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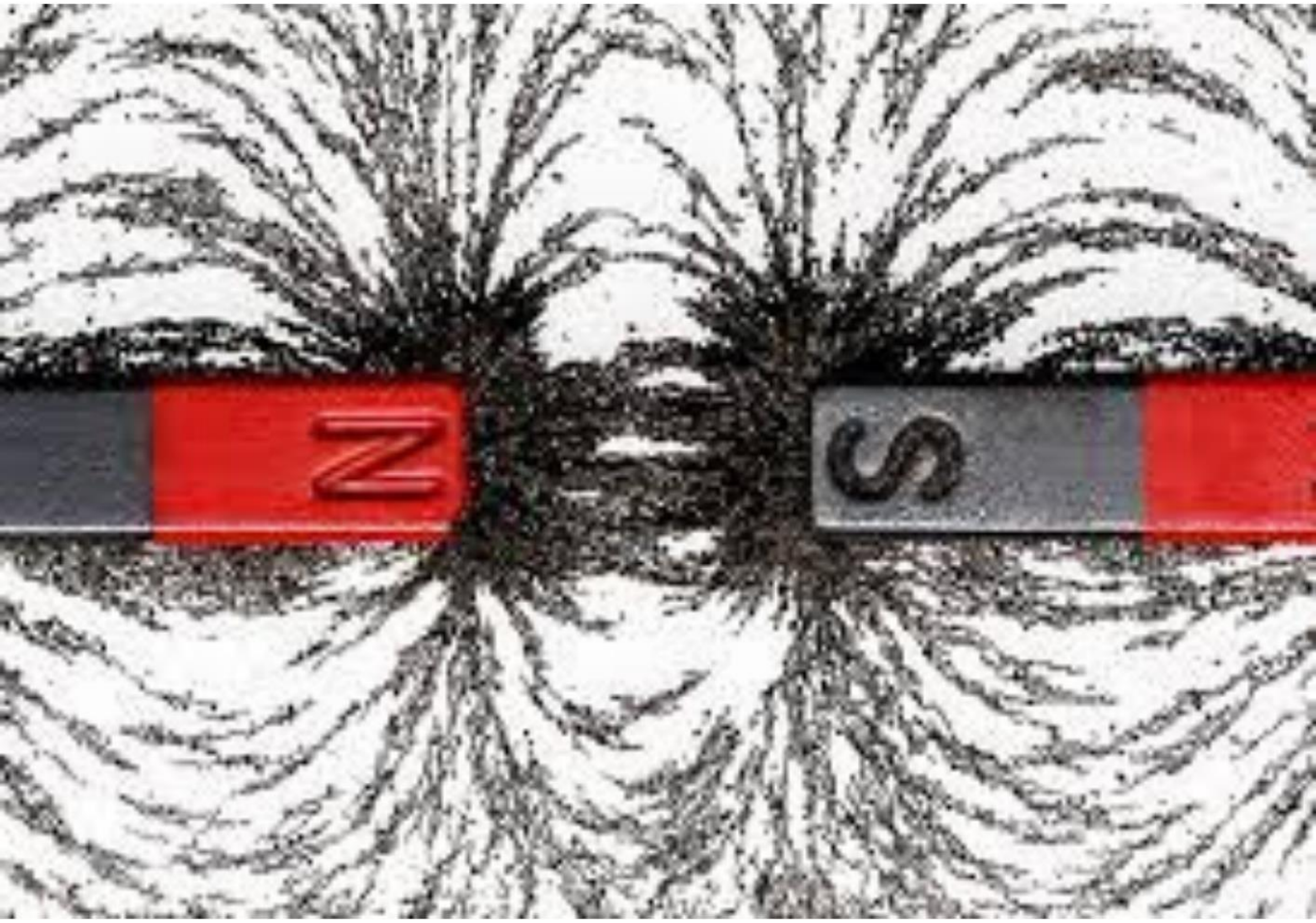

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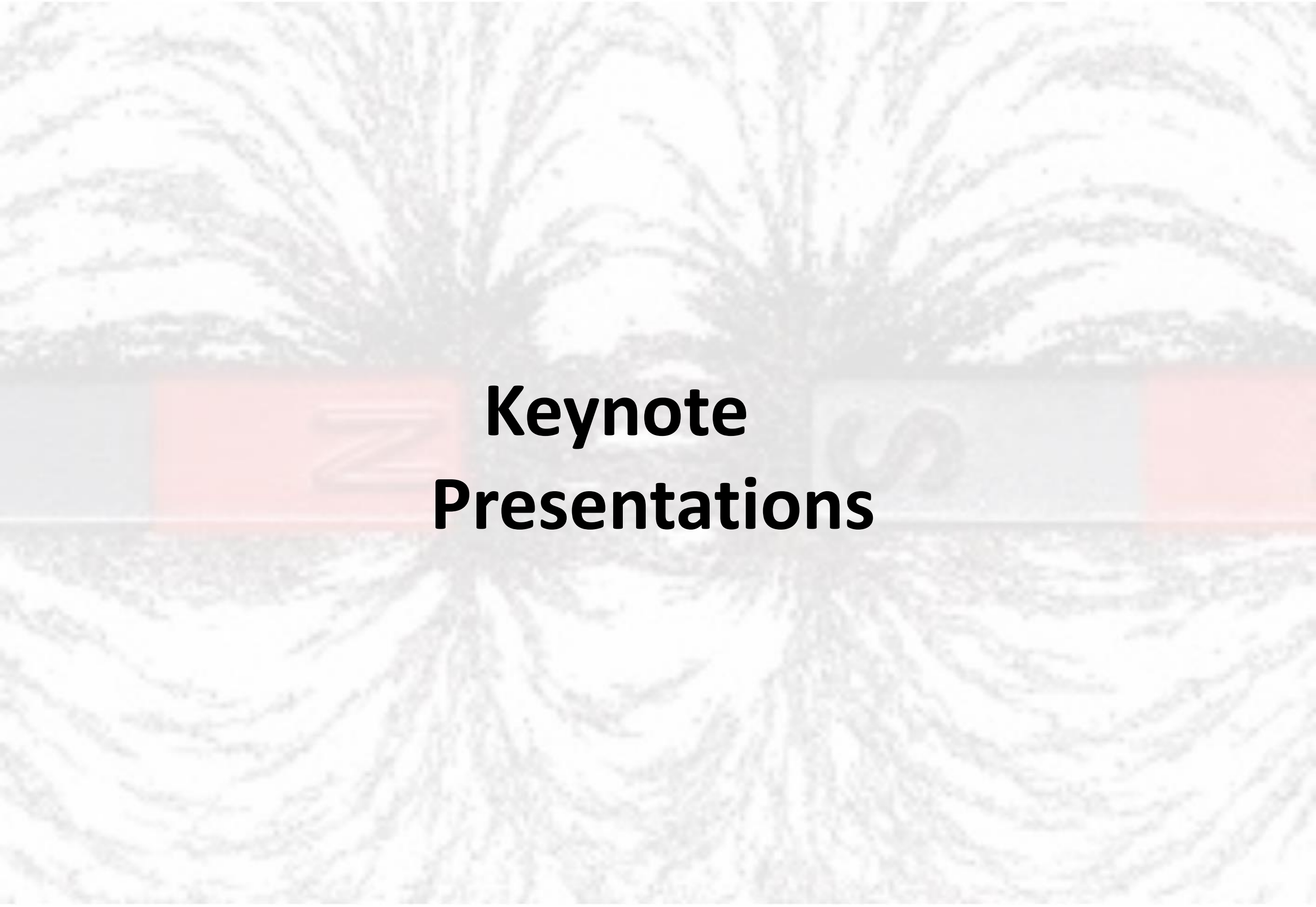
Keynote Presentations



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Field induced ferri-ferromagnetic transitions in $Y_{1-x}R_xFe_2(H,D)_{4.2}$ compounds

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Abstract
Background and Goals

R-Fe intermetallic compounds display a ferrimagnetic ground state when *R* is a heavy Rare Earth element, however in some cases a forced ferri-ferromagnetic transition can be induced by applying a very high magnetic field [1-3]. The transition field can be lowered by hydrogen insertion, due to the reduction of the *R*-Fe interactions as found in [4-7]. We have investigated the influence of the nature of the substituted heavy *R* element (*R* = Gd to Tm) on this metamagnetic transition in $Y_{1-x}R_xFe2(H,D)_{4.2}$ compounds at 4.2 K.

