advanced nanomagnetism workshop

7-9 February 2017

Scientific workshop organized by FunMagMa will be held **from 7 to 9 February.**
Location: STP "Fabrika", auditorium №301.

Invited Speakers: Dr. Gaspare Varvaro (GV), Dr. Sara Laureti (SL) and Dr. Davide Peddis (DP) from Nanostructured Magnetic Material Lab (Rome, Italy).

Poster session: All students, PhD-students and researchers are invited to take part at poster session in order to discuss their scientific work with great researchers.

Tuesday 7 Feb. "Tutorials"	**Wednesday 8 Feb.** "Seminars"	**Thursday 9 Feb.** "Colloquium and discussion"
15:00 Opening ceremony	15:00 GV: Angle and transverse DC magnetic measurements of thin films	17:00 SL: Correlation between chemical order and magnetic properties
15:15 GV: Magnetic thin films and heterostructures	15:40 DP: Supermagnetism	18:00 Poster Session
16:15 DP: Design of Magnetic nano-architecture	16:20 DP: Magnetic Nanoparticles in nature	
	17:00 SL: EXAFS study of magnetic metallic alloys	

FunMagMa 5100 Immanuel Kant Baltic Federal University

Dr. GASPARE VARVARO

bio-sketch

Gaspare Varvaro (PhD in Material Science 2007, University “La Sapienza” of Roma, Italy) works as research at the National Research Center (Italy) since 2010. He is member of the Nanostructured Magnetic Material Lab (ISM – CNR) and head of the thin film deposition lab since 2015. His interests span from the fabrication to the characterization of magnetic and magneto-transport properties of nanostructured magnetic materials including single-phase, magnetic composites and hybrid/multifunctional systems (thin films, multilayers, nanoparticles and nano-patterned systems) for fundamental studies and applications (information storage, energy, sensors, biomedicine). His research activity is witnessed by about 40 papers, 2 book chapters and more than 100 contributions to national and international conferences and workshops. He is co-editor of a book titled “Ultra-High-Density Magnetic Recording: Storage Materials and Media Designs” (Pan Stanford Publishing, 2015). He has been visiting scientist in many international labs (Un. Augsburg, IKBFU, CONICET, Un. Delaware, Trinity College of Dublin and CNRS-Lab. Louis Néel) and has been involved in several national and EU projects. He regularly serves as referee for international journals and independent expert evaluator for international projects and has been member of the organizing, program and scientific committees of several conferences. Also, he has been involved in teaching and didactic activities for high-school students, PhD students, post-graduates and research professionals in the area of magnetism.

Dr. SARA LAURETI

bio-sketch

Sara Laureti is graduated in Chemistry (110/110 cum laude) at the University of Rome "La Sapienza" (2004), with a thesis titled “Pulsed Laser Deposition and structural, microstructural and magnetic characterization of nanostructured film for high density magneto-recording”. She has got a PhD in Material Science at University of Rome “La Sapienza” (2007) with a thesis titled “Magnetic anisotropy in Co-based thin films”, the research activity being carried out at ISM-CNR (supervisor: E. Agostinelli), where she’s currently working as Permanent Researcher. Since the beginning of her scientific career, during the preparation of the PhD thesis, her work was devoted to the study of magnetic materials modulated at the nanoscale for important technological applications. In particular, she was involved in a many National and European Projects (among them, the EU “Self assembled nanoparticles and nanopatterned arrays for high density magnetic recording” which was awarded by the Descartes Prizes for “Excellence in Collaborative Research”). Moreover, due to an Erasmus fellowship, Sara spent six months at the Institute Néel, in Grenoble (Supervisor D. Givord) studying the effects of the size confinement in magnetically exchange coupled systems. She was the coordinator of a national FIRB project entitled “Tailoring the magnetic anisotropy of nanostructures for enhancing the magnetic stability of magnetoresistive devices” and was the principal investigator of a 2-years BAG project at the EXAFS beamline (LISA, ESRF, Grenoble) titled “Correlation between atomic ordering and magnetic properties in binary magnetic alloys”. She is author of about 30 papers on ISI journals and conference proceedings, focused on the fabrication and study of the magnetic properties of nanostructured thin films and multilayers, nanoparticles and patterned systems.

