c of the elementary hexagonal cell of $Mn_{1-x}Co_xTe$ solid solutions were determined. X-ray diffraction analysis showed that synthesis by direct alloying ensures maximum solubility in the $Mn_{1-x}Co_xTe$ system up to 10 mol%
The specific magnetization of received compounds is studied by ponderomotive method in the 77 - 900 K temperature range in a magnetic field with induction B = 0.86 T. Solid solution $Mn_{0.9}Co_{0.1}Te$ have an antiferromagnetic ordering with Neel temperature T_N~315 K.

Poster Session A

Poster A

P-A.170

Temperature dependence of electrical switching in antiferromagnetic thin-film CuMnAs

O. Amin, K. Edmonds, P. Wadley

Text The electrical resistance in antiferromagnetic CuMnAs can be reproducibly 'switched' when a current pulse is applied [1]. The current induces a Néel spin-orbit torque that rotates the staggered magnetisation vector of antiferromagnetic domains from one easy axis to the other, depending on the relative pulse direction. This provides a mechanism to write information to antiferromagnets, which are difficult to manipulate using external fields. Here we explore the temperature dependence of switching behaviour in biaxial CuMnAs films in the range from room temperature to 400 K. For the range of pulsing current used for switching (25 to 40 mA), the high current density results in Joule heating of the material, lowering the energy barrier between the two easy axis states. By varying both the pulsing current amplitude and the substrate temperature, the thermal effect and the Néel spin-orbit torque can be distinguished. Detailed studies allow us to characterise the temperature dependence of the switching threshold current, the signal size and the signal decay.

References:

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Poster Session A

Poster A

P-A.171

The decisive role of magnetic anisotropy in the layered antiferromagnets $MnSb_2O_6$ and $Na_3Ni_2SbO_6$

J. Werner, C. Koo, W. Hergett, M. Gertig, J. Park, E. A. Zvereva, A. N. Vasiliev, R. Klingeler

Text The decisive role of magnetic anisotropy even in systems with small or nearly negligible anisotropy is illustrated for the layered antiferromagnets $MnSb_2O_6$ and $Na_3Ni_2SbO_6$. While the magnetic phase diagrams of both compounds have been studied by static magnetisation, specific heat, and thermal expansion studies up to 15 T, low-energy magnon modes enabling precise quantitative determination of magnetic anisotropy have been investigated by high-frequency/high field electron spin resonance. Both systems show long range antiferromagnetically ordered ground states. In $Na_3Ni_2SbO_6$, there is a tricritical point at T_N = 16.5 K which separates two distinct antiferromagnetic phases from the paramagnetic regime. The phase boundaries are visible in the dynamic response of the antiferromagnetic (AFM) resonance modes, too. The anisotropy gap Δ = 360 GHz implies considerable uniaxial anisotropy. The data suggest a crucial role of axial anisotropy favoring the AF1 spin structure over the AF2 one. In contrast, in $MnSb_2O_6$ we observe AFM resonance modes with a zero-field splitting of Δ = 20 GHz which imply very small planar anisotropy. Again, a crucial role of the anisotropy is suggested by competing antiferromagnetic phases appearing, at T = 2 K, in small magnetic fields. We conclude the importance of the anisotropy favoring the cycloidal ground state at B = 0 T.

Poster Session A

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P-A.172

The structural, magnetic, and electrical properties of cubic Mn_3Ga

H.-W. Bang, W. Yoo, C. Kim, S. Lee, J. Gu, Y. Park, K. Lee, M.-H. Jung

Text Manganese-based Heusler materials has attached much attention due to its exotic properties. Mn_3Ga possesses a wide variety of properties depending on its crystalline structure. Magnetically, the tetragonal Mn_3Ga is a ferrimagnet, and the hexagonal and cubic Mn_3Ga are antiferromagnetic. The tetragonal Mn_3Ga has been extensively studied due to the high spin polarization, strong perpendicular magnetic anisotropy, and low saturation magnetization, which suit the need for spintronics applications. Recently, the cubic and hexagonal Mn_3Ga have received attention due to their interest in antiferromagnets. Especially, the cubic Mn_3Ga is theoretically predicted to be a half-metallic antiferromagnet. In the present work, we first report the experimental results on metastable cubic phase of Mn_3Ga thin films. The samples were deposited by RF magnetron sputtering on MgO(001) substrates. X-ray diffraction and transmission electron microscopy data show that the cubic phase Mn_3Ga is grown heteroepitaxially on the MgO substrate. The cubic Mn_3Ga exhibits antiferromagnetic magnetic ordering at the Neel temperature of T_N ~ 420 K. The electrical resistivity represents half-metallic behavior. These results are compared with simple metallic behavior of tetragonal Mn_3Ga with ferromagnetic order at T_C ~ 820 K.

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P-A.173

The tetragonal CuMnAs compound: structure stability and magnetic properties

E. Duverger-Nédellec, R. H. Colman, J. Volný, K. Carva, B. Vondráčková, K. Uhlířová

Text CuMnAs is a room temperature antiferromagnetic semi-metal, which has recently attracted experimental and theoretical interest in the research fields of antiferromagnetic spintronics[1], and physics of Dirac fermions[2]. The stoichiometric compound is known to have an orthorhombic (Pnma) crystal structure. While Mn deficient material crystallizes in tetragonal structure (P4/nma)[3] the Mn rich compounds form an orthorhombic structure with doubled unit cell compared to the stoichiometric compound[4]. Our current studies on bulk CuMnAs shows that the structure and magnetic properties are very sensitive to the exact composition. We have prepared polycrystalline samples with varying Cu:Mn content. Powder- and single-crystal x-ray diffraction has confirmed that already less than 10% of the Mn deficiency turns the material to tetragonal phase while the stoichiometric CuMnAs and Mn rich CuMnAs stays orthorhombic. High-temperature magnetization measurement and differential scanning calorimetry shows, that the CuMnAs sample with 10% of Mn deficiency has Néel temperature of 505; it decreases monotonically with decreasing Mn content. We will present studies of the central part of the Cu-Mn-As ternary system with the emphasis on crystal structure and magnetic properties.

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Poster Session A

Poster A

P-A.174

Theory of spin injection into noncollinear antiferromagnets

Y. Yamane, O. Gomonay, J. Sinova

Text In recent years, antiferromagnets (AFMs) are generating more attention due to their potential to play pivotal roles in spintronics applications. AFMs are robust against external magnetic fields, produce no or negligibly small stray fields, and can exhibit faster magnetic dynamics compared to ferromagnets. The insensitivity of AFMs to magnetic fields, however, may also indicate that an external magnetic field does not provide an efficient method to manipulate AFMs, a fact that has hindered active applications of AFMs in today's technology.
In this work, the magnetic dynamics in noncollinear three-sublattice AFMs induced by external spin injection is theoretically investigated. Starting from the coupled Landau-Lifshitz-Gilbert equations with spin-transfer torque term for the sublattice magnetizations, we derive an effective model that is applicable when the AFM exchange coupling is dominant over the other energy scales, as is usually the case in realistic materials. The model allows us to deal with dynamical AFM textures such as domain walls in an analytical fashion. We demonstrate that the uniform spin injection into the AFM can drive a domain wall into motion, and its velocity can reach much higher values compared to ferromagnets, being free from the Walker breakdown phenomenon. We hope that our work stimulates more experimental works and leads to deeper understanding of the dynamics of noncolinear AFMs.

Poster Session A

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P-A.175

Thickness dependence of exchange bias fields in polycrystalline antiferromagnetic Mn_3Ge alloy films

T. Ogasawara, J.-Y. Kim, A. Hirohata

Text Exchange bias induced at the interface between ferromagnet (FM) / antiferromagnet (AFM) is a basic building block to pin the magnetization of FM for spintronic device applications. However, the most commonly-used AFM, Ir-Mn should be replaced due to Ir being identified as a critical raw metal. Therefore, we focused on Mn-Ge based binary alloy since Mn based AFM such as Mn_2VSi, Mn_2VAl and Mn-Ga have been reported to show exchange bias and characterized their magnetic properties.