Methods

$Y_{1-x}R_xFe_2$ intermetallic compounds were prepared by induction melting and annealed 4 weeks at 1073 K. Corresponding hydrides and deuterides were synthetized by solid-gas reaction. Their crystal structures were determined by X-ray diffraction on a D8 Bruker diffractometer. Magnetization curves ($M_T(B)$) were measured up to 9 T with a conventional PPMS. For selected hydrides (deuterides) measurements were done under high static magnetic field up to 35 T and under pulsed magnetic fields up to 60 T in the Grenoble and Dresden High Magnetic Field Laboratory respectively.

Results

$Y_{1-x}R_xFe_2$ Laves phases crystallize in cubic C15 structure whereas $Y_{1-x}R_xFe_2H(D)_{4.2}$ compounds are monoclinic [8]. The $M_{4.2K}(B)$ curves of $Y_{0.7}R_{0.3}Fe_2H(D)_{4.2}$ show that the onset field (B_{Ons}) of the metamagnetic transition as well as the saturation field (B_{Sat}) both decrease versus R atomic number. For *R*=Gd, the saturation is not reached at 60 T, and B_{Sat} is larger than 84 T. For *R*= Tb (Er), B_{Ons} remains close to 10 T (8T), whereas B_{Sat} increases with x. For R=Tm, a ferromagnetic state is already present at low field. These results show the strong influence of the H(D) insertion as well as the nature of the *R* element on the forced ferri-ferromagnetic transition in $Y_{1-x}R_xFe_2$ compounds and their origin will be discussed.

Keywords: Laves phases, Hydrides, Deuterides, Metamagnetism

Acknowledgement: We thank the high magnetic field laboratories of Grenoble (LNCMI-CNRS) and Dresden (HLD-HZDR), members of the European Magnetic Field Laboratory (EMFL) for the time given to perform the magnetic measurements under static and pulsed magnetic field respectively.

References:

[1] G. Kido, S. Kajiwara, Y. Nakagawa, S. Hirosawa, M. Sagawa, IEEE Transactions on Magnetics, 23 (1987) 3107.
[2] H. Kato, D. W. Lim, M. Yamada, Y. Nakagawa, H. Aruga Katori, T. Goto, Physica B, 211 (1995) 105.
[3] D. I. Gorbunov, S. Yasin, A. V. Andreev, N. V. Mushnikov, Y. Skourski, S. Zherlitsyn, J. Wosnitza, J. Magn. Magn. Mat., 365 (2014) 56.
[4] N. V. Mushnikov, N. K. Zajkov, M. I. Bartashevich, T. Goto, H. Aruga-Katori, M. Yamaguchi, I. Yamamoto, J. Magn. Magn. Mat., 167 (1997) 229.
[5] O. Isnard, A. V. Andreev, M. D. Kuz'min, Y. Skourski, D. I. Gorbunov, J. Wosnitza, N. V. Kudrevatykh, A. Iwasa, A. Kondo, A. Matsuo, K. Kindo, Phys. Rev. B, 88 (2013) 174406.
[6] O. Isnard, A. V. Andreev, O. Heczko, Y. Skourski, J. Alloys Compds, 627 (2015) 101.
[7] V. Paul-Boncour, O. Isnard, V. Shtender, Y. Skourski, M. Guillot, J. Magn. Magn. Mat., 512 (2020) 167018.
[8] J. Ropka, R. Cerny, V. Paul-Boncour, T. Proffen, J. Solid State Chem., 182 (2009) 1907.

Biography

Valérie Paul-Boncour has an Engineer diploma from ESPCI (France) and has completed her PhD at the University Pierre and Marie Curie (France). She is senior researcher at the CNRS working in East Paris Institute of Chemistry and Materials Science and team leader of the group "Magnetic and Thermoelectric Properties". She is specialist of metal hydrides properties and has published about 180 papers, 2 book chapters, presented 21 invited conferences and more than 250 contributions in national and international conferences.

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Successive Spin Polarization Contribution to the Magnetic Coupling in Diluted Magnetic Semiconductors

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Abstract

Background

The magnetic coupling (MC) among the magnetic dopants in diluted magnetic semiconductors (DMSs) and transition metal oxides (TMOs) is usually attributed to carrier mediated interactions and/or to classical model interactions namely, the superexchange, double exchange, sp-d exchange etc. Less attention has been focused onto the role of the dopant's ligands in the inter-dopant MC. This aspect is investigated within our proposed successive spin polarization (SSP) model, and is found to be related with new contributions to the MC which are competitive to known ones.

Methods

Our investigation is based on ab initio and semiempirical calculations within the density functional theory (DFT) at the level of the spin polarized generalized gradient approximation (GGA), and the Perdew–Burke–Ernzerhof (PBE) level of approximation augmented by including Hubbard-U corrections as implemented in the Vienna ab initio simulation package (VASP).

Results

The MC in DMSs and TMOs appears to be induced either by the intrinsic or the extrinsic defects. It is demonstrated that the ferromagnetic coupling associated with the defect-induced magnetism in these materials is enhanced by codoping (i.e., the simultaneous doping by two or more dopants of different type) leading to the formation of successively interacting spin-polarized radicals, i.e., complexes each consisting of a dopant and its first nearest neighboring anion ligands. In addition to the local and holistic features associated with the MC, codoping emphasizes the synergy among the defects in developing the MC and leads to new contributions to the MC among which we identified the SSP and the successive exchange spins (SSX) ones. These are competitive to the classical MC-contributions (e.g., superexchange) and indicate the major role of the intra-radical dynamics in the development of the inter-dopant MC.

Keywords: magnetic materials, magnetic coupling, diluted magnetic semiconductors, first principles electronic structure calculations

Acknowledgement: The presented work has been performed in collaboration with Prof. Madhu Menon (Department of Physics and Astronomy, University of Kentucky, Lexington, KY 40506, USA) .

References:

1. "Estimation of sp-d exchange constants revisited", Antonis N Andriotis and Madhu Menon, J. Phys.: Condens. Matter (in press 2021)
2. "Goodenough-Kanamori rules applied to wurtzite crystals", Antonis N Andriotis and Madhu Menon, J. Phys.: Condens. Matter 32 , (2020) 295801
3. "Antiferromagnetic successive superexchange interactions underlying ferromagnetic couplings in codoped diluted magnetic semiconductors", Antonis N Andriotis and Madhu Menon, J. Phys. Condens. Matter, 30 , 385703 (2018)
4. "Successive Spin Polarization Contribution to the Magnetic Coupling in Diluted Magnetic Semiconductors: A Quantitative verification", Antonis N Andriotis and Madhu Menon, Journal of Magnetism and Magnetic Materials, 501 , 166313 (2020)
5. "Successive spin polarizations underlying a new magnetic coupling contribution in diluted magnetic semiconductors", Antonis N Andriotis, Zacharias G Fthenakis and Madhu Menon, J. Phys. Condensed Matter (Fast Track Communication), 27 , 052202 (2015)
6. "Defect-induced magnetism: Codoping and a prescription for enhanced magnetism", Antonis N. Andriotis and Madhu Menon, Phys. Rev. B87, 155309 (2013)
7. "Magnetic anisotropy and engineering of magnetic behavior of the edges in Co embedded graphene nanoribbons, Sergey Lisenkov, Antonis N. Andriotis, and Madhu Menon, Phys. Rev. Lett., 108, 187208 (2012).

Biography

Antonis N. Andriotis has completed his PhD at the age of 29 years from the University of Cape Town, (South Africa). He is an Emeritus Research Director in the Institute of Electronic Structure and Laser of the Foundation of Research and Technology – Hellas (Greece). He is the author of three books on Computational Physics and two books on the History of Physics in Greece. He published more than 150 papers in reputed journals focusing on Condensed Matter Physics and Materials. He served as invited Reviewer by the European Commission and various National European Research Organizations.
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Invited Oral Presentations

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Magnetoresistance of nanosized, granular strontium ferromolybdate-strontium molybdate core-shell structures

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Abstract

Background and Goals

The transport properties of Sr_2FeMoO_6 (SFMO) ceramics depend significantly on sample microstructure. Cold pressed, grinded and sintered, as well as nanosized SFMO core-shell structures consist of nanocontacts between conducting grains. Conducting grains separated by a nanoarea tunnel junctions are modeled by the fluctuation induced tunneling (FIT) model developed by P. Sheng et al. in 1978. In this work, we develop a model of the magnetoresistance (MR) for nanosized, granular SFMO core-shell structures comprising $SrMoO_4$ (SMO) shells which are subjected to FIT.

