MA 27 Spindynamik II

Zeit: Dienstag 15:15–18:30 Raum: TU H1012

MA 27.1 Di 15:15 TU H1012

Micromagnetic Dissipation, Dispersion and Mode Conversion in thin Permalloy platelets — •Matthias Buess[1,2], Thomas Haug[1], Michael R. Scheinfein[3] und Christian H. Back[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstrasse 31, 93040 Regensburg, Germany — [2]Laboratorium für Festkörperphysik, Eidgenössische Technische Hochschule Zürich, CH-8093 Zürich, Switzerland — [3]Simon Fraser University, 8888 University Drive, Burnaby BC U5A 156, Canada

Micron sized ferromagnetic permalloy disks exhibiting an in-plane ferromagnetic vortex structure are excited by a fast rise time perpendicular magnetic field pulse and their modal structure is analyzed. We find azimuthal and axial modes. By a fourier filtering technique we can separate and analyze the time dependence of individual modes. Analysis of the experimental data demonstrates that the azimuthal modes damp more quickly than the axial modes. We interpret these results as mode conversion from low-frequency azimuthal modes to the fundamental mode which is higher in frequency, i.e. mode-mode coupling in a system with a single Landau-Lifshitz-Gilbert phenomenological damping constant. We present a method to extract the decay rates for different modes from a single average precession component. These measurements are the first clear demonstration that mode-mode coupling plays a significant role in magnetization dynamics, and, the data demonstrate how mode-conversion could be construed as damping.

MA 27.2 Di 15:30 TU H1012

Damping in thin ferromagnetic films — •H.T. Nembach[1], P. Martin Pimentel[1], M.C. Weber[1], J. Fassbender[2], and B. Hillebrands[1] — [1]Fachbereich Physik und Forschungsschwerpunk MINAS, Technische Universitaet Kaiserslautern, E.-Schroedinger-Str. 56, 67663 Kaiserslautern — [2]Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Rossendorf, 01314 Dresden

The understanding of the damping processes of the magnetization dynamics is an important issue. Several different damping channels are proposed. Here the importance of magnon-magnon processes for the damping is investigated with a magneto-optical method. This method allows to determine the length of the magnetization vector and therefore gives an indication for magnon-magnon processes. Higher order magneto-optic effects are also taken into account, which allows the determination of the quadratic magneto-optic constant.

This work was supported by the DFG-Graduiertenkolleg 792 and the EU-RTN ULTRASWITCH network (HPRN-CT-2002-00318).

MA 27.3 Di 15:45 TU H1012

Damping of ultrafast spin dynamics in nanostructures: An ab-initio study — •Daniel Steiauf and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany

Based on the model of Kamberský [1] we calculated the matrix $\underline{\underline{\alpha}}(\mathbf{M})$ entering the damping term $\mathbf{M}\times(\underline{\underline{\alpha}}(\mathbf{M})\cdot\mathrm{d}\mathbf{M}/\mathrm{d}t)$ in a generalized Landau-Lifshitz-Gilbert equation by the ab-initio electron theory for bulk materials, atomic monolayers and monatomic wires of Fe, Co and Ni. It turns out that in the monolayers and monatomic wires the damping depends extremely sensitively on the momentary orientation of the magnetization and even vanishes for various orientations. We underpin these surprising numerical results by group-theoretical considerations. This discovery represents an additional option for the optimization of the switching behaviour of nanostructured magnets by choosing a trajectory of the magnetization vector which exhibits the desired properties of the damping.

[1] V. Kamberský, Canadian J. Phys. **48**, 2906 (1970).

MA 27.4 Di 16:00 TU H1012

Limitations of the Landau-Lifshitz-Equation and spin-pump effects in magnetic nanostructures — •K. Lenz[1], E. Kosubek[1], T. Toliński[2], K. Baberschke[1], and A. Janossy[3] — [1]Inst. f. Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin — [2]Institute of Molecular Physics, PAS; Smoluchowskiego 17, 60-179 Poznań, Poland — [3]Department of Experimental Physics, Institute of Physics, Budapest University of Technology and Economics, 1521 Budapest, Hungary

Two mechanisms have been the topic of recent discussions concerning the precessional damping at interfaces of ferromagnetic to nonmagnetic materials: (i) The magnon-magnon scattering, with origin in surface or interface defects. (ii) The spin-pump effect, i.e. the transfer of angular momentum from the precessing magnetization excited by ferromagnetic resonance to the conduction electrons of a non-magnetic layer. The commonly used Landau-Lifshitz-Gilbert equation is insufficient to describe transverse scattering within magnetic excitations. In addition to previous results [1] we present FMR data up to 230 GHz showing the importance of two-magnon scattering. Secondly, the linewidth analysis of Ni/Cu/Ni trilayer FMR for parallel and perpendicular alignment of the Ni magnetization shows distinct narrowing as function of the orientation of the external field, which will be discussed in terms of spin-pump effects [2].