All of the films were grown by sputtering onto Si(001) substrates. The samples consisting of Ta (5)/Pt (35)/Mn_3Ge (t_{Mn3Ge} = 10 - 100)/$Co_{60}Fe_{40}$ (3.3)/Ta (5) (in nm) were prepared during substrate heating at 773K only for the growth of the Mn3Ge layer with various Mn_3Ge thickness, t_{Mn3Ge}. Exchange bias fields, H_{EB} were measured by vibrating sample magnetometer (VSM) at 100K after annealing at 500K for 30 minutes under the in-plane magnetic field of -20 kOe.

The results showed a strong dependence of H_{EB} on t_{Mn3Ge}. The largest H_{EB} of 122 Oe appeared for t_{Mn3Ge} = 30 nm and decreased gradually with increasing t_{Mn3Ge}. This indicates the change of roughness at the FM/AFM interface or dominant crystal phases. It should be noted that the Mn-Ge binary alloy has many crystal phases depending on the composition, growth temperature and pressure in bulk state. We will discuss more details on H_{EB} in our presentation. These results are of great use for the development of a new AFM film.

Poster Session A

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P-A.176

Topological Dirac antiferromagnets for spintronics

L. Smejkal, T. Jungwirth, J. Sinova

Text Merging topology with magnetism is rapidly becoming a new direction in the field of topological quantum materials boosted by the recent discoveries of Dirac and Weyl semimetals [1]. Our prediction of the interplay between topological Dirac quasiparticles and Néel spin-orbit torque in an antiferromagnet [2] indicates antiferromagnets might become the leading magnets on the route towards topological spintronics [1].

In this talk, we will classify topological antiferromagnets based on crystalline and magnetic symmetries and minimal models. We will demonstrate that antiferromagnets are natural candidates for combining magnetic order with topological Dirac quasiparticles owing to their unique effective time-reversal symmetries, which are not present in ferromagnets [1,2].

The presence of tunable topological quasiparticles can lead to a large signal/noise ratios and novel functionalities in read-out signals in spintronics devices [1]. For example, based on ab initio theory, we have predicted a large anisotropic magnetoresistance (AMR) reaching 6% in Mn2Au antiferromagnet which was recently observed in experiments [3]. Finally, we will present our proposal of potentially extremely large topological AMR in antiferromagnetic CuMnAs.

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Poster Session A

Poster A

P-A.177

Ultraslow magnetization relaxation in rhombohedral structured weak ferromagnets and piezomagnets

N. Pattanayak, A. Bhattacharyya, A. Bajpai

Text We investigate the remanent magnetization (μ) in α-Fe_2O_3 and $MnCO_3$ which are both rhombohedral antiferromagnets (AFMs). These AFMs are also well known to exhibit the phenomena of weak ferromagnetism and piezomagnetism.The remanent magnetization in the samples are prepared by cooling them through their weakly ferromagnetic transition down to 5 K in presence of a constant magnetic field *H* (FC cycle). After subsequent removal of *H* they are examined both as a function of time and temperature. We see that remanent magnetization obtained in these samples are quasistatic in nature whose relaxation with time is ultra slow. Furthermore, the remanence varies with the strength of the magnetic field in a counterintuitive way. We observe these features of remanence in a defect free single crystal of α-Fe_2O_3 as well. These samples are not geometrically frustrated and the presence of quasistatic remanence in different length scales ranging from nano to mesoscopic crystals to bulk single crystal indicates that the observed features are intrinsic to the samples and are not related to any size and interface related effects. We show that the presence of quasistatic remanence in these systems is firmly associated with the phenomenon of weak ferromagnetism present in the systems. The qualitative features of remanence also unravel the intimate connection between the weak ferromagnetic and the piezomagnetic property of rhombohedral AFMs discussed here.

Poster Session A

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P-A.178

Weak ferromagnetism and field-induced transitions in the exchange frustrated antiferromagnet $PrBa_2Cu_3O_{6.44}$

M. Lahoubi

Text The anomalous magnetic and thermal properties of a nonsuperconducting $PrBa_2Cu_3O_{6.44}$ in an underdoped oxygen state were studied recently [1], [2]. A significant decrease of the Néel temperature T_N = 9 K of the Pr antiferromagnetic (AFM) ordering was observed with the increase of the magnetic field H. T_N approaches T_2 = 6-7 K, the T-region where the small anomaly due to the spin reorientation vanishes above 6 T. While the anomaly at the low-critical point, T_{cr} = 4-5 K related with the Pr magnetic reordering, is still visible when H increases up to 10 T. In this paper, measurements of magnetization in higher DC magnetic fields H up to 16 T and at low temperatures are reported. The data at 1.35 K reveal a weak ferromagnetic (WFM)-like behavior which appears below a field induced phase transition (FIPT) at a critical field H_{cr1} = 3.3 T. Above H_{cr1}, the WFM phase is suppressed and the AFM state is then established up to H_{cr2} = 9.25 T where the FIPT to the paramagnetic state is identified. The T-dependencies up to a few K above T_N of both the magnetization saturation and the differential magnetic susceptibility are analyzed in the WFM phase and a detailed (H-T) magnetic phase diagram was mapped out. The results are discussed in terms of the Pr-Cu coupling and compared with those obtained in previous works.

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Poster Session A

Poster A

P-A.181

A Passive Magneto-Acoustic Tag for Aquatic Animal Tracking

A. S. Almansouri, M. A. Khan, H. Al Malki, K. N. Salama, J. Kosel

Text Marine scientists around the globe utilize acoustic telemetry to study and understand the lifestyle of aquatic animals, including the spatial ecology and migratory behaviors. Current telemetry systems include an acoustic tag powered by a battery and attached to an aquatic animal. The added weight of the battery limits the implementation of these systems to relativity large animals. Also, the operational time of the tag is limited by the lifetime of the battery.

This work introduces a novel self-powered magneto-acoustic tag for animal tracking. The tag promotes the low-frequency motions of the animals to generate high-frequency acoustic pulses. The design consists of a soft magnetic membrane (metallic glass) surrounding a permanent magnet (NdFeB). The imposed magnetic field generates an attractive force between the membrane and the poles of the magnet. This bistable configuration forces the soft magnetic membrane to bend toward one of the two poles. The magnet is attached to a flexible substrate (PDMS-based Si elastomer) that oscillates at low frequencies (i.e. animal motions). As the magnet oscillates, the membrane gets alternatingly attracted to the opposite poles, thereby oscillating at its resonant frequency. The measurement results of the proposed system show a resonant frequency of 3.45 kHz, a peak acoustic signal of -56.4 dBV, and a 37.6 dB SNR, when a microphone is placed 5 cm away from the tag.

Poster Session A

Poster A

P-A.182

Alloys with inverse Heusler structure from family of Mn2NiX (X = Ga, In, Sn, Sb)

A. Kamantsev, E. Dilmieva, A. Mashirov, M. Drobosyuk, V. Sokolovskiy, M. Zagrebin, I. Musabirov

Text In recent years, Mn2Ni-containing Heusler alloys, in particular, Mn2NiX (X = Ga, In, Sn, Sb), attracted great interest of researchers as ferro- or ferrimagnetics alloys with shape memory effect and halfmetals, due to potential applications in production of magnetic actuators and spintronic devices. Investigations of these alloys were stimulated by the discovery of magnetically induced deformations (4%) in a Mn2NiGa single crystal with a martensitic metamagnetostructural phase transition (PT) temperature of 270 K and a high magnetic PT at 588 K [1]. Moreover, the Mn2NiGa alloy is ferrimagnetic in the austenitic (cubic) phase, in contrast to the Ni2MnGa [2]. The experimental studies of the Mn2NiGa system led to the discovery of the "spin lock" type effect in the magnetoresistance for mono- and polycrystalline samples due to the antisite of disorder in which 13% of the positions of Ga are occupied by Mn atoms [3]. The energies of the ground state, equilibrium lattice parameter and magnetic configurations (para-, ferro-, antiferromagnetic) of Mn2Ni1 + xX1-x alloys were calculated using Qauntum Espresso and SPR-KKR packages. The electrical resistivity, magnetization, and MCE in magnetic field up to 14 T in alloys in manufactured alloys of Mn2NiX system.
Support by RFBR grant № 18-08-01434 is acknowledged.
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Poster Session A

Poster A

P-A.184

Assessment of the critical behavior near the FM to PM phase transition in nano-crystalline La0.7Ca0.3Mn1-xNixO3 (x=0.0, 0.02, 0.07, 0.10) samples synthesized by auto-combustion