Methods

The SFMO resistivity was calculated in dependence on temperature T and magnetic flux density B by means of the temperature T_1 characterizing the electrostatic energy of a parabolic potential barrier, the temperature T_0 representing T_1 divided by the tunneling constant, and a pre-exponential factor estimated using Slonczewski's tunnel model for spin-down electrons. The FIT model resistivity is then given by $r(T) = r_0 \cdot \exp(T_1/(T_0+T))$. The magnetic field is considered to affect the tunneling barrier height. The linear and quadratic coefficients of this effect are estimated. The first coefficient is attributed to the Zeeman energy, the second one to the impact of the magnetic field on the ballistic motion of tunneling electrons.

Results

The model calculates the resistance of nanosized, granular SFMO-SMO core shell structures in dependence on temperature and magnetic flux density. The predicted MR increases with increasing magnetic flux density. The calculated temperature dependence of the MR in nanosized, granular SFMO-SMO core-shell structure is much weaker than in the SFMO ceramics. This is beneficial for spintronic device application near room temperature. A small increase of the MR up to a temperature of 50 K following by a decrease at higher temperatures is in agreement with available experimental data.

Keywords: Strontium ferromolybdate, magnetoresistance, fluctuation tunneling

Acknowledgement: This work was supported by the European project H2020-MSCA-RISE-2017-778308–SPINMULTIFILM.

Biography
Dr. Gunnar Suchaneck is currently Senior Researcher and Chief Assistant of the Solid State Electronics Laboratory at TU Dresden. He received his Ph.D. in physico-mathematical sciences from the Electrotechnical University - LETI, St. Petersburg, Russia, in 1983. His current research interests include solid state sensor technology: ferromagnetic and ferroelectric thin film materials, metal oxide thin films, thin film deposition by reactive sputtering and plasma enhanced chemical vapor deposition, characterization of thin films by optical and electrical measurements. He has coauthored more than 280 technical publications in books, scientific journals, and conference proceedings, and has coauthored 15 patents.

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Theoretical study on spin-reorientation transition in an Fe double-layer on W(110) induced by Dzyaloshinsky-Moriya interaction

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Abstract

The Dzyaloshinskii–Moriya interaction (DMI) is an antisymmetric exchange interaction between two magnetic moments due to the spin-orbit coupling. It is behind several fascinating phenomena involving non-collinear magnetism, such as formation of spin spirals and magnetic Skyrmions. The orientation of the magnetization in thin ferromagnetic films is determined by the magnetic anisotropy. The competition among different kind of anisotropy contributions often result in a thickness or temperature driven reorientation of the magnetization. Although DMI is not expected to have impact on a collinear system, however, it may give rise to magnetic anisotropy via the thermal fluctuations of the magnetic moments.
In our contribution we present a study on temperature-driven spin reorientation transition in the case of two atomic layers of Fe on W(110) using well-tempered metadynamics simulations. The magnetic properties of the bi-layer is described by a classical Heisenberg model which is extended by bi-axial second order anisotropy. The interaction between two magnetic moments is characterized by a 3x3 exchange tensor and they are not restricted to the nearest neighbors. All the parameters appearing in the model – exchange tensors, anisotropy constants – are calculated from first principle by means of Korringa-Kohn-Rostoker method using the relativistic extension of the torque method.

We found that omitting the antisymmetric part of the exchange tensors representing the DMI no reorientation occurs till the Curie temperature and the orientation of the magnetization remains normal-to-plane. Including DMI in the simulations we obtained a spin reorientation at a temperature below the ferromagnetic/paramagnetic phase transition. The simulations demonstrate that the chiral DMI can influence the magnetic orientation even in a ferromagnetic system.

Keywords: Dzyaloshinsky-Moriya interactions, magnetic anisotropy, spin reorientation transition

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Magical Lambdas-λ_g – In the DESIGN PARAMETERS

S. Raghavan

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Abstract

Magic in the ideal lossless 'Magic Tee' is nothing other than one port is fully isolated while the power output from other two ports are exactly half the input power and this is happening without any active device inside. Popular Waveguide ideal directional coupler , one port is fully isolated while the other port is coupled port and that's due to the distance between two Bethe holes is λg/4.Rat is fully depend on the various integer multiple of λg/4. The factor behind an antenna is again an integer multiple of λg/4. Matching, Power splitting, Power combining, Phase shifting, K,J Inverters, filters either edge coupling or end coupling dwelves around λg/4. Guide wave length plays pivotal roles in metamaterial, photonic band gap structures , FSS etc. In short the design concepts especially length dimension of most of the planar passive and active components are in terms of λg. It takes care of all types planar transmission lines and also valid for any materials. The researchers should know the concept of design in terms of BASICS and in that aspect the lecture will emphasize the greater and predominant role played by λg.

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Vortex Domain wall pinning in magnetic stepped nanowire for storage memory devices

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Abstract

Background and Goals

This study aims to investigate the Vortex domain wall dynamics and its pinning through the stepped magnetic nanowire by using spin-transfer torque.

Methods

The micromagnetic simulation was conducted by object-oriented micromagnetic framework (OOMMF) software.

Results

Controlling Vortex Domain wall (VDW) dynamics and stability in a nanowire is a crucial issue for DW storage memory. In this study, VDW pinning was investigated by using micromagnetic simulation. A new way is proposed for VDW pinning by creating a stepped notch. This way is a convenient way to pin DW with different structures. A stepped area is constricted at the center of the nanowire with proportions of depth (*d))* and length (λ) to pin the magnetic domain wall (DW) with high barrier potential energy to achieve a high information storage capacity. It is found that, the VDW stability structure and pinning at the stepped area depends on the magnetic material properties and the stepped area geometries.

Conclusions

From this study, it can be concluded that the stability type of the VDW with CW chirality and up polarity during its propagation in stepped nanowire could be controlled by improving the magnetic properties like saturation magnetization (Ms), decreasing the current density and manipulating the stepped area dimensions (*d))* and (λ) .

Keywords: Micromagnetic Simulation, Vortex Domain Wall, Stepped nanowire, Spin transfer

References:

[1] M. Al Bahri, "Geometrical confinement of Vortex Domain wall in constricted magnetic nanowire with in-plane magnetic anisotropy," IEEE Trans. Magn., 2021.
[2] M. Al Bahri, "Vortex domain wall dynamics in stepped magnetic nanowire with in-plane magnetic anisotropy," J. Magn. Magn. Mater., vol. 515, no. April, p. 167293, 2020.
[3] A. U. Suleiman, R. Sbiaa, and M. Al Bahri, "Domain Wall Dynamics in Stepped Magnetic Nanowire with Perpendicular Magnetic Anisotropy," Phys. Status Solidi, no. July, 2020.
[4] M. Al Bahri, B. Borie, T. L. Jin, R. Sbiaa, M. Kläui, and S. N. Piramanayagam, "Staggered Magnetic Nanowire Devices for Effective Domain-Wall Pinning in Racetrack Memory," Phys. Rev. Appl., vol. 11, no. 2, 2019.
[5] R. Sbiaa, M. Al Bahri, and S. N. Piramanayagam, "Domain wall oscillation in magnetic nanowire with a geometrically confined region," J. Magn. Magn. Mater., vol. 456, pp. 324–328, 2018.
[6] M. Al Bahri and S. R. G. pinned magnetic domain ll for multi-bit per cell storage memory. S. R. 2016;6. doi:10. 1038/srep2859. Sbiaa, R.1. Al Bahri M, "Geometrically pinned magnetic domain ll for multi-bit per cell storage memory," Sci. Rep., vol. 6, Jun. 2016.
[7] R. Sbiaa and M. Al Bahri, "Constricted nanowire with stabilized magnetic domain wall," J. Magn. Magn. Mater., vol. 411, pp. 113–115, 2016.

Biography

Mohammed Al Bahri has completed his PhD at the age of 43 years from the University of Sultan Qaboos (Oman). He is a lecture at A'Sharqiyah University (Oman), an assistant professor in physics, and the chairman of community service at A'Sharqiyah University (Oman). He has published since 2016, around 11 papers with more than 72 citations in reputed journals.