Dr. DAVIDE PEDDIS

bio-sketch

Davide Peddis (DP) graduated magna cum laude in Physical Chemistry (2003) and obtained his PhD in Physical Chemistry (2007) at the University of Cagliari. In the years 2007-2009 he worked as Research Fellow at University of Cagliari and at ISM – CNR. Research activity of DP is developed in the framework of Solid State Physical-Chemistry and Condensed Matter Physics, studying the relationship between physical properties, crystalline structures and morphological features of magnetic nano–hetero-structures (nanoparticles, particles embedded in matrix, core shell structures, hollow nanoparticles, anisometric particles). Particular attention has been devoted to the investigation of fundamental properties of magnetic nanoparticles (static and dynamical properties) with particular interest in materials for applications in biomedicine (MRI, drug delivery, hyperthermia), catalysis, and energy field (permanent magnets, hydrogen production). DP research activity is presented over 70 peer reviewed papers (google scholar citations: 1285; h-index:18) in the period 2006-2017 and 5 book chapter. DP personally given 34 Invited talks and 33 oral communication. DP has been co-supervisor of 1 master students, 1 PhD student, 3 post-docs 3 researcher in formation and he was also appointed for one international PhD committee. DP won as principal investigator several national and international competitions for research mobility, experiments at large scale facilities and research projects. Now DP is responsible of the Italian unit of the FET-Proactive Project, MAGnetic nanoparticle based liquid ENergy materials for Thermoelectric device Apllications (MAGENTA) [2016-2020, Total Budget 5 million of euro ; CNR budge: 720 Keuro]. In addition DP is also appointed as Senior Scientist at Vinca Institute (Belgrade, Serbia) in the framework of FP7 – EU project. In this context, he is team leader for synthesis and functionalization of magnetic nanoparticles for biomedical application.

"Magnetic thin films and heterostructures"

GASPARE VARVARO

Magnetic thin films and multilayer heterostructures are the most extensively studied magnetic systems with nanoscopic dimensions. In addition to their interest in fundamental physics, magnetic thin films and heterostructures have been exploited for a number of different applications in particular in the fields of magnetic recording and spintronics. The research field has grown to such an extent in the last decades that only a general overview will be given in this lecture. After the introductory remarks, the preparation and characterization techniques, including also lithographic methods for the fabrication of laterally confined systems, will be presented, with a special emphasis given to physical deposition methods and magnetometry techniques. Next, the magnetic anisotropy, the magnetic domain structure and some aspects related to the reversal mechanism will be covered. Finally, the properties of thin film heterostructures combining magnetic layers in direct contact (direct exchange coupling – exchange bias and exchange coupled systems –) or separated by a non-magnetic spacer (indirect exchange coupling – antiferromagentically coupled systems, GMR effect) will be illustrated. Some examples of applications of thin films and heterostrucures will be also illustrated across the entire lecture.

“Angle and transverse DC magnetic measurements of thin films”

GASPARE VARVARO

Magnetic thin film systems have attracted a great deal of attention in the last decades for both fundamental studies and applications because their magnetic properties can be strongly modulated by changing the thickness and the materials parameters, the crystalline structure and morphology or by exploiting the layering and coupling with different materials (both magnetic and non magnetic). Studying the magnetic properties is of crucial importance not only for fundamental studies but also to optimize the material properties for specific applications. In addition to the most common field-dependent magnetization loop and temperature-dependent measurements, advanced measures are generally needed for a thoroughly investigation of the magnetic behavior. In this seminar, both angle and transverse DC magnetic measurements will be discussed, as powerful tools to investigate the symmetry and magnitude of the magnetic anisotropy as well as the magnetization reversal mechanism in thin films and heterostructures[1-6].

<u>Reference:</u>

1. Th. Speliotis, G. Giannopoulos, D. Niarchos, W.F. Li,, G. Hadjipanayis, G. Barucca , E. Agostinelli, S. Laureti, D. Peddis, A. M. Testa and G. Varvaro, J. Appl. Phys., 119, 233904 (2016)

2. G. Varvaro, D. Peddis, G. Barucca, P. Mengucci, V. Rodionova, K. Chichay, A. M. Testa, E. Agostinelli and S. Laureti, ACS Adv. Mat. Int. 7, 22341 (2015)

3. D.K. Ball, K. Lenz, M. Fritzsche, G. Varvaro, S. Gunther, P. Krone, D. Makarov, A. Mucklich, S. Facsko, J. Fassbender and M. Albrecht, Nanotechnology 25, 085703 (2014)