O. Morán, A. Gómez, I. Supelano, C. A. Parra, J. L. Izquierdo

Text The structural and critical exponent analysis along with the universal behavior of the magnetocaloric effect in nano-crystalline La0.7Ca0.3Mn1-xNixO3 (x=0.0, 0.02, 0.07, 0.10), manganites, exhibiting second order phase transition, are experimentally studied. Structural study using Reitveld refinement of X-ray diffraction patterns shows orthorhombic structure with Pnma space group. Various techniques such as modified Arrott plot, Kouvel–Fisher method and critical isotherm were used to analyze the magnetic-field dependence of magnetization. The Curie temperature could be tuned over a wide temperature range upon variation in the Ni-content. Though the nature of the transition is found to be of second order, the estimated critical exponents beta, gamma, and delta obtained for different values of x seemed to be close to those theoretically predicted for the three-dimensional (3D)-Ising interaction model. Nevertheless, the values are not very far away from other known universality class. In spite of this, the critical exponents obey the single scaling equation M(H,varepsilon)=(varepsilon^beta)*f+/-(H/varepsilon^(beta*gamma)), where f+ corresponds to temperatures higher than the Curie temperature and f- for temperatures lower than the Curie temperature.

Poster Session A

Poster A

P-A.185

Characterization of microstructural properties of nanocrystalline alloys FeSiCuNbB through magnetothermal measurement

N. Boust, O. Geoffroy, H. Chazal, S. Flury, T. Waeckerlé, B. Gony, J. Roudet

Text Nanocrystalline alloy FeSiCuNbB is obtained by annealing of an amorphous precursor, which lead to nano-scaled FeSi grains embed in an amorphous residual matrix. Curie temperature of the residual amorphous phase being lower than the one of the crystalline phase, the material should be superparamagnetic between these two temperatures. Nevertheless, due to dipolar interaction or residual ferromagnetic coupling, a superferromagnetic state, where a spontaneous polarization J_s^{sf} , which depend on the crystalline fraction f_c and the grain size d still exist until the superferomagnetic to superparamagnetic transition temperature T_{tr}. The modelling of T_{tr} and J_s^{sf} have already been carried out [1].
The polarization of nanocrystalline sample with different annealing time, and thus different crystalline fraction, has been measured for temperature from 20°C to 560°C in order to determine T_{tr} and thus f_c . This method allows determining even low crystalline fraction, where the classical X-ray method is difficult to use, opening the possibility to characterize the structure of low annealed samples.

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Poster Session A

Poster A

P-A.186

Charge distribution in H_2O/ γ-Fe_2O_3 interfaces

N. Ntallis, V. Peyre, R. Perzynski, E. Dubois, K. N. Trohidou

Text The charge distribution on magnetic nanoparticles surfaces is important for their dispersion stability in Ionic liquids [1]. We perform DFT calculations using the VASP package [2, 3] to study the charge distribution in the γ-Fe_2O_3 interface with H_2O, in the case of layered and spherical structures. The adsorption energy is calculated by varying the number of water molecules. Our results show that water molecules bond with Fe atoms with O-Fe bonds. For the layered system the addition of water molecules decreases the adsorption energy. The iron atoms show an increased ionic state with the addition of water which varies with the bond length. In the spherical systems some of the water molecules break down to OH and H and they bond with Fe and O atoms respectively.

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Poster Session A

Poster A

P-A.187

Comparison of ferrite's losses measurement with two methods

A. Bounar, V. Loyau, O. De-la-barrière, F. Mazaleyrat

Text Soft ferrites components represent an indispensable part in the most modern power converters.Precise measurement of magnetic losses up to the MHz range is a crucial step in optimal design of high frequency power converters.In the literature the flux-metric method is commonly used to measure the ferrite's losses.Yet,it is known to be inaccurate when the voltage and the current probes of the device introduce a significant phase shift at high frequencies.It is thus necessary to develop alternative methods to measure losses in soft ferrites.
The main aim of our work is to present a new experimental method applied to a toroidal MnZn ferrite in quasi adiabatic conditions.Results are reported for a sinusoidal and triangular 50 mT peak induction for frequencies ranging between 10 and 500 kHz.
The Mn-Zn ferrites cores under study are purchased from Ferroxcube (references 3E27 and 3C11 respectively). The dimensions for the external, internal diameter and the thickness are 26, 15 and 10mm, respectively.
The principle of the calorimetric method is that the power losses dissipated in the material is related to the slope of its temperature variation.
Comparison of the two methods results shows that significant differences appear and error sources were discussed.
Finally,using these results we will be able to establish an appropriate experimental procedure for accurate measurements and then an accurate model to predict the ferrite's losses.

Poster Session A

Poster A

P-A.188

Degradation of the magnetocaloric effect in cyclic magnetic fields

A. Aliev, A. Batdalov, A. Gamzatov, A. Amirov, L. Khanov, A. Mukhuchev, V. Koledov, V. Shavrov

Text From a practical point of view there is a substantial need for studying the magnetocaloric effect (MCE) in promising magnetocaloric materials under prolonged exposure to the cyclic magnetic fields. It is clear, that the efficiency of the refrigerating machine can be improved by the increase of working cycle frequencies. However, you need to be sure that the magnetocaloric properties of the material do not change significantly with frequency of alternating magnetic field or under prolonged exposure to cyclic fields. Most promising magnetocaloric materials are materials with a first-order magnetostructural phase transitions. It can be expected that the value of MCE in these materials in cyclic magnetic fields strongly differ from the value of MCE measured at a single application of the field.
In this work we present results of studying the magnetocaloric properties in various families of promising magnetic materials. The dependence of the MCE on the frequency of alternating magnetic field and the effect of prolonged action of cyclic magnetic field are studied. It is found out, that some materials exhibit strong dependence of the MCE on frequency of the cyclic magnetic fields. The analysis of possible reasons for the decrease in the MCE is performed. Some materials show the effect of degradation of MCE under prolonged action of cyclic magnetic field and the explanation of this phenomena is given.
The study has been supported by Russian Science Foundation (project No 18-12-00415).

Poster Session A

Poster A

P-A.189

Effect of A-site cationic radii on structural, magnetic and magnetocaloric properties in nanocrystalline perovskite Tr0.7Ba0.2Ca0.1MnO3 (Tr = Pr, La, Gd)

K. Rawat, B. Meenakshi, R. N. Mahato*

Text The mixed valent oxides Tr1-xMxMnO3 (where Tr stands for trivalent rare earth elements such as Pr, La, Gd and M for divalent alkaline earth ions such as Ba, Ca etc) have attracted much attention due to their extraordinary magnetic and electronic properties and potential for technological applications. Ideal perovskite (ABO3) are known for their cubic structure. However a distortion in the structure can be produced by doping either on A-site or on the B-site. This distortion causes a structural transition and hence all the physical properties get modified. In the present work, we have synthesized the nanocrystalline perovskite Pr0.7Ba0.2Ca0.1MnO3 using sol-gel method. The Rietveld refinement of the XRD pattern shows Rhombohedral crystal structure with $R\bar{3}c$ space group. The field dependent magnetization measurements show that the sample has a paramagnetic -ferromagnetic phase transition ~128 K. The maximum magnetic entropy change calculated from M-H isotherm data was found to be ~2.3 J kg-1K-1 at an applied field of 5T. The relative cooling power (RCP) value was found to be 230 J kg-1. The relatively large values of RCP make the present compound more environmental friendly, inexpensive and suitable for magnetic refrigeration technology. The result obtained for Pr-based compound motivate us to study how the size of cationic radii affects these properties at nanoscale dimension and the possible enhancement in maximum magnetic entropy change and RCP values near room temperature.