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Enhancing epilepsy diagnosis using MEG signals

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Abstract

Background/ Objectives and Goals

Pharmacoresistant epilepsy affects about 30% of epileptic subjects, where drugs are not sufficient to control or to stop their seizure. This type of epilepsy requires a surgical intervention in order to restrict the epileptogenic zones (illness cortical tissue) responsible of excessive discharges and a buildup of a seizure. Hence, studying and analyzing electrophysiological signal (electroencephalography and magnetoencephalography) with anatomic images (MRI) is an accurate solution to define in a precise way the EZ.

Both MEG and EEG had advantages of temporal resolution, moreover MEG proved to be less sensitive to various cerebral conductivities and free reference comparing to EEG recording.
Hence, MEG is considered as a useful tool to presurgical intervention in refractory epilepsy and during diagnosis of pharmacoresistant epilepsy.

Methods

We proposed to analyze both MEG hallmarks: interictal transient and gamma oscillations. We gathered epileptic pure hallmarks none contaminated by other rhythms through an advanced technique of detection and recognition (despikifying). Then we proceed in source localization of these epileptic events using real MRI of each subject to resolve forward problem and computing the inverse problem by the minimum norm estimation MNE. All preprocessing steps were applied on Matlab and Brainstorm toolbox. Finally, we computed their networks connectivity and confronted it to IEEG networks.

Expected Results/ Conclusion/ Contribution

MEG networks were in concordant with IEEG ones, with more specificity in epileptic generator spatial extend. MEG networks were also able to detect the Seizure On set Zones and the irritative zone. Inerictal transient and gamma oscillation networks are complementary for an efficient presurgical mapping. MEG is a practical tool in epilepsy decision-making process and during surgical intervention for seizure free.

Keywords: MEG, pharmaco-resistant epilepsy, epileptic hallmarks, epileptic zones

Biography

Nawe JMAIL has completed her PhD at the age of 28 years from University of Aix Marseille (France) and University of Sfax (Tunisia). She is a professor at Sfax University and Team Leader of Physiological signal processing Team of CRNS focusing on diagnostic tools for epilepsy. She has published more than 20 papers in reputed journals and serving as an editorial board member of repute.

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Introducing a nickel-core magnetostrictive transducer with special core geometry: numerical and experimental evaluations

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Abstract

Background/ Objectives and Goals

The ultrasonic waves can be generated based on various principles such as piezoelectric and magnetostriction. But magnetostrictive transducers can generate more powerful sound. The core of these transducers is made of some materials such as nickel, Terfenol, etc. Nickel can be used in low-frequency and high-power applications, but have relatively week magnetostrictive effect. Various parameters affect the behavior and performance of magnetostrictive transducers such as core geometry.

Methods

At first, the core geometry was considered as the main independent variable. Some core geometries made of nickel with the same volumes and lengths were numerically investigated using JMAG-Designer software, while some parameters including wire type, wire cross-sectional area, wire length, coil resistance, etc. were constant. Followed by, the other relevant parameters including electrical current, frequency, the number of coil turns, and lamination factor were applied to the optimal core geometry for analyzing the ultrasonic wave propagation along the longitudinal and the radial direction of the transducer. For evaluating the performance of this transducer, a comparison between the sound pressure calculated in the simulation environment of JMAG-Designer software and the sound pressure produced in the real transducer was performed.

Expected Results/ Conclusion/ Contribution

According to numerical simulation results achieved from JMAG-Designer software, a conical core with a cone angle of 30° and low operating frequency has the highest variations of magnetostrictive force in the axial direction. It was also tried to improve its ultrasonic performance by proper selection of lamination factor along the radial axis. Moreover, the nickel particles of core were thermally treated to reduce the maximum output magnetic hysteresis and decreases the maximum input magnetic hysteresis. The experimental result showed that the real model is well consistent with the computer model. With further investigations, this transducer can be used in some biomaterials processing operations.

Keywords: Magnetostrictive ultrasonic transducer, Conical core, Nickel, magnetic, Sound pressure

Acknowledgements:

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Biography

Danial Gandomzadeh is a Ph.D student (2015) in Mechanical Engineering of Biosystem at the Ferdowsi University of Mashhad (FUM) studying under supervision of Professor Mohammad Hossein Abbaspour-Fard. He completed the BSE (2009-2013) and MA (2013-2015) programs in Mechanical Engineering of Biosystem at FUM. His thesis is focused on adopting ultrasonic magnetostrictive transducer for biomaterials processing applications. His major research interests are electronics and ultrasonic applications in biosystem engineering, development of postharvest technology, and renewable energy. He has published some papers in national and international journals and teaches in parallel at some local universities.

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FSMA based Magnetoelectric Heterostructures for MEMS Applications

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Abstract

Background/ Objectives and Goals

Ferromagnetic shape memory alloys (FMSAs) belong to a particular class of materials that display coupling between the ferromagnetic, mechanical and thermal orders. FSMAs exhibits martensite transformation from a high-temperature austenite phase to a low-temperature martensite phase. The large magnetic field-induced strain in FSMAs can be used to fabricate magnetoelectric heterostructures for various micro-electro-mechanical systems (MEMS) applications.

Methods

The multifunctional devices have been fabricated by combining FSMA with Pb(Zr,Ti)O3 (PZT), La-doped PZT (PLZT), and AlN materials for magnetic sensing, tunable resonator, and memory device applications. The magnetoelectric random-access memory device has been fabricated based on Cr/Ni-Mn-In/PZT/STO/Ni-Mn-Sb multiferroic tunnel junction using DC/RF magnetron sputtering. The magnetoelectric coupling coefficients are calculated for Ni-Mn-In/PLZT and Ni-Mn-In/AlN-based magnetoelectric heterostructures. The magnetic sensing characteristics of the Ni-Mn-In/PLZT and Ni-Mn-In/AlN bulk acoustic wave (BAW) resonators are investigated in terms of the influence of externally applied magnetic fields on their resonant frequencies. The Agilent Advanced Design Software is used for fitting the S-parameter results of the fabricated resonators.

Expected Results/ Conclusion/ Contribution

The fabricated magnetoelectric RAM shows four-state logic memory due to coupling between electric polarization and magnetization. The shift of nearly 360 MHz and 730 MHz have been observed for AlN/Ni-Mn-In and PLZT/Ni-Mn-In resonators in the presence of 1200 Oe magnetic field, respectively. This shift in the resonant frequency of the resonator with the magnetic field could be ascribed to the alteration in the effective Young modulus of the resonator due to magnetoelectric coupling between the resonators' constituent layers. These FSMA based magnetoelectric heterostructures can play a leading role in next-generation magnetic field sensors, memory, and tunable resonators applications.

Keywords: multiferroics, magnetoelectric, memory, bulk acoustic wave, magnetic sensor.

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Biography
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Rare Earth Element (REE) Recovery from End-of-Life (EoL) NdFeB Permeant Magnet Waste: A comprehensive Review

Muammer KAYA and Angela Manka Tita
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Abstract

The rare earth elements (REEs) are becoming increasingly important in the transition to a green and sustainable economy due to their essential role in permeant magnets used in electrical and electronic equipment (computers, smartphones, and audio systems), green energy generators, home appliances, automation, electrical/hybrid (H(EVs)) car motors, medical instruments, etc. REEs are classified as critical materials in high-tech economies. The size of the EoL NdFeB magnets ranges from 1 g in small consumer electronics to 1 kg in H(EV)s, and can be as large as 1-2 t in wind turbine generators. The life span of the small magnets is 2-5 years and large magnets 15-25 years. Sustainable REE shortages can be solved by direct recycling or urban mining of EoL NdFeB magnets.
This paper covers REE production, supply and demand; NdFeB magnet application areas, production techniques, and recycling; automotive, HDD, and air conditioner compressor magnets; EoL NdFeB magnet urban mining by hydrometallurgical, pyrometallurgical, and hydrogen decrepitation methods; leaching, REEs from NdFeB magnets, precipitation separation, solvent extraction of REEs, refining; current efforts and future trends and life-cycle-assessment (LCA) of NdFeB magnet recycling.