Supported by DFG (Sfb 290, TP A2).

[1] J. Lindner *et al.*, Phys. Rev. B **68**, 060102(R) (2003)
[2] K. Lenz *et al.*, Phys. Rev. B **69**, 144422 (2004)

MA 27.5 Di 16:15 TU H1012

Dynamic losses and domain refinement in nanocrystalline tape wound cores — •Sybille Flohrer[1], Rudolf Schäfer[1], Jeffrey McCord[1], Stefan Roth[1], Giselher Herzer[2] und Ludwig Schultz[1] — [1]Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstraße 20, D-01069 Dresden, Germany — [2]VACUUMSCHMELZE GmbH & Co. KG, Grüner Weg 37, D-63450 Hanau, Germany

The analysis of dynamic magnetization processes is the basis for the understanding of energy loss mechanisms in magnetic materials. Stroboscopic Kerr-microscopy observations on a variety of nanocrystalline $Fe_{73}Cu_1Nb_3Si_{16}B_7$ tape wound cores with different strengths of the induced longitudinal anisotropy are presented. In the frequency range from the quasi-static case up to 10 kHz domain refinement is distinctive. The correlation between domain refinement, the strength of the induced anisotropy, and the cycle losses is studied. The strongest wall multiplication is observed in the cores with the weakest induced anisotropy, where the wide domains even decay into a patchy pattern at elevated frequencies. The arising of the patchy domains is discussed in terms of the induction rate and the influence of residual anisotropies.

MA 27.6 Di 16:30 TU H1012

FMR study of thin Fe layers grown on hexagonal GaN — •Matthias Buchmeier[1], Ralph Meijers[2], Raffaella Calarco[2], and Daniel E. Bürgler[1] — [1]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich — [2]Institut für Schichten und Grenzflächen, Forschungszentrum Jülich GmbH, 52425 Jülich

Fe films with thicknesses between 5 nm and 50 nm have been prepared by MBE on top of GaN(0001) substrates. XRD and LEED results suggest the growth in crystallographic Fe(110) domains with three different orientations. The magnetic properties have been investigated by in-plane angle-dependent FMR at frequencies from 4.5 GHz to 15.5 GHz. All samples show a weak thickness-independent hexagonal in-plane anisotropy with hard-axis saturation field of 8 mT. The FMR linewidth versus frequency curves are linear with no zero-frequency offset indicating a good homogeneity of the magnetic properties over the sample area. However the effective damping parameter α shows a pronounced anisotropy and thickness dependence, with enhanced damping along the hard-axis and for thicker layers. We suggest that the additional damping can be explained by two-magnon scattering at defects which are due to the triple domain formation.

MA 27.7 Di 16:45 TU H1012

Modifikation der magnetischen Dämpfung in Permalloy-Schichten durch Cr-Implantation — •J. Fassbender[1], J. McCord[2], M. Weisheit[2] und R. Mattheis[3] — [1]FZ Rossendorf, Institut für Ionenstrahlphysik und Materialforschung, 01314 Dresden — [2]IFW Dresden, Institut für Metallische Werkstoffe, 01069 Dresden — [3]Institut für Physikalische Hochtechnologie e. V. Jena, 07745 Jena

Das magnetische Dämpfungsverhalten, die Curie-Temperatur und die uniaxiale magnetische Anisotropie von 20 nm dicken Permalloy-Schichten wurde mittels Cr-Implantation modifiziert. Die Implantation wurde bei 30 keV Beschleunigungsspannung im Dosisbereich zwischen 2×10^{15} und 2×10^{16} Ionen/cm^2 durchgeführt. Daraus resultiert ein Implantationsprofil mit einer mittleren Konzentration an Cr innerhalb der Permalloy-Schicht von 1 bis 10 %. Bei einer mittleren Konzentration von ca. 7% wird die Curie-Temperatur der Permalloy-Schicht auf Raumtemperatur abgesenkt. Damit einher geht eine leichte Verringerung der uniaxialen magnetischen Anisotropie. PIMM-Messungen ("pulsed inductive microwave magnetometry") zeigen jedoch eine starke Vergrösserung des magnetischen Dämpfungsverhaltens durch die Cr-Implantation. Die möglichen Ursachen dieser Erhöhung werden diskutiert.