Poster Session A

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P-A.191

Effect of carbon doping on the structure, phase transition and magnetocaloric properties of Mn1.15Fe0.80P0.50Si0.50 alloys

Q. Zhou, Z. Zheng, D. Zeng, Y. Hong

Text The Mn-Fe-P-Si based alloy is one of the most promising giant magnetocaloric materials for practical application. It is reported that Boron or Carbon doping is an effective way to tune the Curie temperature(Tc) and thermal hysteresis(□Thys) for first-order magnetic transition materials. However, effect of Carbon doping on the non-stoichiometric (Mn,Fe)2(P,Si) alloys is not clear. In this work, the structure and magnetocaloric effects of Mn1.15Fe0.80P0.50Si0.50Cx alloys are investigated.
The Mn1.15Fe0.80P0.50Si0.50Cx alloys were prepared by arc-melting followed by twice sintering process. The crystal structure and magnetic properties are examined by XRD, DSC and VSM. The results indicate that all samples crystallize into hexagonal Fe2P-type structure. C atoms both occupy the 6k interstitial sites and the 2c substitutional sites for x=0.03/0.05, and occupy the 2c substitutional sites for x=0.01. Tc can be tuned from 279K to 321K and □Thys drops from 31.4K to 21.5K after Carbon doping. For a field change of 2 T, the corresponding values of □SM obtained from the isothermal magnetization curves for x = 0.01, 0.03 and 0.05 are 21.5, 19.7 and 23.2 JK−1kg−1, respectively, larger than 18.7 JK−1kg−1 of x=0. □SDSC derived from calorimetric measurements and □SM are compared. The results both reveal that alloys with C doping still maintain the large entropy change.
Due to low cost of Carbon, (Mn,Fe)2(P,Si,C) alloys have great potential for room-temperature magnetic refrigerant applications.

Poster Session A

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P-A.192

Effect of deformation on a composite of Cu and the soft magnetic amorphous metallic glass $Fe_{73.4}Cu_1Nb_3Si_{15.5}B_{6.6}$

M. Antoni, R. Größinger, J. Eckert, R. Pippan, C. Polak, F. Spieckermann

Text Applying severe plastic deformation can be used to influence and induce the crystallisation process in amorphous $Fe_{73.4}Cu_1Nb_3Si_{15.5}B_{6.6}$. However due to its high strength this material has been a challenge for mechanical deformation processing up to now. It is the scope of this work to study experiments for creating a bulk compound of – possibly partly crystallised - $Fe_{73.4}Cu_1Nb_3Si_{15.5}B_{6.6}$ in order to investigate the change of crystallization process and magnetic properties under mechanic deformation. Thin Cu foils were used as a mechanical soft additive in order to support the deformation process.
Initial samples were created by swaging tapes of amorphous $Fe_{73.4}Cu_1Nb_3Si_{15.5}B_{6.6}$ and Cu foils inside a steel pipe at room temperature. Afterward disks where cut from this rod and subjected to severe plastic deformation (HPT) under different loading conditions at room temperature.
All samples were investigated by XRD and DSC searching for an induced crystallisation process. The magnetic properties at room temperature were studied by frequency dependent hysteresis measurement on ring shaped samples.
The samples didn't show cracks in light microscopy, which is important for hysteresis loop measurements. XRD experiments indicate a significant deformation induced change of the microstructure. Minor loop hysteresis measurements showed a magnetic hardening due to the enhanced magnetoelastic energy compared to amorphous $Fe_{73.4}Cu_1Nb_3Si_{15.5}B_{6.6}$.

Poster Session A

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P-A.193

Entropy changes driven by charge transfer

N. de Oliveira

Text The quantities ΔS_{iso} and ΔT_{ad} which characterize the conventional magnetocaloric effect always get their highest values around a transition from an ordered magnetic phase to a disordered one. Similarly, the largest values of the corresponding magnetic barocaloric quantities also occur around a magnetic phase transition. Besides that to get high values of the caloric functions in the most studied magnetic materials is necessary to use large magnetic field variation. Thus, the search for new magnetic materials and thermodynamic process to get large caloric effects are still good challenges in this area of research.
In this work we propose a new mechanism to yield large values of the caloric variables. This new mechanism, which is based on the process of charge transfer between two parts of a given physical system, can take place even in non magnetic materials. In order to present the main idea involved in the process, we adopt a simple model where a narrow correlated electron band is coupled with a wide conduction electron band which is considered as a large reservoir. We perform systematic analysis of the caloric quantities as a function of the model parameters. Our results show that large entropy changes appear as the occupation number of the narrow band changes around a given temperature. This scenario, which can be idealized in real compounds with volume collapse as a function of temperature, opens a new horizon in the research of the caloric effects.

Poster Session A

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P-A.195

Finite-element micromagnetic simulation study of grain-easy axis alignment effect on the magnetization reversal process in exchange-decoupled granular NdFeB magnets

S. Hwang, J.-H. Lee, S.-K. Kim

Text We investigated the effect of misaligned grains on the nucleation-driven reversal model, which can best be clarified from finite-element micromagnetic simulations[1] by providing grain-by-grain reversal processes. In this study, we modeled exchange-decoupled but dipolar coupled granular NdFeB magnets for a cubic system consisting of 27 grains arranged at different degrees of grains' easy-axis alignment α. Our simulation results for the α-dependence of the magnetization reversal process show that the nucleation-driven mechanism dominates the reversal process for α = 1, 0.87, and 0.79. Microscopic observations of the demagnetizing field distributions for α< 1 showed that the nucleation sites for the reverse domains were formed near the grain boundaries or triplet contacts of the grains within the cubic: the smaller α, the stronger the demagnetizing fields that form reversed domains as well as the more nucleation sites within the cubic. This is because the easy axis misalignment of the grains results in highly localized demagnetizing fields near the grain boundaries and the triple junctions, causing a relatively easy reversal of the adjacent grains' magnetization. Therefore, the reversal process of the dipolar coupled granular magnets depends essentially on the degree of alignment of the grains' easy axes in the nucleation-driven reversal process.

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Poster Session A

Poster A

P-A.196

First principle studies of Electronic, Magnetic, Elastic and Optical properties of (Pt and Ni) ZrTiAl Quaternary Heusler Alloys.

R. Paudel, J. Zhu

Text In this study, we investigated the structural, magnetic, elastic and optical properties of (Pt and Ni) ZrTiAl quaternary Heusler alloys by utilizing density functional theory within the CASTEP code. Investigated equilibrium lattice parameters of these compounds are in great concurrence with other theoretical work. The total magnetic moments of (PT and Ni) ZrTiAl were obtained to be 3μB and 2.99μB per unit formula respectively obeys the Slater Pauling rule. (PT and Ni) ZrTiAl is found to have spin-flip/half-metallic gap in the minority spin channel while majority spin channel is metallic. Therefore, both composites showed half-metallic nature and 100 percent spin polarization at the Fermi level. The calculated elastic results revealed that both materials are mechanically steady and ductile in nature. Optical properties including reflectivity, refractive index, conductivity, energy loss and absorption coefficient are investigated from the dielectric function.

Keywords: (Pt and Ni) ZrTiAl; Magnetic properties; elastic properties; Optical properties; Spintronics

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P-A.197

Half-metallic completely compensated ferrimagnets in Cr doped BaP

B. Asmaa, R. Habib, S. Adlane, X. Wang

Text On the basis of ab-initio calculations we have investigated the electronic and magnetic properties of Cr1-xBaxP alloy, our calculations suggest that as we dope BaP with Cr atoms and move towards Cr1-xBaxP where x=0, 0.125, 0.25, 0.50, and 0.75 all alloy are HM-FM. Interestingly Cr0.25Ba0.75P is a HM-AFM otherwise 'fully compensated ferrimagnet', this alloy should be of special interest for applications since it creates no external stray field and thus exhibit minimal energy losses. In addition, the robustness of half-metallicity with respect to the variation of lattice constants of Cr1-xBaxP is also discussed; moreover ferrimagnetism co-exists with the half-metallicity, resulting in the desired fully compensated half-metallic ferrimagnetism, for a wide range of lattice constants. Furthermore we found that this new HMFCF is stable according to its small formation energy.