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A magnetocaloric study of the magnetostructural transitions in $NiCr_2O_4$

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Abstract
Background and Goals

We present a detailed magnetocaloric and Arrot plot study as a function of magnetic field and temperature on the spinel material $NiCr_2O_4$. $NiCr_2O_4$ is an interesting material where magneto-elastic coupling drives multiple structural and magnetic phase transitions. Two transitions at Tc = 70 K and T = 30K have been reported several times in literature using conventional techniques likes magnetization and heat capacity. We find two additional phase transitions at T = 20K and T = 8 K using a detailed magnetocaloric and Arrot plot study. We further use a scaling analysis to shed light on the type of phase transitions (Mean field or not, second or first order) observed by us. This work gives several new results. 1) It shows that the magnetocaloric effect (MCE) is a sensitive probe of magneto-structural changes. 2) The new phase transitions at T = 20K (reported in just one other report by indirect capacitance measurements) and at T = 8 K suggest that the magnetic and crystallographic structures in $NiCr_2O_4$ continue to relax and change as temperature is lowered. 3) A pronounced negative magnetocaloric effect is observed at the T = 8 K transition. Positive MCE was observed at all the other phase transitions suggesting a fundamentally different mechanism to the T = 8 K transition. 4) Scaling analysis of the MCE data for the three prominent transitions at T = 70K, 30K, and 8K is carried out. We use this to shed light for the first time on the nature of these phase transitions.

Methods
The polycrystalline samples of $NiCr_2O_4$ were prepared by conventional solid state reaction as reported previously. Stoichiometric amounts of NiO (99:995 % Alfa Aesar) and Cr_2O_3 (99:999 % Alfa Aesar) were mixed in an agate mortar and pestle for approximately 1 hour. This mixture was pelletized and sintered at 800 ◦C for 12 hours in air. The resulting pellets were reground, mixed, re-pelletized, and annealed at 1100 ◦C for 24 hours. This step was repeated twice. The X-ray powder diffraction data were collected at room temperature and analyzed using GSAS software27. The magnetic measurements were performed using a physical property measurement system from Quantum Design in the temperature range 2K ≤ T ≤ 300K and in magnetic fields in the range 0 ≤ H ≤ 9 T.
Results

The spinel $NiCr_2O_4$ is a magneto-elastic material where the lattice degree of freedom is strongly coupled with spin and orbital degrees of freedom. This coupling drives several temperature dependent phase transitions which are magnetic or magneto-structural in nature. In this work we study the magnetization, heat capacity in zero and 9 T field, and the magnetocaloric (MCE) response -ΔSM of $NiCr_2O_4$ as the temperature is varied across the various magnetic, structural or coupled magneto-structural transitions. The magnetization confirms two clear anomalies at Tc = 70 K and Ts = 30 K. At each of these transition, there is an increase in the magnetic moment. Another weak anomaly at T ∼ 7 K with a reduction of moment for lower temperatures is observed in M(T). The MCE shows three positive anomalies at Tc = 70 K, Ts = 30 K, and To ≈ 20 K. The positive anomaly at Tc is expected as it is a ferrimagnetic transition. However, the transitions at Ts and To are antiferromagnetic transitions within the two Cr sublattices and therefore one would expect the magnetic entropy to increase on the application of a magnetic field and hence a negative MCE should be observed. The positive MCE anomalies at Ts and To are therefore unexpected and suggest some ferromagnetic component to the magnetic order below these temperatures. This is inconsistent with current understanding of the magnetic structures of this material 25,26 and will require further work to clarify. Additionally, the MCE shows a negative anomaly at ≈ 8:5 K which is close to the temperature at which a weak anomaly in M(T) is observed. This robust inverse MCE anomaly points to a hitherto unreported change in the magnetic or crystallographic structure. We point out that the To transition which has no accompanying features in bulk measurements like magnetic susceptibility or heat capacity, was first revealed by magneto-capacitance measurements18 and only later found by microscopic probes like neutrons26. Similarly, no heat capacity anomaly is observed at T = 8:5 K and further studies using microscopic probes will be useful to look for the possibility of a further magneto-structural change below 8:5 K. A scaling analysis of the ΔSM data near the various critical temperatures reveals that the transition at Tc is a second-order Mean field like transition, the transition at Ts is not second order and is non-mean field like.

Keywords: Magnetocaloric effect, double perovskite, scaling analysis

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References:

1. H. Jin Fan, M. Knez, R. Scholz, K. Nielsch, E. Pippel, D. Hesse, M. Zacharias, and U. Goesele, Nature Materials, 5, 627 (2006).
2. V. Franco, J. Blazquez, B. Ingale, and A. Conde, Annual Review of Materials Research 42, 305 (2012).
3. N. Mufti, A. A. Nugroho, G. R. Blake, and T. T. M. Palstra, Journal of Physics: Condensed Matter 22, 075902 (2010).
4. S. Lee, A. Pirogov, M. Kang, K.-H. Jang, M. Yonemura, T. Kamiyama, S.-W. Cheong, F. Gozzo, N. Shin, H. Kimura, Y. Noda, and J.-G. Park, Nature 451, 805 (2008).

5. M. Lapine, I. V. Shadrivov, D. A. Powell, and Y. S. Kivshar, Nature Materials 11, 30 (2011).
6. W. Eerenstein, N. D. Mathur, and J. F. Scott, Nature 442, 759 (2006).
7. M. Bibes and A. Barthelemy, Nature Materials 7, 425 (2008).
8. S.-W. Cheong and M. Mostovoy, Nature Materials 6, 13 (2007).
9. R. Ramesh and N. A. Spaldin, Nature Materials 6, 21 (2007).
10. T. Kimura, T. Goto, H. Shintani, K. Ishizaka, T. Arima, and Y. Tokura, Nature 426, 55 (2003).
11. M. Fiebig, T. Lottermoser, D. Meier, and M. Trassin, Nature Reviews Materials 1, 16046 (2016).
12. A. P. Ramirez, R. J. Cava, and J. Krajewski, Nature 386, 156 (1997).
13. S.-H. Lee, C. Broholm, W. Ratcliff, G. Gasparovic, Q. Huang, T. H. Kim, and S.-W. Cheong, Nature 418, 856 (2002).
14. P. G. Radaelli, Y. Horibe, M. J. Gutmann, H. Ishibashi, C. H. Chen, R. M. Ibberson, Y. Koyama, Y.-S. Hor, V. Kiryukhin, and S.-W. Cheong, Nature 416, 155 (2002).
15. W. H. Bragg, Nature 95, 561 (1915).
16. G. Ueno, S. Sato, and Y. Kino, Acta Crystallographica C 55, 1963 (1999)

Biography

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Multiwalled carbon nanotubes, Ferrites and graphene oxide composites for microwave shielding applications

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Abstract

To eliminate the increasing adverse effects of electromagnetic pollution in everyday life, the shielding abilities of ferrite nanoparticles, multiwalled carbon nanotubes, and graphene oxide based hybrid composites have been investigated. Zinc substituted nickel and cobalt ferrite nanoparticles synthesized by sol-gel method with average crystallite size of 15-20 nm and incorporated with MWCNT and MWCNT-GO in 1:1 weight ratio. Detailed investigations have been done for prepared nano-composites by using X-ray diffraction, scanning and transmission electron microscopy, Fourier-transform infrared spectroscopy (FTIR), thermogravimetric analysis, magnetic hysteresis loops, and vector network analyzer. The microwave shielding capacity of multiwalled carbon nanotube-zinc doped cobalt ferrite-graphene oxide hybrid composite was significantly enhanced up to 81.6 dB for the thickness of 2.4 mm in the X-band frequency region. Such a high SE indicates attenuation of the entire incoming EM radiation, which corroborates the potential of these materials in terms of high efficiency, tuneable, stability, and lightweight shielding applications. The synthesized MWCNT-CZFO-GO nano-composite was used as an absorbent and was incorporated to the cotton fabric, camouflage fabric, cement, and gypsum to prepare high-efficiency daily life radiation shielding applications. These incorporated shielding samples (52.3 dB for cement, 31.4 dB for gypsum, 40.8 dB for camouflage fabric, and 28.6 dB for cotton fabric) showed a high attenuation capacity with more than 99.999% attenuation of the incident EM radiations establishing a promising behavior to neutralize the harmful effects of radiations in day-to-day life.

Keywords: Electromagnetic Pollution, Saturation Magnetization, Microwave shielding

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Biography

Dr. Vivek Kumar Verma has completed his B.Sc. and M.Sc. from University of Lucknow, India. He has done his PhD in Physics at the age of 29 years from University of Delhi and National Physical Laboratory (CSIR), India. In 2009 he has joined Department of Physics, Hindu College, University of Delhi as an assistant Professor. Dr. Vivek Kumar Verma is lifetime member of Magnetic Society of India. He has supervised many Ph.D. students. His area of interest are nano magnetic materials, EMI shielding, ferroelectric materials and energy materials. He has published more than 50 papers in reputed journals and serving as an active member of scientific society.

