MA 31: Magnetic Particles and Clusters I

Time: Thursday 10:15–13:00 Location: HSZ 401

MA 31.1 Thu 10:15 HSZ 401

Direct characterization of the superparamagnetic-ferromagnetic transition of single nano-islands — •Guillemin Rodary, Sebastian Wedekind, Hirofumi Oka, Dirk Sander, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120, Halle, Germany

The transition from a superparamagnetic to a ferromagnetic state is studied on single Co nano-islands by spin-polarized scanning tunneling spectroscopy. Magnetic hysteresis loops of the local differential conductance on individual island are measured [1] as a function of the size of the nanostructure and of the temperature. A clear transition of magnetic response from a hysteresis free to a hysteretic behavior due to magnetization direction switching [1] is observed when increasing the island size. This is ascribed to the superparamagnetic to ferromagnetic transition. The same transition is demonstrated to be also accessible by decreasing the temperature and crossing the blocking temperature. We find a blocking temperature of 10 K for an island of 1010 atoms. We discuss these experimental results in the perspective of a simple model of thermally activated magnetization switching that allows quantitative finding of local magnetic anisotropy.

[1] G. Rodary, S. Wedekind, D. Sander, and J. Kirschner, JJAP (in press)

MA 31.2 Thu 10:30 HSZ 401

Size-selected supported ferromagnetic clusters: correlation of structural and magnetic properties — •Wolfgang Rosellen[1], Furkan Bulut[1,2], Christian Kleinhans[1], R. Kerstin Gebhardt[1], Joachim Bansmann[2], Armin Kleibert[3,4], Karl-Heinz Meiwes-Broer[3], and Mathias Getzlaff[1] — [1]Institute of Applied Physics, University Düsseldorf — [2]Dep. of Surface Chemistry, University Ulm — [3]Institut of Physics, University Rostock — [4]now Paul Scherrer Institute, Switzerland

The bulk and thin film behaviour of softmagnetic materials have extensively been studied in the past. Concerning the increase of density in magnetic data storge systems magnetic clusters become interesting because of their particular size dependence of electronic and magnetic properties. We report on the magnetic properties of size-selected clusters, deposited on bare W(110) and on a thin Ni(111)/W(110) film system, by the element specific XMCD spectroscopy allowing the determination of spin and orbital moments. The crystalline nanoparticles consist of pure Fe and Co as well as an FeCo alloy and exhibit tunable diameters between 5-15 nm. The clusters are produced using an UHV compatible gas aggregation source avoiding any oxidation. Mass separation is carried out by a subsequent electrostatic quadrupole. The shape after deposition was investigated in situ by STM and compared with the lateral size being determined by HRTEM. This enables a direct correlation of structural and magnetic properties in combination with the XMCD measurements.

MA 31.3 Thu 10:45 HSZ 401

Influence of stress on the magnetic properties of nanoparticles — •Srinivasa Rao Saranu, Ulf Wiedwald, Sören Selve, Ute Kaiser, Paul Ziemann, and Ulrich Herr — Ulm University,89081 Ulm,Germany

Magnetic nanoparticles are interesting candidates for high density data storage. However, thermal stability of the stored information requires sufficiently large magnetic anisotropy. Here we present a new approach to optimization of the magnetic anisotropy of nanoparticles by applying large persistent stress. Fe and Ni nanoparticles were produced using plasma gas condensation technique and analyzed using XRD, SEM and TEM. Particles were deposited on Ta substrates and in-situ covered with Cu films. The Ta substrate was subsequently loaded with hydrogen. The volume expansion of the substrate induces a biaxial tensile stress in the Cu film. For 40nm Ni particles embedded in Cu films, we find that the effective anisotropy increases linearly with the applied stress. Fe particles with an average diameter of 14nm show super-paramagnetic behavior at room temperature. Upon applying in-plane biaxial stress, the blocking temperature as determined from FC/ZFC cooled magnetization measurements increases significantly.