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P-A.198

Highly permeable soft magnetic laminated amorphous thin films without secondry resonance peaks for high-frequency applications

A. Masood, P. McCloskey, C. O'Mathuna, S. Kulkarni

Text Soft magnetic amorphous thin films possessing in-plane uniaxial magnetic anisotropy, high permeability, and high ferromagnetic resonance frequency are attaining greater importance for high-frequency applications such as digital recording media and energy transferring devices. The present work addresses the challenge of eliminating the multiple resonance peaks in the soft magnetic amorphous thin film materials for high-frequency applications. In this work, thickness dependent static and dynamic soft magnetic properties of the single layer and multilayer Co-Zr-Ta-B amorphous thin films were investigated. Single layer and multilayer thin films of different thickness were fabricated by dc-magnetron sputtering on 4-inch silicon wafers from a single alloy target. The emergence of multiple resonance peaks in the high-frequency response of permeability of 500 nm single layer films revealed detrimental soft magnetic properties and later could be attributed to the two-phase magnetic evolution developed due to plasma heating effect during the thin film growth process. We propose that the emergence of these additional peaks in amorphous thin films can be eliminated by a multilayer laminated thin film structure with enhanced soft magnetic properties. The quality factor (Q=μ'/μ") of the laminated stacks improved as compared to the single layer thin films. In addition, the effect of capacitive coupling on the soft magnetic properties of multilayer films was investigated in detail.

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P-A.199

Hybrid Cobalt ferrite nanoparticles for novel rare-earth free magnets

C. de Julian Fernandez, E. Lottini, G. Bertoni, M. Petrecca, A. Caneschi, A. López-Ortega2, C. Sangregorio

Text Nowadays, a strong research activity is focused on finding novel materials that can replace currently used Rare Earth (RE) compounds- based magnets. The reduction of the size of traditional RE-free magnetic materials to the nanoscale can be a promising approach. The main challenge is the fine control of the nanostructure and the composition that is requested.
Between the spinel ferrites, cobalt ferrite exhibits the best properties to be employed in magnets thanks to its large magnetic anisotropy and magnetization. In this presentation we have investigated the optimization of the particle size and the enhancement of the anisotropy thanks to coupling effects. We found the large magnetic anisotropy for 20 nm size NPs but, at room temperature, the larger coercive field is obtained for NPs of 40 nm size. On the other hand, CoxFe1−xO core- CoxFe3-xO4 shell NPs were synthesized by thermal decomposition. Part of these NPs were transformed in pure cobalt ferrite by solvent-mediated oxidation. We found enhancement of the coercive field and of the energy product at low temperatures. Both can be further increased exploiting the field-cooling induced exchange bias (EB) coupling. We will shown that the different EB phenomenology are associated to the exchange between the antiferromagnetic core and the ferrimagnetic shell or due to coupling between spinel subdomains and antiphase boundaries.
Research supported by EU-FP7 NANOPYME (n. 310516) and EU- H2020 AMPHIBIAN Projects (n. 720853).

Poster Session A

Poster A

P-A.200

Influence of Crystal Orientation on the Magnetostriction Behavior of Fe Films Formed on MgO Single-Crystal Substrates

K. Serizawa, M. Ohtake, T. Kawai, M. Futamoto, N. Inaba, F. Kirino

Text Fe and Fe-based alloys have been used for the core materials of transformers and motors. In order to reduce the core vibration, the magnetostriction needs to be decreased. For understanding the basic magnetostriction behavior, it is useful to prepare epitaxial films with different crystal orientations. In the present study, Fe films are prepared on MgO(001), (110), and (111) substrates. The magnetostriction is measured by using a cantilever method under rotating magnetic fields up to 1.2 kOe. Fe(001) single- and Fe(211) bi-crystal films are formed on MgO(001) and (110) substrates and they show four- and two-fold symmetries in in-plane magnetic anisotropy, respectively. Fe film formed on MgO(111) substrate consists of nine (110) variants with NW and KS orientation relationships and shows almost isotropic magnetic anisotropy. Magnetostriction waveforms measured as a function of applied field rotation angle are deformed from an ideal sinusoidal shape for the (001) single- and the (211) bi-crystal films. With increasing the strength of rotating magnetic field, the magnetization approaches saturation and the waveforms change to sinusoidal. The magnetostriction behaviors are related with the difference between magnetic field and magnetization directions. On the contrary, sinusoidal waveforms are observed for the (110) film consisting of nine variants under low magnetic fields. The magnetization behavior is apparently influenced by the symmetry of magnetic anisotropy.

Poster Session A

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P-A.201

Influence of severe plastic deformation on magnetocaloric effect of Dy

M. Ulyanov, S. Taskaev, K. Skokov, D. Karpenkov, V. Khovaylo, D. Bataev, A. Dyakonov, O. Gutfleisch

Text The changes in the magnetic properties of rare-earth metals subjected to severe plastic deformation (SPD) have proven to be a complex matter and their interpretation is rather difficult [1-4]. It may be attributed to the fact that the magnetic order of their highly localized 4-f electrons is mediated by indirect exchange interaction of itinerant 5-d electrons, and this RKKY interaction depends on the interatomic distances. As a result, these interactions are very sensitive to the presence of interstitial defects or vacancies located nearby the rare-earth atoms [5]. All of these make the magnetic properties of the rare-earth metals highly responsive to severe plastic deformation. Nevertheless, despite a lot of publications about physical properties of rare earths metals there is lack of information in the literature concerning the influence of SPD on magnetocaloric properties of rare earths metals.
Recently we showed that SPD has a great effect on the physical properties of Gd and Tb, especially on its MCE and heat capacity [6-7]. In present work we report the magnetic and thermodynamic properties of Dy ribbons treated with the help of cold rolling: it is shown that plastic deformation has a great influence on magnetization processes in low and moderate magnetic fields, coercive force and magnetocaloric effect.
The authors gratefully acknowledge: RFBR grant № 16-07-00679 and the Ministry of Education and Science of the Russian Federation (project № 3.6782.2017).

Poster Session A

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P-A.202

Magnetic Field Dependent Thermal Conductivity Measurements of Magnetic Nanofluids by AC Hot-Wire Technique

S. Doğanay, A. Turgut, L. Çetin

Text Magnetic nanofluids are colloidal mixtures which consist of nano-sized magnetic particles suspended in a base fluid such as water, oil, ethylene glycol etc. These nano-sized magnetic particles could be maghemite (γ–Fe2O3), magnetite (Fe3O4) or cobalt ferrite (CoFe2O4) etc. The ability of being manipulated by an external magnetic field made them considerable for many different applications such as electronics cooling, heat transfer applications, biosensors, drug delivery. When the magnetic nanofluids are exposed to an external magnetic field, their thermophysical properties are influenced. In this study, the experiments were made in order to investigate the external magnetic field effect on the thermal conductivity of Fe3O4-water magnetic nanofluid. AC hot wire 3-omega method has been utilized for the measurements. Experiments were conducted with different concentrations of Fe3O4-water magnetic nanofluid. The external magnetic field was applied by using permanent magnets. The direction of the external magnetic field was altered as perpendicular and parallel to the temperature gradient. It is observed that the thermal conductivity increases with the addition of magnetic nanoparticles. Moreover, applying an external magnetic field causes an enhancement in the thermal conductivity of Fe3O4-water magnetic nanofluid up to a specific point and then it decreases. Additionally, it is observed that the magnetic field influence is more significant for parallel orientation.

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P-A.203

Magnetic characterization of Ni50Fe19Ga27Co4 glass coated microwire

M. Hennel, P. J. Ibarra-Gaytán, L. Galdun, T. Ryba, J. Kovac, Z. Vargova, J. L. Sánchez Llamazares, R. Varga

Text Heusler alloys are materials with promising technological applications for magnetocaloric cooling [1]. On the other hand, Taylor–Ulitovsky method gives the opportunity of fast preparation of very thin metallic Heusler-based microwires suitable for micro-applications [2].
In this work, structural and magnetic properties of Heusler-based Ni50Fe19Ga27Co4 glass-coated microwire are presented. The SEM/EDX analysis approved that the chemical composition of the microwire, Ni47.7Fe18.5Ga29Co4.8 is in good agreement with the desired one. The smooth surface of the metallic nucleus may indicate the monocrystalline structure similarly as in the previous studies [2]. Additionally, the wire is characterized by high Curie temperature TC ≈ 315 K. Magnetic measurements predict the structural change of microwires from martensite to austenite around room temperature. This phenomenon may increase entropy change and magnetocaloric effect. Therefore, Heusler-based microwire is promising candidate for application in micro-magnetic cooling.