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Magnetic properties of Hydrothermally Synthesized δ-MnO_2 Nanowhiskers

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Abstract

We report novel 2D monoclinic, $P6_3/mnm$, δ-MnO_2 nanowhiskers synthesized through a simple and facile hydrothermal route under the optimized condition without using any template. The X-ray diffraction pattern shows the formation of the δ phase of MnO_2 which is further confirmed from Fourier transform infrared spectroscopy (FT-IR) and Raman spectroscopy. Transmission electron micrograph reveals nanowhiskers of diameter ~7 nm and high-resolution TEM and SAED pattern demonstrate the interplanar spacing and distinguished diffraction rings corresponding to the monoclinic phase of δ-MnO_2 (Fig 1). Temperature dependent magnetization shows magnetic transition to paramagnetic phase at 13.2K which decreases to lower temperature with increasing the applied field (Figure 2). Temperature dependent susceptibility after fitted with Curie-Weiss law confirms the strong antiferromagnetic ordering and high effective magnetic moment than that of Mn^{4+} present in δ-MnO_2. A large effective magnetic moment is attributed to the presence of both Mn^{3+} and Mn^{4+} as confirmed from XPS. Reduced valency of Mn from 4 to 3 is accompanied with oxygen vacancies giving the exact composition as $MnO_{1.58}$. The dynamic magnetic properties of δ-MnO_2 nanowhiskers investigated using frequency-dependent ac susceptibility fitted with various phenomenological models like Vogel-Fulcher law and power law clearly gives an indication of the existence of the interacting spin clusters which freezes at ~ 11.2 K. Time dependence of thermoremanent magnetization, fitted well with stretched exponential function, supports the existence of relaxing spin clusters. Thus, spin glass relaxation in δ-MnO_2 nanowhiskers is attributed to the interaction between Mn^{4+} and Mn^{3+} which results in an intrinsic magnetic frustration and weak ferromagnetism with finite coercivity below T_f.

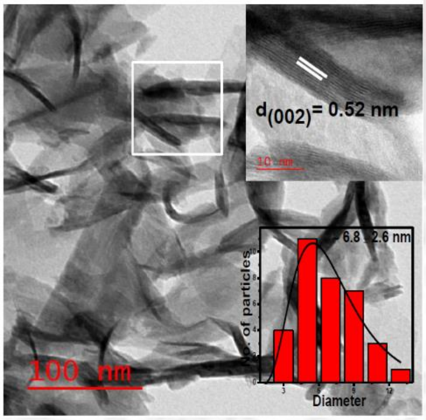
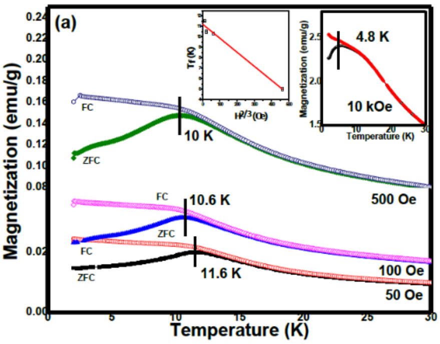


Figure 1: High resolution TEM with SAED pattern and size distribution graph

Figure 2: Temperature dependent magnetization measured under applied field og 50, 100 and 500Oe.

Inset shows M vs. T at 10 kOe and the field dependence of reduced temperature with the best fit in terms of A-T line.



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Study of magnetic and nonmagnetic specular layers in spin valve systems

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Abstract

Background/ Objectives and Goals

GMR based specular spin valve (SSV) has been identified as a promising system in a variety of linear device applications due to the scope of persistent improvement in performance. Though the phenomenon is highly beneficial, the complete understanding of relation between structural and magnetic properties is still deficient. In view of this scenario, the present study focuses the use of magnetic and nonmagnetic specular scattering material (SSM) to improve sensitivity, linearity, magnetic hysteresis, and temperature drifts.

Methods

Specular SV systems were sputter deposited on Si/SiO2 substrates with the form Seed/AFM/PL1/SSM/PL2/Cu/FL/SSM/Cap, the SSM was incorporated in the PL and on top of FL of conventional SVs to confine the electrons movement within the active scattering region. A magnetic SSM was formed at respective locations by exposing the ferromagnetic Co90Fe10 layer (PL1 and FL) to pure oxygen gas pressure for duration of 40 min in the load lock chamber without breaking the vacuum (termed as NOL-SSVs). While, non-magnetic MgO was deposited as SSM in MgO-SSVs, the barrier MgO layer was RF sputtered for a short duration. A detailed examination of structural and temperature dependent magnetoresistive behaviour is performed to understand the dependence of density of oxides on the characteristics of SSVs. Subsequently, a hypothesis is proposed to explain the discrepancy in the FM/oxide interface**.**

Expected Results/ Conclusion/ Contribution

Magnetic and magnetotransport characteristics of SSVs were studied in comparison with the convention SVs (CSV) to optimize the specular scattering effect. At the optimum O2 pressure (10-3 mbar) and MgO thickness (5 sec of sputter), it is seen that the MR ratio increased from 6.4 % to 10.25 %, confirms the specular effect. Despite similar MR enhancement, reversible minor loop characteristics and highest exchange bias of 625 G were important observations in MgO based system. From structural investigations, zero hysteresis behaviour was confirmed due to the reduction of grain growth of the stacks above the fine-textured MgO layer.

From the observed XRD and XRR data, we have postulated the possible scenarios of interface between SSM and FM. Due to higher surface roughness of FM layer (here it is PL1), a 3-dimensional FM/oxide core shell structure was suggested, where the outer shell represents the oxide layer and the inner core has FM properties. On the other hand, MgO as fine textured with few mono layers will be sitting on the top 2-dimensional surface, and due to its smaller grain size it may reduce the effective surface roughness. Therefore, improvement in the interface along with specular reflection confined in the active region yields enhanced spin-dependent scattering and hence higher MR ratio in both SSVs.

Keywords: spin valve GMR, spin dependent scattering, specular effect, hysteresis

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References:

[1]. P. P. Freitas, R. Ferreira, and S. Cardoso, “Spintronic Sensors,” Proceedings of the IEEE, vol. 104, p. 1894, 2016.

[2] J. Ventura, J. Araujo, J. Sousa, A. Veloso, and P. Freitas, “Influence of the domain structure of nano-oxide layers on the transport properties of specular spin valves,” J. Appl. Phys., vol. 101, p. 113901, 2007.

[3]. P. V. Sreevidya, U. P. Borole, T. Gawade, J. Khan, C. L. Prajapat, Y. Kumar, H. C. Barshilia, and P. Chowdhury, “MgO based specular spin valve with reversible minor loop and higher exchange bias for futuristic magnetic sensor,” J. Magn. Magn.Mater., vol. 486, p. 165292, 2019.

[4] P. V. Sreevidya, U. P. Borole, T. Gawade, J. Khan, C. L. Prajapat, Y. Kumar, H. C. Barshilia, and P. Chowdhury, “Evolution of magnetoresistance behavior at low temperatures in naturally oxidized specular spin valve systems,” J. Magn. Magn.Mater., vol. 481, pp. 170–175, 2019.

Biography

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Spin-induced Band-gap Opening in Strained Graphene

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Abstract

Background/ Objectives and Goals

Graphene exhibits remarkable electrical, optical, mechanical and thermal properties and is excellent for various technological applications [1-6]. However, Graphene is gapless material [7,8-11]. Strain-engineering modifies band-structure [12-21]. Also, electro-optic and thermo-mechnaical properties of Graphene exhibit subtle dependence on strain. E.g. helical or tube-like Graphene structures under torsion and corrugated sheets under uniaxial compression show remarkable variation in thermal conductivity [22]. Moreover, mechanical properties of Graphene are suitable for strain-engineering. E.g.: high intrinsic strength (Young's Modulus ~ 1.1TPa) [23], capacity to withstand high reversible elastic tensile strain (>20%) [24], etc. Therefore, this talk describes straintronics-based solution for gap-opening in Graphene. Strain alone does not suffice. Strong interplay between strain and magnetic effects, i.e. spin, in Graphene suggests a combination of strain- and spin-engineering will be a perfect solution for gap-opening.

