Friday Morning, November 6, 1998

Magnetic Interfaces and Nanostructures Technical Group
Room 324/325 - Session MI-FrM

Magnetization Dynamics and Magneto-Optics

Moderator: J. Unguris, National Institute of Standards and Technology

8:20am **MI-FrM1 Magnetization Dynamics: A Study of the Ferromagnet/Antiferromagnet Interface and Exchange Biasing**, ***R.E. Camley,*** University of Colorado, Colorado Springs **INVITED**

We use a method which employs a dynamic calculation of magnetization motion to find both the static configuration and the spin wave excitations in a ferromagnet/antiferromagnet layered structure. Our results for the static structure are similar to those found in Koon's model; i.e. in zero applied field the ferromagnet points perpendicularly to the easy axis of the antiferromagnet, and the surface spins of the antiferromagnet are in a surface spin flop configuration. The calculated hysteresis curve for this structure shows a small exchange bias, in agreement with typical experimental results. We explore how this bias depends on the parameters of the antiferromagnet and on the nature of the interface coupling. The spin wave modes are developed using the same simple model. The frequency of the lowest spin wave in the ferromagnet shows a dramatic dip when the ferromagnet spins begin to rotate - where the hysteresis curve drops as the field is reduced from the saturated state. The spin wave modes in the ferromagnet should be easily observed by Brillouin Light Scattering. The spin waves in the antiferromagnet also show dramatic changes as the antiferromagnet structure is changed.

9:00am **MI-FrM3 Switching Field Measurements of Longitudinal Magnetic Recording Media**, ***A. Moser,*** *D. Weller, M.E. Best,* IBM Almaden Research Center **INVITED**

Media stability is one of the key issues in the development of future high density magnetic recording media, as it determines the lifetime of a disk. At short time scales the coercivity strongly increases and recording information requires high write fields. Both, media stability and enhanced coercivity at short time scales can be examined using switching field measurements H@sub CR@ as a function of the magnetic field pulse width t. The data can be analyzed within the framework of the Arrhenius-Neel law using the equation H@sub CR@ = H@sub 0@ (1 - [C log(t f@sub 0@)]@super n@).@footnote 1@ Here, the constant C describes the stability of the media and is related to the viscosity parameter. H@sub 0@ is an intrinsic switching field related to the anisotropy field H@sub K@, f@sub 0@ is an attempt frequency (of the order of 10@super 9@ Hz) and n is an exponent which takes values between 1/2 and 1. By measuring H@sub CR@ over more than 9 decades in time using a novel experimental method, we can determine both the stability parameter C and the switching field H@sub 0@ for a series of CoPtCr media of different thicknesses.@footnote 2@ These samples have varying areal moment densities Mrt between 0.17 and 0.39 memu/cm@super 2@ and remanence coercivities H@sub CR@ between 500 and 2500 Oe at a pulse width of 1 s. It will be shown that H@sub CR@ can vary by more than a factor of 3 over the observed range of pulse widths. The results are compared to conventional signal decay measurements and to experimental and theoretical results found in literature.@footnote 3@ @FootnoteText@ @footnote 1@M.P. Sharrock, IEEE Trans. Magn. 26, (1990) 193. @footnote 2@Samples provided by M. Doerner, IBM Storage Systems Division, 5600 Cottle Rd., San Jose, CA 95193 @footnote 3@M.Yu, M.F. Doerner, D.J. Sellmyer, MMM-Intermag ?98, San Francisco, Jan. 6-8, 1998

9:40am **MI-FrM5 Magnetic Properties of Submicron Magnetic Wires Fabricated by e-beam Lithography Investigated by using GMR Effect**, ***T. Ono,*** *H. Miyajima,* Keio University, Japan; *K. Shigeto, K. Mibu, N. Hosoito, T. Shinjo,* Kyoto University, Japan