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Poster Session A

Poster A

P-A.204

Magnetic domain structure studies in high coercivity permanent magnets using the X-ray magnetic circular dichroism technique

T. Nakamura, R. Kato, K. Ishigami, Y. Kotani, K. Toyoki, D. Billington, K. Sumitani, K. Kajiwara, Y. Matsuura, R. Tamura

Text High performance permanent magnets are indispensable materials for energy saving and generation technologies. Not only high $(BH)_{max}$ is crucial, but the squareness and/or thermal behavior of the hysteresis loops are important depending on the type of application. These magnetic properties are directly linked to the magnetic reversal process which includes the nucleation of reversed magnetic domains and domain wall displacement. In order to visualize the domain reversal process, a magnetic domain imaging technique up to magnetic fields of 8 T has been developed using the soft XMCD technique at SPring-8. In the present study, we measured the magnetic field dependence of the domains in anisotropic $SmCo_5$ and Sm_2Co_{17}. In the thermally-demagnetized state, $SmCo_5$ and Sm_2Co_{17} show maze-like magnetic domain patterns with different characteristic sizes, and the changes in features of the magnetic domains with applied magnetic field are completely different. The observed differences may be due to different coercivity mechanisms, because it has so far been regarded that the nucleation of reversed magnetic domains in $SmCo_5$, and the pinning of magnetic domain walls in Sm_2Co_{17} dominate the magnetic domain reversal processes.
We thank Shin-Etsu Chemical Co., Ltd., and TOKIN Corporation, for providing the Sm_2Co_{17}, and $SmCo_5$ samples, respectively. The magnetic domain observation technique was developed by ESICMM. This work is partly supported by the JST (No.20110111).

Poster Session A

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P-A.205

Magnetocaloric characterization of glass-coated Ni2MnGa microwires

P. Ibarra, L. Frolova, L. Galdum, T. Ryba, P. Diko, V. Kavecansky, J. L. Sanchez, Z. Vargova, R. Varga

Text The magnetocaloric properties of magnetic glass – coated microwires of nominal composition Ni2MnGa have been investigated. The XRD, EBSD and SEM analysis revealed the formation of single crystalline microwires whit a Cu2MnAl-type crystal structure (space group Fm-3m; cell parameter a= 5.832 Å). The metallic core thickness in microwires was estimated to be approximately 350 µm. Hopkinson effect have been observed, which is demonstrated by a sharp increase of the magnetization just below the Curie temperature. At low magnetic field values, was observed an increasing in the magnetic entropy change as a result of the Hopkinson effect. The refrigerant capacity, is higher at low magnetic field values compared with the estimated for high magnetic field values. With this regarding, the Hopkinson effect help to increase the efficiency of the magnetocaloric effect at low magnetic fields which result interesting for practical applications in magnetic refrigeration.

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P-A.206

Magnetocaloric effect in Heusler alloys by direct and indirect methods in high magnetic field

E. Dilmieva, Y. Koshkidko, V. Koledov, A. Kamantsev, A. Mashirov, V. Shavrov, V. Khovaylo, V. Marchenkov

Text In recent years, searches and studies of new materials for the presence of the maximum magnetocaloric effect (MCE) have been actively pursued. A huge number of papers have been devoted to the study of MCE [1]. At the moment, prototypes of a magnetic refrigerator based on MCE have been created. However, the use of magnetic refrigerators in everyday life remains unprofitable, since it is inferior in terms of technical parameters to freon refrigerators.The main technical parameters are magnetocaloric effect and isotermal heat flow values. The authors of the studies use an indirect method for determining the MCE value or small magnetic fields in the direct method, which are insufficient for the complete completion of the first-order phase transition. In modern literature, only in a small number of works MCE is studied under isothermal conditions with direct methods [2]. Therefore, the authors of this paper study the MCE by unique device [3] and direct method in high magnetic fields up to 14 T in a wide range of temperatures under adiabatic and quasi-isothermal conditions. Heusler alloys Ni-Mn-X (Ga, In, Sn, Co) are chosen as samples, which are of great interest as a solid in the magnetic cooling technology.

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Poster Session A

Poster A

P-A.207

Martensitic transformations in severe plastically deformed FeNi alloy by extreme dynamic loading

S. Taskaev, K. Skokov, M. Bogush

Text Since the development of Nd–Fe–B magnets, rare-earth magnets have been the essential components in many fields of technology because of their ability to provide a strong magnetic flux. There are essentially two ways how to achieve the large values of these properties necessary for today's applications. First, the microstructure of the material can be optimized (in our case with the help of explosion) to prevent rotation of ferromagnetic domains. The second factor is the intrinsic spin–orbit coupling of electrons that forces the spins to align along a particular crystallographic direction, giving rise to the magnetocrystalline anisotropy energy of the material.
The meteoritic tetrataenite phase of FeNi has the outstanding magnetic properties as a rare-earth free permanent magnet [1], but the synthesis of this phase is extremely difficult. Stabilization of the tetrataenite phase could be possible with addition of some extra elements [2]. Other way is consist in increasing diffusion kinetic in the raw material, it is possible to achieve higher rate of atomic diffusion by stress loading material i.e. by direct explosion. In this work we report the results of investigation severe plastically deformed FeNi, it is shown that stress loading initialize martensitic phase transformations.
We acknowledge: RFBR grant № 16-07-00679 and the MES of the RF (project № 3.6782.2017).

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Poster Session A

Poster A

P-A.208

Micromagnetic models of Nd-Fe-B nanocomposites

D. Berkov, S. Erokhin, A. Michels

Text We present micromagnetic simulation results for the magnetization reversal of Nd-Fe-B nanocomposites, which grain size does not exceed several tens of nanometers. High remanence and large magnetic energy product make this material to a promising candidate for usage in next-generation permanent magnets. For this reason, the understanding of the influence of microstructural features of this nanocomposite on its macroscopic magnetic properties is very important.

In this study, we compare hysteresis loops measured on a sample produced by the melt-spinning technqiue with simulation results obtained for the following three models: (i) the material model based on Stoner-Wohlfarth particles including the magnetodipolar interaction, (ii) the core-shell particles model, and (iii) the core-shell model where the possible presence of superparamagnetic clusters is taken into account.

The systematical scan of the parameter space of these three models has been performed by means of our recently developed micromagnetic methodology for the simulation of the magnetization processes in nanocomposites (S. Erokhin, D. Berkov, Phys. Rev. Applied, 7 (2017) 014011). Coupled with the high-throughput approach in micromagnetism, this method has revealed that the superparamagnetic contribution is crucial for the understanding of the experimentally obtained hysteresis loops.

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Poster Session A

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P-A.209

Microstructural and magnetic properties of Mn53.3-xAl45C1.7Tix (x = 0; 0.5; 1.0; 1.5) melt spun ribbons

S. Ener, F. Maccari, K. Skokov, O. Gutfleisch, J. S. Trujillo Hernandez

Text The binary Mn-Al alloy is a promising rare-earth-free permanent magnet due to its intrinsic magnetic properties and low cost of the raw materials [1, 2]. In this system, carbon addition promotes and stabilizes the formation of the desired hard magnetic L10 (τ-phase) and improve magnetic properties but, as a drawback, reduces the Curie temperature [2, 3]. In this work, the effects of Ti addition were investigated in terms of magnetic behavior and phase stability. For this purpose, Mn53.3-xAl45C1.7Tix (x = 0; 0.5; 1.0; 1.5) alloys were subject to melt spinning at different wheel speeds and annealing under different temperatures. The X-ray diffraction patterns and scanning electron microscope images indicates that was possible to obtain pure □-phase after melt spinning at 20 m/s for all compositions. For all the other solidification conditions, the melt spun ribbons shown secondary phases (□, □ and □2). The annealing of the single phase ribbons above 550oC has shown a clear transformation, from high temperature □-phase, to the desired τ-phase. Magnetic measurements indicate a slight increase in the coercivity values with increasing Ti concentration and an increase in Curie temperature by 20 K. The best magnetic behavior was obtained for Mn51.8Al45C1.7Ti1.5 alloy: Ms(3T) = 93.6 Am2/Kg, μoHc = 0.198 T, Mr = 43.3 Am2/Kg, and Tc = 650 K.
Keywords: Mn-Al-C-Ti alloy, Permanent magnets, Melt spinning.