Methods

Till date a few technologies have been proposed:
1) Substrate-induced band-gap opening
2) Gap-opening due to chemical substitution doping
3) Graphene hybrids
4) Graphene-Nano-Ribbons (GNRs)
5) Gap-opening by patterning Graphene
6) Graphene-origami

However, all such techniques suffer from the unacceptable drawback of low carrier mobility. On the otherhand, mass-less fermions [25,26,27] and room temperature quantum-Hall effect [27-30] of Graphene renders this 2D-material particularly suitable for spin-engineering. Therefore, this research aims at gap-engineering of Graphene through spintronics. Interaction of electronic properties of Graphene with strain depends heavily on symmetry. First principles calculations predict asymmetrically distributed strain is effective for band-gap opening in Graphene. Moreover, Density-Function-Theory (DFT) calculations show asymmetric biaxial strain, compression (-20%) in armchair- and tension (11%) in zigzag-directions, results in band-gap of up to 1eV [31]. However, DFT calculations for Armchair-Graphene-Nano-Ribbons (AGNRs) show ferromagnetic to non-magnetic transition under tensile strain in armchair direction [32]: a) monoloyer: 11%, b) bilayer: 3% and; c) trilayer: 2%, due to reduction of spin-polarization along armchair edges and subsequent decrease in spin-splitting at Fermi level. Increased strain results in steady decline of spin-moment. Strain-dependence of magnetic properties in Graphene is evident from Molecular Dynamics (MD) study, Large-scale- Atomic/Molecular-Massively-Parallel-Simulator (LAMMPS) [33]. Results are supported by Scanning-Tunneling-Microscopes (STMs) observations. Experiments reveal that strain-engineering of Graphene-nano-structures result in charging effects and pseudo magnetic fields in monolayers [33].

Expected Results/ Conclusion/ Contribution

Entanglement between strain and magnetic properties has been analyzed and suitably engineered for band-engineering in Graphene.

Keywords: Graphene, Spintronics, Straintronics, Band-gap opening, Dirac material

References:

1. R. Sun, Y. Zhang, K. Li, C. Hui, K. He, X. Ma and F. Liu, Appl. Phys. Lett., 2013, 103, 013106.
2. L. P. Biró, P. Nemes-Incze and P. Lambin, Nanoscale, 2012, 4, 1824–1839.
3. Z. Wang and F. Liu, Nanoscale, 2011, 3, 4201–4205.
4. Castro Neto, A. H., Guinea, F., Peres, N. M. R., Novoselov, K. S. & Geim, A. K. The electronic properties of graphene. Rev. Mod. Phys. 81, 109–162 (2009).
5. Schwierz, F. Graphene transistors. Nature Nanotech. 5, 487–496 (2010).
6. Novoselov, K. S. et al. Roadmap for graphene. Nature 490, 192–200 (2012).
7. Geim, A. K. & Novoselov, K. S. The rise of graphene. Nature Mater. 6, 183–191(2007).
8. Novoselov, K. S. et al. Roadmap for graphene. Nature 490, 192–200 (2012).
9. Novoselov, K. S. et al. Two-dimensional gas of massless Dirac fermions in graphene. Nature 438, 197–200 (2005).
10. K. S. Novoselov, Z. Jiang, Y. Zhang, S. V. Morozov, H. L. Stormer, U. Zeitler, J. C. Maan, G. S. Boebinger, P. Kim and A. K. Geim, Science, 1137201 (2007).
11. Miller, D.L., Kubista, K.D., et al.: Observing the Quantization of Zero Mass Carriers in Graphene. Science. 324, 924 (2009).

12. Sulagna Chatterjee and M. Mukherjee, "Strained Si/Si1-yCy Superlattice based Quasi-Read Avalanche Transit-Time Devices for Terahertz Ultrafast Switches", Applied Physics A, Volume: 127: 155, 2021, https://doi.org/10.1007/s00339-020-04187-w. (impact factor:1.82), Electronic ISSN:1432-0630, Print ISSN:0947-8396
13. Sulagna Chatterjee and M. Mukherjee, "Direct band gap silicon nanowire avalanche transit time thz opto-electronic sensor with strain-engineering", Optical and Quantum Electronics, Volume: 52:488, 2020, https://doi.org/10.1007/s11082-020-02563-7. (impact factor: 1.842). Electronic ISSN: 1572-817X, Print ISSN:0306-8919
14. Sulagna Chatterjee and M. Mukherjee, "Strain-Engineered Asymmetrical Superlattice Si/Si1-xGex Nano-ATT ⟨p++-n-n$^-$-n++⟩ Oscillator: Enhanced Photo-Sensitivity in Terahertz Domain", IEEE Transactions on Electron Devices, Volume 66, Issue 8, pp. 3659 – 3667, July 2019, DOI:10.1109/TED.2019.2923108. (impact factor: 2.704), ISSN: 0018-9383
15. Sulagna Chatterjee, S. Sikdar, B. N. Chowdhury and S. Chattopadhyay, "Investigation of the performance of strain-engineered silicon nanowire field effect transistors (ε-Si-NWFET) on IOS substrates", Journal of Applied Physics, Vol. 125, pp. 082506, 2019, https://doi.org/10.1063/1.5051310. (impact factor: 2.328), Print ISSN: 0021-8979, Online ISSN: 1089-7550.
16. Sulagna Chatterjee and S. Chattopadhyay, "Fraction of Insertion of the Channel-Fin as Performance Booster in Strain-Engineered p-FinFET Devices with Insulator-on-Silicon (IOS) Substrate", IEEE Transactions on Electron Devices, Vol. 65, Issue. 2, pp. 411 – 418, 2018, DOI: 10.1109/TED.2017.2781264. (impact factor: 2.605), ISSN: 0018-9383
17. Sulagna Chatterjee and S. Chattopadhyay, "Analytical modeling of the lattice and thermo-elastic coefficient mismatch-induced stress into silicon nanowires horizontally embedded on insulator-on-silicon substrates", Superlattices and Microstructures, Vol. 101, pp. 384-396, Jan. 2017, https://doi.org/10.1016/j.spmi.2016.12.001. (impact factor: 2.123). ISSN: 0749-6036
18. Sulagna Chatterjee and S. Chattopadhyay, "Modeling and estimation of process-induced stress in the nanowire field-effect-transistors (NW-FETs) on insulator-on-silicon substrates with high-k gate-dielectrics", Superlattices and Microstructures, Vol. 98, pp. 194-202, Oct. 2016, https://doi.org/10.1016/j.spmi.2016.08.022. (impact factor: 2.123), ISSN: 0749-6036.
19. Sulagna Chatterjee, B. N. Chowdhury, A. Das and S. Chattopadhyay, "Estimation of step-by-step induced stress in a sequential process integration of nano-scale SOS MOSFETs with high-k gate dielectrics", Semiconductor Science and Technology, Vol. 28, pp. 125011, Nov. 2013.(impact factor:1.92), https://doi.org/10.1088/0268-1242/28/12/125011, Online ISSN: 1361-6641, Print ISSN: 0268-1242.
20. D. Chakraborty, Sulagna Chatterjee and M. Mukherjee, "Hybrid Multi-Graphene/Si Avalanche Transit Time< h-ATT> Terahertz Power Oscillator: Theoretical Reliability and Experimental Feasibility Studies", IEEE Transactions on Device and Materials Reliability, Volume: 20, Issue: 4, pp.: 667 - 677, 2020. (impact factor: 1.407), 10.1109/TDMR.2020.3018664. Electronic ISSN: 1558-2574, Print ISSN: 1530-4388.
21. M. Mukherjee and Sulagna Chatterjee, "Millimeter-Wave High-Low IMPATT Source Development: First On-Chip Experimental Verification", Electronics Letters, accepted November, 2020, (impact factor: 1.316), https://doi.org/10.1049/ell2.12058. Online ISSN 1350-911X, Print ISSN 0013-5194
22. N. Wei, L. Xu, H.-Q. Wang and J.-C. Zheng, Nanotechnology 22 (2011) 105705.
23. C. Lee, X. D. Wei, J. W. Kysar and J. Hone, Science 321 (5887), 385 (2008).
24. C. Si, Z. Suna and F. Liu, Nanoscale, 2016, 8, 3207.
25. Castro Neto, A. H., Guinea, F., Peres, N. M. R., Novoselov, K. S. & Geim, A. K. The electronic properties of graphene. Rev. Mod. Phys. 81, 109–162 (2009).
26. Novoselov, K. S. et al. Two-dimensional gas of massless Dirac fermions in graphene. Nature 438, 197–200 (2005).
27. K. S. Novoselov, Z. Jiang, Y. Zhang, S. V. Morozov, H. L. Stormer, U. Zeitler, J. C. Maan, G. S. Boebinger, P. Kim and A. K. Geim, Science, 1137201 (2007).
28. Miller, D.L., Kubista, K.D., et al.: Observing the Quantization of Zero Mass Carriers in Graphene. Science. 324, 924 (2009).
29. Stander, N., Huard, B., Goldhaber-Gordon, D.: Evidence of Klein tunneling in graphene pn junctions. Phys. Rev. Lett. 102, 026807 (2009).
30.Bolotin, K.I., Sikes, K.J., Hone, J., et al.: Temperature-Dependent Transport in Suspended Graphene. Phys. Rev. Lett. 101, 096802 (2008).
31. N. Kerszberg and P. Suryanarayana, RSC Adv., 2015, 5, 43810, Doi: 10.1039/c5ra03422a.
32. L. Yang and D. Diao, AIP Advances 5, 127106 (2015); https://doi.org/10.1063/1.4937434.
33. N. C. Yeh, C. C. Hsu, M. L. Teague, J. Q. Wang, D. A. Boyd, C. C. Chen, Acta Mech. Sin. Doi: 10.1007/s10409-015-0548-9.