MA 31.4 Thu 11:00 HSZ 401

Surprising insensitivity of the orbital magnetism in $L1_0$ ordered FePt nanoparticles to surface modifications by Al — •Carolin Antoniak[1], Marina Spasova[1], Anastasia Trunova[1], Florian Römer[1], Bernhard Krumme[1], Markus E. Gruner[1], Tobias Umbach[2], Adham Amyan[2], Kai Fauth[2], and Heiko Wende[1] — [1]Fachbereich Physik, Universität Duisburg-Essen, D-47048 Duisburg — [2]Physikalisches Institut, Universität Würzburg, D-97074 Würzburg

FePt nanoparticles in the chemically ordered $L1_0$ state are the subject of intense research activities driven both by fundamental interest and technological perspective. In this work, the influence of an Al cap layer on the magnetism of pure metallic $L1_0$ FePt nanoparticles of different sizes between 6nm and 2nm in diameter is studied by means of x-ray absorption spectroscopy and its associated magnetic circular dichroism (XMCD) at the Fe $L_{3,2}$ absorption edges. It was found that the net magnetisation at the Fe sites is reduced significantly with respect to the non-capped particles. The ratio of orbital-to-spin magnetic moment remains largely unchanged indicating that the enhanced orbital magnetism reported earlier [1,2] is not affected by an Al cap layer. The experimental results will be compared to recent ab-initio calculations for chemically ordered FePt clusters covered by an additional Al layer. Financially supported by the DFG (SFB445 and SPP1239), the BMBF (05 ES3XBA/5), and the ESRF.

[1] C. Antoniak et al., Phys. Rev. Lett. 97, 11201 (2006)
[2] O. Dmitrieva et al., Phys. Rev. B 76, 064414 (2007)

MA 31.5 Thu 11:15 HSZ 401

Near-surface strain in FePt nanoparticles — •Ulrich Wiesenhütter, Darius Pohl, Elias Mohn, Ludwig Schultz, and Bernd Rellinghaus — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

The structure of single crystalline, decahedral, and icosahedral FePt nanoparticles is systematically investigated by aberration-corrected HRTEM. Particular attention is paid to near-surface lattice strains which are indicative of a possible Pt segregation towards the surface. Statistical HRTEM investigations reveal that in icosahedral FePt nanoparticles, an average expansion of the crystal lattice of 9.5% is observed within the outermost atomic layers. In order to check if this reproducibly observed near-surface strain is merely a property of the bare particle surface or if it is rather due to a segregation of Pt towards the surface, the effect of electron beam-induced sintering of adjacent particles on the lattice expansion is studied. It is found that the near-surface strain survives the inter-particle coalescence and remains located at the former surface position which in deed corroborates the picture of a local enrichment of Pt at the particle surface. Similar lattice expansions are observed in decahedral and truncated octahedral FePt nanoparticles. In single crystalline particles however, the magnitude of the lattice dilation is found to be smaller as compared to the icosahedra. This indicates that in the latter, the observed near-surface lattice dilation may be enhanced due to strains inherent to the particle structure. The effect of the particle size on the magnitude of the strain will be discussed.

MA 31.6 Thu 11:30 HSZ 401

Detailed study on oxidation behavior of FePt thin film and nanoparticles — •Luyang Han[1], Kuerbanjiang Balati[1,2], Ulf Wiedwald[1], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, A.-Einstein-Allee 11, 89081 Ulm, Germany — [2]Institut für Mikro- und Nanomaterial, Universität Ulm

FePt nanoparticles and thin films attract great attention due to their potential application as magnetic data storage media [1]. In this study the oxidation of FePt nanoparticles and an epitaxial FePt reference film are investigated in detail. The nanoparticles are prepared by means of reverse micelles [2]. Oxidation is tracked in detail using X-ray photoelectron spectroscopy and a core-shell model is established to extract the oxide layer thickness. During the oxidation process a layer of Fe_2O_3 is formed at the surface, while Pt atoms remain metallic. After oxygen exposure of 10^8 L chemically disordered FePt particles start to oxidize, while the partially ordered particles after in-situ annealing at 950 K show only slight oxidation after 10^{10} L oxygen exposure. Similar behavior is observed for FePt thin films, indicating that the formation of the chemically ordered $L1_0$ structure reduces the oxidation speed significantly.