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P-A.210

Microstructure and magnetocaloric effects of Mn1.2Fe0.8P0.6Si0.4B0.05 alloys prepared by ball milling and spinning methods

Z. Zheng, W. Wang, D. Zeng, Y. Hong

Text The magnetic materials with high magnetocaloric effect (MCE) have attracted considerable attention for magnetic refrigeration applications. It is all known that the (Mn,Fe)2(P,Si,B) alloys with no expensive nor toxic elements have large MCEs, but their magnetic properties are very sensitive to the composition and microstructure, leading to increase the difficult for preparation. In this work, the effects of microstructure on magnetic properties and magnetocaloric of Mn1.2Fe0.8P0.6Si0.4B0.05 alloys prepared by different methods are investigated.
The polycrystalline Mn1.2Fe0.8P0.6Si0.4B0.05 alloys were prepared by ball milling and spinning methods, respectively. The sample prepared by ball milling for 5 hours was followed by pressing and annealing at 1100 ℃for 5 hours, labeled bulk sample. The sample prepared by spinning was sealed in quartz tubes and annealed at 1100 ℃for 10 min, labeled belt sample. Results show that all samples have the major phase of hexagonal Fe2P-structure type and a small amount of secondary (Mn,Fe)3Si phase. The Curie temperature is 162K and 196K for bulk and belt sample, respectively. The peak values of magnetic entropy change and refrigerant capacity at 5T are 22, 16 J kg−1 K−1, and 290, 298 J kg−1 for bulk and belt sample, respectively. In particular, the effects of microstructure are investigated in detail. The potential applications of this series of alloys as magnetic refrigerant will be also discussed in this paper.

Poster Session A

Poster A

P-A.211

Novel SMC materials with the insulating layer treated at high temperature

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Text The magnetic materials play an important role in several industrial sectors, mainly in the field of electrical machines. In such applications, the magnetic core is generally made of laminated steel, while the permanent magnets are used as flux generators. In recent years new magnetic materials have been proposed in substitution of the traditional ones, as in the case of Soft Magnetic Composites (SMC) in place of laminated steels. The SMCs are compacted powders where each grain has been covered by a particular layer. In general, such layer can be of inorganic (metal oxides) or organic (resins) typology. The use of SMC materials allows different advantages: low eddy currents, low iron losses at a medium frequency and the possibility to implement the magnetic core in very complex geometries. Some of these geometries, typical of high efficiency electrical machines, cannot be made with laminated steel. However, some drawbacks characterize the SMC materials: thermal constraints, that limit the heat treatment below 600°C, and low mechanical performances. Such thermal limit is due to the usually adopted layer. Therefore novel SMC materials will be proposed with the aim of improve the mechanical performances and raise the heat treatment temperature. The layer will be based on insulating materials, which will be able to be treated at different ranges of temperatures. The magnetic and energetic characteristics will be similar to other common SMC materials.

Poster Session A

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P-A.212

On Ferrofluid Magnetic Buoyancy on Bubbles and its Potential Application to Boost Magnetic Pumps

F. J. Arias, S. De Las Heras

Text Consideration is given to the potential use of magnetic buoyancy on bubbles to largely boost pumping power of traditional magnetopumps. It is known that a magnetic fluid under the action of an external magnetic gradient can generates a body force on the fluid. Here, it is discussed that by introducing a gas-bubble (for example air) inside a ferrofluids pump, the magnetic buoyancy force acting on the bubble is much more stronger than that obtained by simple variations of temperature (magnetocalori pump) or the gradient magnetic. Because this magnetic buoyancy, the bubble moves through the ferrofluid and propelling the fluid away from the bubble with a velocity equal than the terminal velocity of the bubble. This velocity may be up to one order of magnitude higher, than that obtained in classical magnetocaloric pumping technology being only limited by the critical Weber number We at which bubble break-up occurs. Utilizing a simplified physical model, the basis behind the bubble-magneto-pump idea will be discussed. By defining a "fictitious density" derived by balancing the magnetic, drag and gravitational force on the bubble, some Computational Fluid Dynamic (CFD) simulations were performed which agree with the discussed theory. Bubble magnetic pumping in ferrofluids and its capability to boost largely the pumping power of traditional magnetic-pumps technology can encourage a reawakened on this kind of technology.

Poster Session A

Poster A

P-A.213

Polymerized rare earth-free permanent magnet particles for bonding and 3D-printing applications

E. M. Palmero, J. Rial, D. Casaleiz, J. de Vicente, A. Bollero

Text 3D-priting of functional structures with complex shapes allowing tailored magnetic properties is an emergent route for a new generation of rare earth (RE)-free permanent magnets (PMs) with more efficient designs and potential applications in energy, transport and aeronautics sectors. MnAl-based alloys have been proposed as a RE-free PM alternative, particularly, gas-atomized particles which after ultrafast ball-milling (30-270 s) achieve high values of coercivity (4.2-5.1 kOe) [1]. For magnets fabrication by bonding and 3D-printing it is necessary to synthesize composites made of magnetic particles embedded in a polymeric matrix giving to the particles mechanical resistance and working as holder for the particles during the printing process.

This study focuses on the synthesis of composites with tuned content of gas-atomized MnAl-based particles provided by Höganäs AB into a polymer matrix by solution casting. Two magnetic products were produced, i.e. cold compacted magnets and extruded filaments. Composites and compacted magnets with high filling factor (> 85%) and the polymer covering homogeneously the particles were obtained. Continuous MnAl-based filament (length > 10 m) was fabricated for the first time [2]. All products show no deterioration of PM properties of the particles after processing, allowing their efficiently use in advanced 3D-printing and related technologies.

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Poster Session A

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P-A.214

Preparation and characterization of soft magnetic composites based on iron particles coated by SiO_2 layer prepared by modified Stöber method

P. Slovenský, A. Zeleňáková, P. Kollár, J. Füzer, M. Fáberová

Text Soft magnetic composites (SMC) are characterized as ferromagnetic powder particles homogenously coated by non-conducting insulating layer and are usually manufactured by powder metallurgy, which consists of compression of the coated powder into the desired shape and subsequent annealing at high temperatures. Nowadays is a tendency to develop such coatings that fulfil the role of the insulator and at the same time resist the necessary heat treatment. The studied samples of SMC materials were prepared by coating pure iron particles with SiO_2 layer using a modified Stöber method. Then the quality of the formed layers was compared in dependence on the duration of the coating process. The formed insulating layer was investigated and characterized by scanning electron microscopy (SEM) and the chemical composition was verified by energy-dispersive X-ray (EDX) analysis. Thus prepared powders were then compacted by hot pressing method at 400 °C and 700 MPa to form a ring shaped sample. After compacting, the specific electrical resistivity was measured on the samples by four-point method to verify the insulation properties of the coating. Subsequently, measurements were performed to characterize the coercivity and permeability of the samples. We found out that the best insulating properties are achieved when the coating was prepared for relatively long period (at least 7 h) where the sample exhibits coercivity of 480 A/m and initial relative permeability of 100.

Poster Session A

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P-A.215

Scalar Hysteresis Model Including a Simple Description of the First Order Reversal Curves

M. Jesenik, A. Hamler, M. Beković, M. Trlep

Text Our work presents a scalar hysteresis model. Precise material modelling of the electromagnetic devices helps us to develop energy efficient devices. The model is developed to be used in the scope of the Finite Element Method software. It is based on the analytical expression developed to satisfy the following objective: To cover as many different types of hysteresis curves as possible and describe the history of the magnetization of the material simply. We want to store as little data as possible to describe the history of the material's magnetization process, because the magnetization of material inside each finite element could be different. The analytical expression has a large number of parameters to ensure the best coverage of different hysteresis. Parameters are different for the upper and lower parts of the major hysteresis loop and for each first order reversal curve. Parameters of the upper and lower major hysteresis loop are determined using the heuristic method combined with local search, which is the most appropriate method for the considered problem according to tests of different heuristics. To get expressions of the first order reversal curves, only some parameters are changed using known points on the major hysteresis loop, which allows fast calculation of the reversal curve. For the test of the used analytical expression we used a measured major hysteresis loop together with the measured first order reversal curves.