MA 27.8 Di 17:00 TU H1012

Angle dependent switching of spherically shaped nanostructures — •Till C. Ulbrich[1], Ildico L. Guhr[1], Dieter Süss[2], Tomas Schrefl[2], Denis Makarov[3], Günter Schatz[1], and Manfred Albrecht[1] — [1]University of Konstanz, Department of Physics, 78457 Konstanz, Germany — [2]Vienna University of Technology, A-1040 Wien, Austria — [3]Taras Shevchenko University, 01033 Kiev, Ukraine

Co/Pd multilayer films provide uniaxial magnetic anisotropy K_u mainly generated by interface anisotropy. The strength and orientation of K_u depends strongly on the individual Co and Pd layer thicknesses. By evaporating of a Co/Pd multilayer film onto a monolayer of self-assembled polystyrene nanoparticles a novel type of magnetic nanostructures is formed on top of the spheres. Due to the spherical shape a spread in anisotropy orientation is present in the magnetic nanostructures. Furthermore, the strength of the anisotropy varies across the nanostructure due to the changing Co layer thickness. These variations have a drastic impact on the switching mechanism which differs remarkably from a Stoner-Wohlfahrt behavior expected for a single domain particle. Here we present first results on the angle dependent switching using nanospheres in the size range of 50 to 310 nm investigated by focused MOKE and MFM. These results were compared to micromagnetic simulations clearly revealing the importance of the local variation of anisotropy induced by the spherical shape of the nanostructures.
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MA 27.9 Di 17:15 TU H1012

Current-induced precessional magnetization reversal — •Hans Werner Schumacher[1], Claude Chappert[2], Ricardo C. Sousa[3], and Paulo P. Freitas[3] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig, Germany — [2]Institut d'Electronique Fondamentale, UMR 8622, CNRS, Université Paris Sud, Bât. 220, 91405 Orsay, France — [3]Instituto de Engenharia de Sistemas e Computadores, Rua Alves Redol, 9, 1 Dt., P-1000 Lisboa, Portugal

We report magnetization reversal in microscopic current-in-plane spin valves by ultra short current pulses through the device. Current densities of the order of 1011 A/m2 with pulse durations as short as 120 ps reliably and reversibly switch the cells free-layer magnetization. Variations of the pulse parameters and of an easy axis bias field reveal the full signature of precessional switching, which is triggered by the transverse magnetic field generated by the device current. This current switching mode allows for the design of a two-terminal nonvolatile magnetic memory cell combining ultra fast access times and high magnetoresistive readout. The possible scaling of such memory cells towards smaller lateral dimensions is discussed.

MA 27.10 Di 17:30 TU H1012

Small and large angle precession in exchange biased bilayers — •Markus C. Weber[1], Hans Nembach[1], Burkard Hillebrands[1], and Jürgen Fassbender[2] — [1]Fachbereich Physik und Forschungsschwerpunkt MINAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institut für Ionenstrahlphysik und Materialforschung, Forschungszentrum Rossendorf, 01314 Dresden, Germany

Small and large angle excitations in exchange bias systems have been investigated in real time by means of all-optical pump-probe experiments. Due to an increased spin temperature upon photoexcitation, an unpinning of the interfacial exchange coupling takes place resulting in a collapse of the unidirectional anisotropy. In terms of an internal pulse field the excess energy of the spin system leads to the excitation of a high frequency precessional response. The magnitude of the internal pulse field can be controlled by the absorbed photons [1]. Hence, the precessional motion depending on the precession angle can be investigated. The extracted Gilbert parameter does not depend on the magnitude of the internal pulse field. Both small and large angle precession can be modeled within the Landau-Lifshitz-Gilbert framework. Employing the antiferromagnetic thickness dependence of the exchange bias field, the exchange bias field dependence of the Gilbert parameter was investigated. The dissipation rate increases linearly with the exchange bias field magnitude which can be understood taking local fluctuations of the interfacial exchange coupling as an additional dissipation mechanism into account [2].