4. G. Varvaro, A.M. Testa, E. Agostinelli, D. Fiorani, S. Laureti, F. Springer, C. Brombacher, M. Albrecht, L. Del Bianco, G. Barucca, P. Mengucci, D. Rinaldi, Mat. Chem Phys. 141, 790 (2013)

5. G. Varvaro, F. Albertini, E. Agostinelli, F. Casoli, D. Fiorani, S. Laureti, P. Lupo, P. Ranzieri, B. Astinchap and A.M. Testa, New J. Phys. 14, 073008 (2012)

6. G. Varvaro, E. Agostinelli, S. Laureti, A.M. Testa, J.M. García-Martin, F. Briones and D. Fiorani, J. Phys. D: Applied Physics 41 134017 (2008)

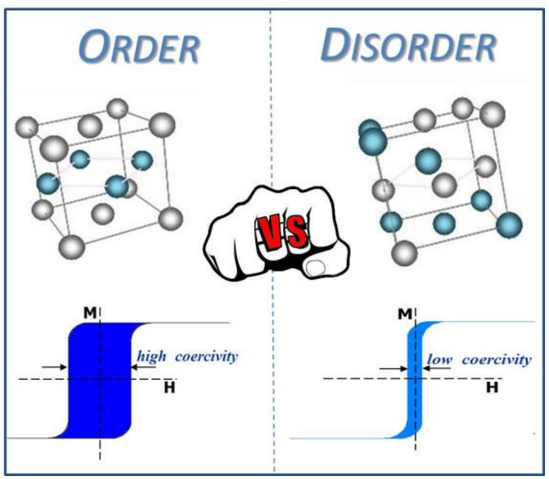
colloquium

"Correlation between chemical order and magnetic properties"

SARA LAURETI

Nowadays, the development of new advanced technologies in the field of information storage and electronic devices requires a great effort in improving the performance of magnetic materials that are at the basis of the device's functioning. Among the magnetic materials, chemically ordered binary alloys are of significant interest due to their peculiar atomic arrangement within the crystallographic cell, which induces in the material, through the spin-orbit interaction, a high magnetocrystalline anisotropy.

The colloquium is aimed at getting inside the matter, exploring the atomic arrangement within typical magnetic materials and elucidating the role of the chemical order on their magnetic behaviour.



Examples of different synthesis strategies and characterization approaches will be illustrated in order to show the influence of specific process conditions (growth and annealing temperature, addition of a third element) on the transformation from a low anisotropy chemically disordered state (fcc structure) to the high anisotropy chemically ordered structure (fct or fcc L10, L12). Among the characterization techniques applied to investigate the structural properties at the local-scale, X-ray Absorption Spectroscopy (XAS) represents an effective tool to investigate the local structural properties in many systems whose behaviour is strongly affected by the atomic arrangement, thus providing useful guidelines for the samples' optimization for specific technological applications.

“EXAFS study of magnetic metallic alloys”

SARA LAURETI

The aim of this seminar is to present an Extended X-ray Absorption Fine Structure (EXAFS) study carried out for defining experimental preparation conditions for the highly anisotropic L1o-chemically ordered FePt phase with addition of a third element (Cu). In particular, EXAFS of ternary Fe–Pt–Cu alloys with different Cu content have been acquired at the Cu K and Pt LIII edges in order to describe the local environment around these elements in the Fe–Pt–Cu samples and to compare the structural evolution as a function of the Cu content. The EXAFS study, based on a substitutional model where the Cu atoms occupy Fe or Pt sites in the tetragonal structure, has been performed by using linear dichroism to enhance the sensitivity to differently oriented bonds and to gain a detailed description of the atomic environment. The study allowed the effects on the chemical order and lattice distortion induced by the Cu atoms to be distinguished experimentally. The determined positions of the Cu atoms in the chemically L1o-ordered face-centred tetragonal lattice were correlated with the magnetic properties of Fe–Pt–Cu ternary alloys. In particular, the main effect of Cu atoms in the alloy is a linear reduction of the c/a ratio, while the nonmonotonic behaviour of the chemical order is consistent with the variation of the magnetocrystalline anisotropy.

<u>Reference:</u>

S. Laureti et al. J. Appl. Cryst. 47, (2014) 1722

"Design of Magnetic nano-architecture"

DAVIDE PEDDIS

A physical property depends on the size of an object, if its size is comparable to a dimension relevant to that property. In magnetism typical sizes – as for example the dimension of magnetic domains or lengths of exchange coupling interaction - are in the nanometer range. For this reason, starting some decades ago, great attention has been directed towards nanostructured magnetic materials where constituent phase or grain structures are modulated on a length scale from 1 to 100 nm. In particular magnetic iron oxide nanoparticles with spinel structure have generated much interest because of their application, ferrofluid technology, catalysts and biomedicine (drug delivery, contrast enhanced, MRI, Hyperthermia).

