MA 6: Magnetic Particles/Clusters II

Time: Monday 15:15–17:00 Location: H10

MA 6.1 Mon 15:15 H10

Strukturelle und magnetische Charakterisierung der FePt Nanopartikel aus der Gasphase — •Olga Dmitrieva, Mehmet Acet, Günter Dumpich, Jochen Kästner, Carolin Antoniak und Michael Farle — Experimentalphysik, AG Farle, Universität Duisburg-Essen, 47048 Duisburg

In diesem Beitrag werden Herstellung und Charakterisierung von vorwiegend L10-geordneten FePt Nanopartikel aus der Gasphase vorgestellt. Mittels gezielter Zugabe von Stickstoff während der Partikelproduktion werden Bedingungen für eine begünstigte Einstellung der geordneten Phase erzeugt. Hochauflösende transmissionsmikroskopische Analysen zeigen, dass ca. 70% aller Nanopartikel eine einkristalline L10-geordnete Struktur besitzen [1]. Um zu prüfen, ob die Nanopartikel in der Gasphase Oxidationsprozessen ausgesetzt sind, wird der Oxidierungszustand der Partikel mittels Röntgensabsorptionsspektroskopie untersucht. Wir können damit nachweisen, dass die Partikel oberflächlich oxidiert sind. Die magnetische Charakterisierung der Nanopartikel erfolgt mittels Röntgenzirkulardichroismus. Da die Oxidationsschicht durch Behandlung in einem Wasserstoffplasma entfernt werden kann, ist es möglich, magnetische Bahn- und Spinmomente an anoxidierten und an oxidfreien Nanopartikeln zu ermitteln. Somit wird der Einfluss der Oxidation auf die magnetischen Eigenschaften festgestellt. Gefördert aus Mitteln der DFG im Rahmen des SFB 445. [1] O. Dmitrieva, M. Acet, G. Dumpich, J. Kästner, C. Antoniak, M. Farle, K. Fauth, J. Phys. D: Appl. Phys. 39, 4741 (2006).

MA 6.2 Mon 15:30 H10

HR-TEM Studies of FePt Nanoparticles by Exit Wave Reconstruction — •Daniela Sudfeld[1], Olga Dmitrieva[1], Nina Friedenberger[1], Günter Dumpich[1], Michael Farle[1], ChengYu Song[2], Christian Kisielowski[2], Markus Gruner[1], and Peter Entel[1] — [1]Department of Physics and the Center for Nanointegration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg — [2]National Center for Electron Microscopy, LBNL, One Cyclotron Road, Berkeley CA 94720, USA

To understand the magnetic properties of FePt nanoparticles [1] it is essential to get insights into the lattice structure of isolated clusters. FePt nanocrystals were investigated carrying out a direct reconstruction of the phase and the amplitude of the scattered electron wave from a focal series of HR-TEM images, resulting in a determination of the layer-resolved structure with sub Ångstrom resolution [2]. As an example, the formation of 5-fold twinned structures of 3 to 7 nm sized monodisperse FePt nanocrystals is discussed for fcc particles from colloidal solution and L10 ordered particles prepared by inert gas condensation [3]. In addition, ab initio density functional theory (DFT) calculations of FePt particles with a diameter larger than 2 nm were performed to obtain structural data which were used to model the microscopy data. This work was supported by the DFG (SFB 445) and the EU MRTN-CT-2004-0055667. References: [1] C. Antoniak et al.; Phys. Rev. Lett. 97, No. 11, 117201 (2006). [2] C. Kisielowski et al.; Ultramicr. 89 243 (2001). [3] O. Dmitrieva et al.; J. Phys. D: Appl. Phys. 39 (2006) 4741.

MA 6.3 Mon 15:45 H10

Structural stability of multiply twinned FePt nanoparticles — •Michael Müller and Karsten Albe — TU Darmstadt, Institut für Materialwissenschaft, FG Materialmodellierung, Petersenstr. 23, D-64287 Darmstadt

The structural stability of FePt nanoparticles in multiply twinned and single crystalline morphologies is investigated by means of molecular statics calculations based on a recently developed analytic bond-order potential. The results obtained from the atomistic calculations are used for validating a continuum model which allows to assess the contributions of elastic strain, surface and and twin boundary energies, separately. The static model calculations predict a strong energetic preference for single crystalline morphologies in the ordered L1_0 and disordered A1 phases, if the particle size exceeds 2.6 nm, while smaller particles tend to form icosahedral structures. Based on these results, experimentally observed shapes of FePt nanoparticles are discussed.