[1]S. Sun, *Adv. Mater.*, **18**, 393, (2006)

[2]A. Ethirajan et al., *Adv. Mater.*, **19**, 406, (2007)

MA 31.7 Thu 11:45 HSZ 401

Spectroscopic investigation of magnetic CoPt nanoparticles — •Leif Glaser[1], Michael Martins[1], Christine Boeglin[3], Vesna Alesandrovic[2], Host Weller[2], and Wilfried Wurth[1] — [1]Department Physik, Universität Hamburg, 22761 Hamburg , Germany — [2]Department Chemie, Universität Hamburg, 20146 Hamburg, Germany — [3]Institut de Physique et Chimie des Materiaux de Strasbourg,23, 67034 Strasbourg, France

The size dependent magnetic properties of wetchemically synthesized Co_xPt_{100-x} nanoparticles (3.7nm to 8.4nm) in their organic ligand shell were investigated at the Cobalt L-edges with X-ray magnetic circular dichroism (XMCD). A 7 Tesla high field magnet setup was used at the Bessy II storage ring. Oxidization effects due to the synthesis process and post synthesis aging were adressed by choosing particles of equal size, but different age and storage condition. The particles were deposited on silicon wafers as a single layered thin film using dip and spin coating techniques. The quality of the films was checked with Scanning Electron Microscopy (SEM).

Strongly enhanced magnetic moments of the investigated particles compared with bulk and thin film systems could be determined, The orbital magnetic moments of fresh particles displayed a favour of in plane magnetization increasing with cluster size.

Size dependent oxidization and size dependent aging effects could be detected and explained by model calculations.

Funding for this project by BMBF under contract 05 KS4 GUB/6 is gratefully acknowledged.

MA 31.8 Thu 12:00 HSZ 401

Structure and magnetism of free and decorated Fe-Pt nanoclusters — •Markus Ernst Gruner and Peter Entel — Department of Physics and Center for Nanointegration CENIDE, University of Duisburg-Essen, 47048 Duisburg, Germany

Arrays of $L1_0$ ordered nanoparticles of near-stoichiometric Fe-Pt and Co-Pt with diameters are considered as promising material for future ultra-high density recording media due to the large magnetocrystalline anisotropy energy (MAE) in their bulk alloys. In small particles, the required magnetic properties are not realized in experiments. Possible reasons are the occurrence of multiply twinned morphologies which are frequently encountered in experiment and energetically preferred for small diameters as demonstrated in recent large scale ab initio calculations of Fe-Pt clusters [1,2] of up to 923 atoms. On the other hand, preparation of particles in a carbon matrix has been recently reported to support $L1_0$ order.

Within this contribution we present first principles structure optimizations on the basis of density functional theory of small Fe-Pt particles decorated with monolayers of typical covering elements as gold, aluminum or carbon. Based on these results, we discuss the influence of a surrounding matrix on structural and magnetic properties of small Fe-Pt nanoparticles, taking into account spin-orbit coupling and non-collinear spin-structures.

[1] M. E. Gruner, G. Rollmann, P. Entel and M. Farle, Phys. Rev. Lett. **100**, 087203 (2008).
[2] M. E. Gruner and P. Entel, Psi-k Newsletter **89**, 36 (2008).