After a brief introduction on the fundamental concept of magnetism at the nanoscale the correlation between crystalline structure, morphology and magnetic properties relevant to several applications will be discussed[1–3].

<u>Reference:</u>

1. D. Peddis. in Magn. Nanoparticle Assem. (Trohidou, K. N.) 7, 978–981 (Pan Stanford Publishing, 2014).
2. C. Cannas, and D. Peddis. Design of Magnetic Spinel Oxide Nanoarchitetures. La Chim. e l'industria (2012).
3. L. Suber, and D. Peddis. in Nanomater. life Sci. (Kumar, C. S. S. R.) 4, 431475 (Wiley, 2010).

seminar

"Supermagnetism"

DAVIDE PEDDIS

Among nanostructured magnetic materials, nanoparticles are unique complex physical objects. In fact, at the nanoscale, a multidomain organization is energetically unfavorable and single magnetic domain particles are formed. A magnetic monodomain particle can be considered as a "superspin" with a magnetic moment, depending on the particle volume, in the range of 10^3–10^5 μ_B. Depending on the type (e.g. dipolar interaction, exchange interaction) and the strength of the interactions among the magnetic entities, the magnetic behaviour of an assembly of superspins evolves from ferromagnetic (FM)-like behaviour to paramagnetic-like behaviour, through spin glass like behaviour. Due to the enhanced time and magnetization scale with respect to atomic systems, the suffix super has been used to define these magnetic states, for example, superferromagnetism (SFM) superparamagnetism (SPM) and superspinglass (SSG). Then the magnetism of nanoparticle assemblies has been often called supermagnetism[4,5]. In this contest, non-equilibrium magnetization dynamics of (bi)-magnetic nanoscaled systems will be discussed in detail[6–9].

<u>Reference:</u>

4. S. Bedanta, and W. Kleemann. Supermagnetism. J. Phys. D. Appl. Phys. ***42,*** *13001 (2009).*

5. D. Peddis, P.E. Jonsson, G. Varvaro, and S. Laureti. in Nanomagnetism Fundam. Appl. (Binns, C.) 129–189 (Elsevier B.V, 2014).

6. D. Fiorani, and D. Peddis. Understanding Dynamics of Interacting Magnetic Nanoparticles: From the Weak Interaction Regime to the Collective Superspin Glass State. J. Phys. Conf. Ser. ***521,*** *12006 (2014).*

7. D. Peddis, M. Vasilakaki, K.N. Trohidou, and D. Fiorani. Dynamics in Superspin Glass Systems. IEEE Trans. Magn. ***50,*** *6–9 (2014).*

8. D. Peddis, M.T. Qureshi, S.H. Baker, C. Binns, M. Roy, S. Laureti, D. Fiorani, P. Nordblad, and R. Mathieu. Magnetic Anisotropy and Magnetization Dynamics of Fe Nanoparticles Embedded in Cr and Ag Matrices. Philos. Mag. ***6435,*** *1–10 (2015).*

9. G. Margaris, M. Vasilakaki, D. Peddis, K.N. Trohidou, S. Laureti, C. Binns, E. Agostinelli, D. Rinaldi, R. Mathieu, and

“Magnetic Nanoparticles in nature”

DAVIDE PEDDIS

Magnetic nanoparticles (MPs) play an important role in nature, as they are commonly found in soils, sediments and rocks and may store information on the past Earth’s magnetic field as well as environmental conditions at the time of sediment deposition. Magnetic NPs are in several ways also important for the functioning of living organisms that, in several cases, utilize the magnetism of the particles themselves. This seminary will give a short overview on this topic, with particular attention to magnetic properties of Fe_3O_4 nanoparticles produced by magnetotactic bacteria[10].

Reference:

10. D. Peddis, G. Muscas, R. Mathieu, P.A. Kumar, G. Varvaro, G. Singh, I. Orue, D. Gil-Carton, L. Marcano, A. Muela, and M.L. Fdez-Gubieda. Studying Nanoparticles’ 3D Shape by Aspect Maps: Determination of the Morphology of Bacterial Magnetic Nanoparticles. Faraday Discuss. 0, 1–12 (2016).