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P-A.216

Shape-controlled synthesis and magnetic properties of CoFe2O4 nanostructures: sphere, cubic, and hexagonal

Y. Kumar, A. Sharma, P. M. Shirage

Text Spherical, cubic, and hexagonal morphology of cobalt ferrite (CoFe2O4) nanoparticles were achieved by careful adjustment of reaction parameters, i.e., capping agent, solvent concentration, and reaction time. The growth of varied nano-morphologies were attributed to the competition in between the growth rate of {100} and {111} planes. X-ray diffraction, Raman spectroscopy, and high-resolution transmission electron microscope (HR-TEM) were utilized to investigate the structure, phase purity, and morphology of NPs. Magnetic studies of NPs showed that coercivity (Hc), saturation magnetization (Ms), remanent magnetization (Mr), and blocking temperature dependent on shape and size. Furthermore, hexagonal CoFe2O4 NPs exhibits the highest coercivity and blocking temperature due to higher surface to volume ratio area and more structural facets. The controlled nano-morphology varients of CoFe2O4 NPs show excellent magnetic properties, ensuring its potential for the next generation high-density information storage media and permanent magnet applications.

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P-A.217

Structural and Magnetic Proprieties of $L1_0$ $Mn_{50}Ni_{50-x}Al_x$ Alloys

R. Hirian, A. Mercea-Abrudan, R. Gavrea, O. Isnard, V. Pop

Text The metastable τ-phase (tetragonal $L1_0$ structure) of the Mn-Al system was reported to have interesting magnetic properties for permanent magnet applications. As the Mn-Ni system also presents a $L1_0$ ordered magnetic phase with high c/a ratio, the current study sets out to obtain a stable ferromagnetic $L1_0$ phase with a high c/a ratio by modifying the intraplanar Mn-Mn distance trough Al doping of the MnNi antiferromagnetic phase on the Ni site. The phase transformations in the investigated alloys were studied using DSC measurements and XRD, while the magnetic properties were determined on both as-cast and annealed samples using demagnetization curves (± 10 T) and magnetization versus temperature measurements.

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P-A.218

Structure and magnetic properties of the substituted hexaferrites for microwave applications

A. Trukhanov, S. Trukhanov, L. Panina, V. Kostishyn

Text The main purpose was to establish the correlation between the influence of the Al3+ and In3+ ions and microwave properties of the substituted hexaferrites. This required a precise determination of the unit cell parameters, which was done with the help of neutron powder diffraction. It was demonstrated that the dependence of unit cell parameters on concentration was closely related with the size of the ionic radius for susbtituted ions. The nature of the preferences of the occupied by DI3+ positions was investigated by Mossbauer spectroscopy demonstrating that all the samples had similar cation distribution at low concentrations. Depending on the substitution type and level, the transmission and absorption spectra demonstrate a change in the frequency and amplitude of the maximum absorption (due to the natural ferromagnetic resonance) owing to the corresponding change in the crystalline magnetic anisotropy. Additional contribution to the anisotropy field may come from the occurrence of internal stresses and microdeformations. The change in the crystalline anisotropy was explained by the weakening of stiffness of the intrasublattice superexchange interactions. Tailoring the electromagnetic characteristics in the frequency range of 20-65 GHz is of high interest from the practical perspectives. Possibility of the electromagnetic properties control by chemical substitution and by external magnetic field was demonstratedю

Poster Session A

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P-A.220

The Origin of field-induced discontinuous phase transitions in R2Fe17 (R = Sm, Nd)

L. Diop, M. Kuzmin, K. Skokov, Y. Skourski, O. Gutfleisch

Text The R2Fe17 compounds (where R stands for a rare-earth element or yttrium) are interesting because of their unusual anisotropic magnetic properties and it is for that reason that single crystals of R2Fe17 have been the subject of intensive study during the last decades. A notable exception are the compounds with the lightest rare earths, in particular Sm2Fe17 and Nd2Fe17, which are little studied. The reason for the deficiency lies in
the difficulty of obtaining these R2Fe17 in single-crystalline form. Their magnetic behavior remains largely a mystery.
we set out to grow single crystals and carry out a systematic study of the magnetocrystalline anisotropy and magnetic phase transitions. The orientation of the spontaneous magnetization in Sm2Fe17 is not fixed by the symmetry and has been unknown so far. The hard-axis magnetization arrives at saturation discontinuously, by way of a first-order phase transition (FOMP). This is a rather unusual kind of FOMP – a symmetry FOMP. As regards Nd2Fe17, our most interesting finding is a double FOMP in a field directed along the magnetic hard c-axis. One of them (at 20 T) is a symmetry FOMP similar to that observed in Sm2Fe17. The second transition (at 10.4 T) is without precedent: as the magnetization turns abruptly towards the applied field, it also changes its azimuthal orientation (the angle φ) by 60°. Both transitions can be reasonably accounted for by the presence of a significant sixth-order trigonal anisotropy term.

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P-A.221

The effect of cationic distribution and shape on the magnetic properties of small $CoFe_2O_4$ clusters.

N. Ntallis, M. Vasilakaki, D. Peddis, K. N. Trohidou

Text Surfactants are used for surface coating of MNP for energy applications, in order to avoid or decrease agglomeration and to increase their dispersion stability in ferrofluids [1]. We study the effect of surfactant coating of Co ferrite nanoparticles on their magnetic behavior. By performing DFT calculations, using the VASP package [2,3], we study the modification of the magnetic moments, magnetocrystalline anisotropy and magnetic exchange constants for two different shapes, orthogonal and spherical, and three different ionic distributions formed by the oleic acid, the diethylene glycol [4] and the uncoated one for comparison. Our calculations show (a) overpopulation of octahedral sites by Fe ions that increases the magnetic moment in glycol coating, (b) transfer of Co ions in tetrahedral sites that increases the magnetic anisotropy in oleic acid and (c) effect on the exchange parameters strength but not in the sign. The two different shapes exhibit qualitatively the same magnetic behaviour.

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Poster Session A

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P-A.222

The magnetic, structural properties and magnetocaloric effect of Mn-Fe-Al alloys

L. Lei, Z. Zheng, D. Zeng, Y. Hong

Text The existence of a new ferromagnetic phase, so-called κ phase, in Mn-Fe-Al alloy has been reported. The Curie temperature is near room temperature. But little effort has been dispensed in the investigation of the magnetocaloric effects about this alloy. In this paper, the effects of Mn and Fe on magnetic properties and magnetocaloric for Mn-Fe-Al alloys are explored.
FexMn40Al100-x(x = 12, 13, 14 and 15) and Fe15MnyAl100-y (y = 37, 38, 39 and 40) alloys were prepared by arc melting, and annealed at 1000℃for 7 days. The microstructure and magnetic properties are characterized by XRD, SEM, and VSM. All samples crystalized in CsCl type Cubic structure (Space group: $Pm\bar{3}m$). And for Fe15MnyAl100-y, with increasing Mn contents, the lattice parameters increase from 2.9613Å to 2.9678 Å, while the curie temperatures can be tuned from 288K to 330K. As for the FexMn40Al100-x alloys, the curie temperatures rises from 315K to 340K with the lattice parameters from 2.9658 Å to 2.9689Å. The ΔSMax are −2.4 and − 3.1 J□kg-1K-1 for Fe15Mn40Al45 and Fe14Mn40Al44 respectively, and the values of refrigerant capacity power are 223.4 and 232.5 J□kg-1 under 5T. The arrott plots and universal curve are also employed to investigate the magnetic phase transition, showing all samples undergo a second order ferro-paramagnetic phase transition. The potential applications of these alloys as magnetic refrigerant will be also discussed in this paper.

Poster Session A

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P-A.223

Transport study by Ir doping at Ru site in SrRuO3

R. Gupta, A. K. Pramanik

Text Here we study the transport behavior of SrRr1-xIrxO3 series compounds with of bulk polycrystalline materials. Without a change of orthorhombic structure of SrRuO3, the lattice parameters increase by Ir doping. The SrRuO3 shows ferromagnetic (FM) to paramagnetic (PM) phase transition and FM interaction decreases by Ir doping with decreasing Curie temperature (θp). The temperature dependent electrical resistivity, ρ (T) of SrRuO3 shows metallic nature in the entire temperature range with kink around Tc and similar behavior also shows Ir doped sample with decreasing metallic nature. As the Ir doping increase, the SrRr1-xIrxO3 show metal to insulator transition. Above Tc, ρ (T) increases linearly while below Tc, sharp decrease of ρ (T) of both the compounds. By applying 8 T of the magnetic field, the ρ (T) decreases of both compound and show negative magnetoresistance.