MA 31.9 Thu 12:15 HSZ 401

Splitting of the Curie temperature for two-dimensional anisotropic nanoparticles — •Elena Y. Vedmedenko, Thim Stapelfeldt, and Roland Wiesendanger — University of Hamburg, Jungiusstr. 11, 20355 Hamburg

The Curie temperature Tc is defined as the critical temperature above which magnetization vanishes. For superparamagnets the magnetization vanishes at the so-called blocking temperature Tb < Tc. Therefore, the determination of the Curie point via measurements of the mean magnetization is often impossible. In another common procedure the Curie point is determined via the peak in the susceptibility and/or the peak in the specific heat, which should appear at the same characteristic temperature. We demonstrate by means of Monte-Carlo simulations that for two-dimensional superparamagnets with uniaxial anisotropy these two peaks appear at different, size-dependent characteristic temperatures Tc > Ts. At temperatures Tb < T < Tc such a particle is in the regime of thermally induced switching. The Néel-Brown switching mechanism is only possible below Ts. The attempt frequency of the switching via a domain wall is size- and form-dependent.

MA 31.10 Thu 12:30 HSZ 401

Fe nanoparticles embedded in MgO crystals — •Artem Shalimov[1], Kay Potzger[1], Dorin Geiger[2], Hannes Lichte[2], Georg Talut[1], Andrzej Misiuk[3], Helfried Reuther[1], Frank Stromberg[4], Shengqiang Zhou[1], Carsten Baehtz[1], and Jürgen Fassbender[1] — [1]Forschungszentrum Dresden-Rossendorf, Bautzner Landstraße 128, 01328 Dresden — [2]Technical University, Dresden, Germany — [3]Institute of Electron Technology, Warsaw, Poland — [4]Universität Duisburg-Essen, Germany

Iron nanoparticles embedded in MgO crystals were synthesized by Fe+ ion implantation at an energy of 100 keV and varying fluences from 3*10E16 to 3*10E17 cm-2. Investigations of structural and magnetic properties of Fe nanoparticles have been performed using magnetometry, x-ray diffraction, transmission electron microscopy and Mössbauer spectroscopy, as well as by theoretical Preisach modeling of bistable magnetic systems. It has been found that alpha- and gamma-Fe nanoparticles are formed for all fluences. The content of the alpha-Fe phase increases at higher fluences and after annealing. The influence of post implantation annealing at 800 C in vacuum and under enhanced up to 10 kbar hydrostatic pressure in argon atmosphere on the formation of nanoparticles has been analyzed. Investigations have been performed within DFG project PO1275/2-1 "SEMAN".

MA 31.11 Thu 12:45 HSZ 401

Growth and magnetism of ordered alloy nanostructures — •yasmine nahas[1,2], vincent repain[1], and sylvie rousset[1] — [1]Laboratory Material and Quantum Phenomena, University Paris 7, UMR 7162, 10 rue Alice Domon et Léonie Duquet, 75205 Paris, France — [2]Physikalisches Institut, Universität Karlsruhe (TH), Wolfgang-Gaede-Str., D-76131, Karlsruhe, Germany

Nanomagnetism is a growing field of interest both from technological and fundamental motivations. Ordered growth allows to obtain structures with a controlled size and density [1], so enables the use of averaging technique to study magnetic properties of nanostructures. I will present two original systems of ordered magnetic nanostructures on gold surfaces. The first one deals with ordered alloy nanostructures of Fe-Pt, the second deals with core-shell nanostructures of Co-Au. Fe-Pt alloy nanodots well caracterized, regular in size, and ordered, were obtained. Systems with various concentrations of magnetic atoms can be elaborated. Moreover, magnetic measurements on Co-Au system were done with a good knowledge of the structure at the atomic scale. An increase of the magnetic anisotropy energy is observed for a given gold coverage. To interpret magnetic measurements on these systems of nanostructures of alloy, importants effects have to be taken into account, beyond the morphology : the atomic structure first, and an other effect very important even for simple structures : the relaxations.

[1] V. Repain et al., J. Phys.: Condens. Matter. 18 (2006) S17-S28