Biography

Dr. Sulagna Chatterjee has five years of teaching experience as Assistant Professor, ECE. She has obtained her Ph.D. (Tech.) degree in Nano-Science and Nano-Technology, in April, 2019 from University of Calcutta. She won many prestigious fellowships for her Ph.D.: CSIR SRF (Govt. of India), DST INSPIRE Fellowhip (Govt. of India) and I.I.T. Institute Fellowship, Dept. of ECE (I.I.T. Kharagpur). She did her M.Tech. in Radio Physics and Electronics from University of Calcutta, where she stood FIRST CLASS FIRST and was AWARDED GOLD MEDAL. She was AWARDED for OUTSTANDING ACADEMIC EXCELLENCE by scoring a CGPA of 9.09. She did M.Sc. with 79.67% in Electronic Science from University of Calcutta. She has received National MERIT scholarship from Govt. of India. Her research area is nanoscale quantum-confined strain-modeling. She is reviewer and editorial board member for many esteemed international SCI journals with high IFs. She has been awarded "EXCELLENT REVIEWER" in 2020. She has been awarded in various categories: Young Achiever, Research Excellence, Academic Excellence and Best Teacher for 2020. She has been INVITED and VISITED several times to UK, Italy, USA, Japan etc. as an EXPERT and INVITED SPEAKER. She has 20 international research papers: among them 8 high impact SCI Journals (as First author, including two IEEE TED).

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Relationship between roughness and magnetic properties of thin films

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Abstract

We study the influence of film's roughness on the magnetic properties of Ag-Co thin films and reveal possible reasons for the feature evolution with film thickness from the aspect of microstructure. Finding a correlation between film thickness and magnetic property is of significance to achieve optimal combination of performance and cost, which will be advantageous to further industrial usage of Ag-Co films. In this work, Ag-Co films with different thickness are prepared by electrodeposition technique. The crystalline structure of Ag-Co films was characterized by XRD and results showed that the Ag-Co films was single phase fcc Ag and despite the strong tendency of Ag-Co system for phase separation, neither fcc or hcp Co was seen in all films. The evolution of the Ag-Co surface with various film thicknesses was studied using atomic force microscopy. The results showed that the surface growth of the Ag-Co thin films has an intrinsic anomalous scaling behavior that were evaluated with a set of local exponents $\alpha_{loc}=0.72\pm0.06$ and $\beta_{loc}=0.25\pm0.06$, and global ones, $\alpha= 1.69\pm0.05$ and $\beta=0.61\pm0.05$. The in-plane and out-of-plan magnetic properties of Ag-Co thin films were measured by VSM. No considerable anisotropy was seen, and no clear difference was observed in the shape of hysteresis loops obtained in the in-plane and out-of-plan direction. The loops become narrower with increasing the film thickness. It was found that the thicker films have less squareness compared with the thinner ones. In-plan demagnetizing factor increased with thickness (growth time) as a power-law and reaches to the value of of 0.17. This value confirmed our dynamic scaling results. The results showed that the coercivity of Ag-Co films decrease with the film thickness while the local slope increased with the film thickness. It is concluded that thin film growth mechanisms and surface roughness can have sturdy effect on magnetic features of thin films.

Keywords: Magnetic property, Surface roughness, Power spectral density, Film thickness, demagnetizing factor.

Acknowledgement: This work is financially supported by Iran National Science Foundation

Biography

Maryam Nasehnejad has completed her PhD at the age of 32 years from University of Arak (Iran). She is post-doctoral position at University of Arak. She has published 8 papers in reputed journals. Her favorite researches are surface evolution, thin films, fractals, magnetic properties.

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Parametric Resonances in Ferromagnetic Systems Revisited

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Abstract

The basic task of magnetic dynamics is to study the frequencies and relaxations of magnetic excitations (spin waves). The advent of Suhl's pioneer paper [1] placed parametric resonance of spin waves in a microwave field as one of the primary methods for studying the dynamic properties of ferro- and antiferromagnets. Parallel pumping [2,3], in which a microwave field modulates a parallel static magnetic field applied to a sample, is the most common method of
parametric spin-wave excitation. Historically, parallel pumping considered only the case of main resonance when the pump field excites a spin wave pair of half-frequency each $\omega p/2$
$= \omega k = \omega{-k}$ with oppositely directed wave vectors [4-6]. Using the general theoretical approach developed for a harmonic oscillator [7], we calculated the thresholds of parametric resonances of all orders n=1,2,3,... for 1) a ferromagnetic single-domain particle $n\omega p = 2\omega 0$ and 2) for ferromagnetic bulk and thin film samples $n\omega p = \omega k + \omega{-k}$ [8]. The ratio of thresholds of different orders can be expressed by the following formula:

$$\frac{h_c^{(n)}}{h_c^{(1)}} \approx \frac{1}{n}(n!)^{1/n}\left(\frac{\omega_k}{\eta_k}\frac{|B_k|}{A_k}\right)^{1-1/n} \xrightarrow[n\to\infty]{} 0.37\frac{\omega_k}{\eta_k}\frac{|B_k|}{A_k},$$

where ηk is the damping, *A*k and *B*k are the coefficients of the quadratic form of spin deviations. The critical amplitudes, in principle, can be attained even if the frequency of the parametric resonance is smaller than the FMR frequency or frequency of the spin-wave pair.
Parametric resonances are excited exponentially quickly and force the magnetic system to adapt to new states. The study of these adapted states is of interest for the development of microwave devices. The modulation method in parametric resonance of spin waves [6] is a universal tool for studying the adaptation of the magnetic systems to powerful microwave signals.
Keywords: Parametric resonance, parallel pumping, spin-wave pair, single-domain grain

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References:
1. H. Suhl, J. Phys. Chem. Solids 1, 209 (1957).
2. F.R. Morgenthaler, J. Appl. Phys. 31, 95 S (1960).
3. E. Schlömann, J.J. Green, U. Milano, J. Appl. Phys. 31, 386 S (1960).
4. V.S. L'vov, Wave Turbulence under Parametric Excitation, Springer-Verlag, Berlin, 1994.
5. A.G. Gurevich, G.A. Melkov, Magnetization Oscillations and Waves, CRC Press,
Boca Raton, 1996.
6. V.L. Safonov, Nonequilibrium Magnons, Wiley-VCH, Weinheim, 2012.
7. V.L. Safonov, M.E. McConney, and M.R. Page, Phys. Rev. E 100, 040201(R) (2019).
8. V.L. Safonov, M.E. McConney, and M.R. Page, J. Magn. Magn. Mater. 490, 165486 (2019).

Biography

Vladimir L Safonov received the M.Sc. degree in physics from the Moscow Institute of Physics and Technology in 1978, the Ph.D. and D.Sc. degrees from the National Research Center "Kurchatov Institute" (Russia) in 1984 and 1992, respectively. His main research interests lie in the field of magnetic and magnetoelastic dynamics in ferro- and antiferromagnetic systems. He authored and co-authored more than 130 papers. He is author of the book "Nonequilibrium Magnons". In the present time Dr. Safonov has a fellowship from NRC at the Air Force Research Laboratory.

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