[1] M. C. Weber et al., Phys. Rev. B, submitted. [2] M.C. Weber et al., J. Appl. Phys., in press.

MA 27.11 Di 17:45 TU H1012

Ultrafast direct writing schemes for SAF MRAM cells — •H.T. Nembach, C. Bayer, M.C. Weber, P. Martin Pimentel, P.A. Beck, B. Leven, and B. Hillebrands — Fachbereich Physik und Forschungsschwerpunkt MINAS, E.-Schroedinger-Str. 56, Technische Universität Kaiserslautern, 67663 Kaiserslautern

Magnetic random access memory (MRAM) will be essential for future data storage. Two important issues, which still need to be improved, are access time and insensitivity against parameter variations, as for instance pulse length and amplitude. Recently a new switching scheme has been introduced for a 4Mbit MRAM demonstrator using a toggle mode for switching [1]. Here we present two direct writing schemes for such a so-called Savtchenko-type MRAM [2]. These writing schemes using two orthogonally oriented bipolar and unipolar magnetic field pulses with time delay allow for ultrafast direct writing with high stability against half select switching. The numerical simulations are based on the Stoner Wohlfarth model and a Runge Kutta integration of the Landau-Lifshitz and Gilbert equation.

This work was supported by the DFG-Graduiertenkolleg 792, the Studienstiftung des Deutschen Volkes, and the EU-RTN ULTRASWITCH network (HPRN-CT-2002-00318).

[1] Savtchenko et al., US Patent 6,545,906 B1, Apr. 8 (2003).
[2] H. T. Nembach et al, submitted to APL.

MA 27.12 Di 18:00 TU H1012

Dynamics of magnetic domain wall motion: Dependence on wall energy, mobility, and Zeeman energy — •K. Fukumoto[1], W. Kuch[1], J. Vogel[2], J. Camarero[3], S. Pizzini[2], F. Romanens[2], M. Bonfim[2], A. Fontaine[2], and J. Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany — [2]Laboratoire Louis Néel, CNRS, 25 avenue des Martyrs, B. P. 166, F-38042 Grenoble Cedex 9, France — [3]Dpto. Física de la Materia Condensada, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

Nowadays the response time of magnetic recording devices is going down to the ns range. For the fast switching of magnetic trilayered systems it is important to know the factors influencing the speed of domain nucleation and subsequent domain wall propagation. We studied magnetic domain nucleation and wall motion in the permalloy layer of a magnetic-tunnel-junction like system by a novel combination of x-ray magnetic circular dichroism, photoelectron emission microscopy, and stroboscopic pump-probe technique. The expansion of micron-sized magnetic domains was followed with ns time resolution for various amplitudes of the external field. Since these applied external fields were well above the static coercive field, viscous wall motion was observed, in which the wall velocity is a linear function of the external field. The onset of domain expansion was observed to take place after the beginning of the pulse, with a delay depending on the pulse amplitude. This apparent delay in domain nucleation can be understood taking into account the domain wall energy, causing a lower domain wall speed when the domains are small.

MA 27.13 Di 18:15 TU H1012

AC-driven Domain Walls in Random Media — •Andreas Glatz[1], Thomas Nattermann[1], and Valery Pokrovsky[2] — [1]Institut für theoretische Physik, Universität zu Köln, Zülpicher Str. 77, 50937 Köln — [2]Department of Physics, Texas A&M University, College Station, Texas 77843-4242

The viscous motion of an interface driven non-adiabatically by an *ac external field* of frequency ω_0 in a random medium is considered. The velocity exhibits a smeared depinning transition showing a *double hysteresis* in the case when the amplitude of the external field is larger than the depinning field. This hysteresis is absent in the adiabatic case $\omega_0 \to 0$. Using scaling arguments and an approximate renormalization group calculation we explain the main characteristics of the hysteresis loop. In the low frequency limit these can be expressed in terms of the depinning threshold and the critical exponents of the adiabatic case. If the amplitude is smaller than the depinning field, also the avalanche motion of the interface has to be taken into account leading to a pronounced effect in the velocity hysteresis.