MA 6.4 Mon 16:00 H10

Lagenaufgelöste Kristallstruktur von FePt Nanopartikeln mit sub-Ångstrom Auflösung — •Nina Friedenberger[1], Olga Dmitrieva[1], Daniela Sudfeld[1], Christian Kisielowski[2] und Michael Farle[1] — [1]Universität Duisburg-Essen, Fachbereich Physik und das Center for Nanointegration Duisburg-Essen (CeNIDE), Lotharstr. 1, 47048 Duisburg — [2]National Center for Electron Microscopy, LBNL, One Cyclotron Road, Berkeley CA 94720, USA

Die Kristallstruktur nass-chemisch und durch Kondensation in der Gasphase hergestellter FePt Nanopartikel wurde mittels hochaufgelöster Transmissionselektronenmikroskopie und Exit-Wave-Reconstruction (EWR) untersucht. Anhand der rekonstruierten vollständigen Amplituden- und Phaseninformationen der HRTEM-Aufnahmen können fehlende Atomkolonnen an der Oberfläche identifiziert und die lagenaufgelöste Relaxation an der Partikeloberfläche bestimmt werden. Wir finden sowohl für kolloidale als auch für Gasphasen-Partikel im Mittel eine Aufweitung der Gitterkonstante bis zu 4% im Vergleich zur entsprechenden Gitterkonstante des Volumenmaterials. Diese Resultate bieten eine mögliche Erklärung für stark erhöhte orbitale Momente wie sie vor kurzem mittels Röntgenzirkulardichroismus beobachtet worden sind [1,2]. Unterstützt durch DFG (Sfb 445) und EU MRTN-CT-2004-0055667. [1] O. Dmitrieva, et al., J. Phys. D: Appl. Phys. 39 (2006) 4741 [2] C. Antoniak, et al., Phys Rev. Lett. 97 (2006) 117201

MA 6.5 Mon 16:15 H10

Kinetics of the ordering transition in FePt nanoparticles — •Michael Müller and Karsten Albe — TU Darmstadt, Institut f'ur Materialwissenschaft, FG Materialmodellierung, Petersenstr. 23, D-64287 Darmstadt

Kinetic Monte Carlo simulations based on an Ising-type lattice Hamiltonian are employed to investigate the kinetics of ordering processes in FePt nanoparticles. In non-supported particles, the A1 to L1_0 transition proceeds with a higher rate in layers at the surace than in the volume of the particles, which demonstrates the important influence of surface diffusion. Because of the statistical nucleation of the ordered phase, however, no single domain particles are obtained and an elimination of the antiphase boundaries can not be observed within the time scales accessible by the simulations. Based on these findings, possibilities for increasing the transition rate in supported nanoparticles are investigated. By systematically modifying interface energetics, surface diffusion can be increased and a preferential ordering direction in the particle can be induced.

MA 6.6 Mon 16:30 H10

$L1_0$-ordering of FePt nanoparticles by in-flight optical heating — •Elias Mohn, Darius Pohl, Franziska Schäffel, Ludwig Schultz, and Bernd Rellinghaus — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

FePt nanoparticles with sizes in the range of 4-6 nm are prepared by DC-magnetron sputtering in argon. Upon leaving the nucleation and growth chamber, the particles are ejected into high vacuum via differential pumping. This allows to effectively control both the degree of agglomeration and the primary particle size. Prior to their deposition, the particles are heated in flight by means of a newly constructed paraxial light furnace. Transmission electron microscopy (TEM) investigations reveal that upon increasing the furnace power, particle agglomerates successively coalesce, and fully sintered spherical particles are formed at powers of $P \geq 3$ kW. This proves that effective radiative heating of the particles is accomplished even though the heating times are as short as 1 ms. A comparison of these findings with recent experiments of Stappert et al. [1] allows to estimate a minimum particle temperature of $T \geq 800\ ^oC$ at $P = 3$ kW. Structural characterization by high resolution TEM reveals the onset of the $L1_0$ order in likewise treated FePt nanoparticles. This goes along with an increase of the coercivity which is, however, substantially smaller as compared to that of fully ordered FePt thin films. The obtained results are analyzed with respect to the $L1_0$ ordering kinetics. They confirm our assumption that the ordering is predominantly governed by volume diffusion. [1] S. Stappert et al., J. Cryst. Growth 252 (2003) 440.

MA 6.7 Mon 16:45 H10

Improved kinetics of the phase transformation of FePt nanoparticles from fcc to fct by ion irradiation — •Andreas

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$Fe_{50}Pt_{50}$ alloy nanoparticles are promising candidates for ultra high density data storage due to their huge magnetic anisotropy energy in the chemically ordered $L1_0$ phase (fct). Starting from chemically disordered particles in fcc phase, the transformation into the chemically ordered fct phase is obtained by annealing at typically 600° - 800° C. We present experiments on arrays of $Fe_{51}Pt_{49}$ fcc nanoparticles (diameter 7 nm, inter-particle distances 60 nm), which were prepared using a micellar technique. The particles were irradiated with 350 keV He^+ ions up to 10^{16} ions/cm^2 at room temperature. Using XMCD measurements the transformation into the chemically ordered $L1_0$ phase can be extracted from the hysteresis in the magnetisation curves. A comparison of irradiated and non-irradiated samples reveals improved kinetics of the phase transformation of the ion irradiated nanoparticles. Thus coercive fields of 330 Oe at 300 K were obtained after 600° C annealing temperature for the irradiated particles, whereas the unirradiated ones still show superparamagnetic behaviour under identical annealing conditions.