The magnetization reversal study of a single submicron magnetic wire is presented. The magnetization reversal in a single submicron magnetic wires can be very sensitively observed by utilizing the giant magnetoresistance (GMR) effect.@footnote 1@ GMR is the electrical resistance change accompanied with the change of magnetic structure. This means, in turn, the magnetic structure of the system can be determined from the resistivity measurements. In a wire case, the magnetic shape anisotropy restricts the direction of the magnetization to be parallel or antiparallel along the wire axis. The GMR change is directly proportional to the magnitude of the switching layer magnetization. A single NiFe(40nm)/Cu(20nm)/NiFe(5nm) trilayer wire 500 nm in width was prepared. An artificial neck was introduced in the wire. The temperature dependences of the nucleation field and the propagation velocity of the magnetic domain wall in the wire were studied by using the GMR effect. The result clearly shows that the artificial neck works as a pinning center for the magnetic domain wall. The temperature dependence of the nucleation field in a single submicron magnetic wire was investigated by measuring the coercive field at which the electrical resistance abruptly changes by the GMR effect. The nucleation field shows a thermal excitation behavior down to 5 K. The study at lower temperatures, down to 50 mK, is now in progress. By measuring the time dependence of the resistance during the magnetization reversal, the propagation velocity of the magnetic domain wall was estimated. Under the external magnetic field of 90 Oe, the velocity in the NiFe layer (40 nm in thickness and 500 nm in width) is about 5 cm/s at 77 K, the velocity of which is much smaller than that reported by Sixtus and Tonks for bulk NiFe wire in 1931.@footnote 2@ @FootnoteText@ @footnote 1@T. Ono, H. Miyajima, K. Shigeto and T. Shinjo, Appl. Phys. Lett. 72, 1116 (1998). @footnote 2@K.J. Sixtus and L. Tonks, Phys. Rev. 37, 930 (1931).

10:00am **MI-FrM6 Magnetic Reversal on Vicinal Surfaces**, *R.A. Hyman,* Georgia Institute of Technology; ***M.D. Stiles,*** National Institute of Standards and Technology; *A. Zangwill,* Georgia Institute of Technology

Ultrathin films of magnetic material on non-magnetic vicinal substrates may be the simplest systems that exhibit non-uniform magnetization reversal. These systems can be modeled by equally spaced and infinitely long step edges separating flat terraces. The intrinsic four-fold anisotropy of the terraces is augmented by uniaxial anisotropy localized at the step edges. For in-plane magnetization, the zero temperature behavior of these systems depends on two dimensionless parameters: the ratio of the step anisotropy energy to the domain wall energy on the flat terraces, and the ratio of the terrace length to the domain wall width. Numerical results give a rich phase diagram for the hysteresis loop structure as a function of these two parameters. In some cases, simple analytic formula for the domain wall depinning field can be derived that agree well with numerical work. For some values of the system parameters, the calculated hysteresis curves exhibit the shifted loop structure found in experiments. The reversal processes are a combination of domain nucleation at step edges, depinning due to domain wall interactions, and coherent rotation in the center of flat terraces. No sharp transition separates the limit of reversal by coherent rotation from that of reversal by domain wall depinning from steps. Instead, there is a smooth crossover from coherent rotation dominated reversal to domain wall depinning dominated reversal and most major loop structures are obtained in both limits.

10:20am **MI-FrM7 Magneto-optics: Science and Technology**, ***M. Mansuripur,*** University of Arizona **INVITED**

The current trend in rewritable optical data storage is toward the use of novel techniques to achieve densities and data rates that are superior to those achievable in hard disk magnetic recording. After a brief review of the magneto-optical properties of amorphous rare earth-transition metal alloys, we describe the methodology and potential advantages/disadvantages of solid immersion lens (SIL), front-surface recording, magnetic super resolution (MSR), land & groove recording, and partial-response-maximum-likelihood (PRML) detection schemes. We point out the differences between magneto-optical and phase-change media, which are the contenders for the rapidly developing market in Rewritable Digital Versatile Disk (DVD) products.

11:00am **MI-FrM9 Magnetism of Oxide NiO/@alpha@Fe@sub 2@O@sub 3@ Multilayers Studied by Magneto-Optical Faraday Effect**, ***N. Keller,*** *M. Guyot, R. Krishnan,* Université de Versailles - CNRS, France

Magneto-optical Faraday measurements were performed on magnetic oxide NiO/@alpha@Fe@sub 2@O@sub 3@ multilayers. These samples have been prepared by pulsed laser deposition technique. The magnetic particularity of this model system is given by the antiferromagnetism of both base oxides NiO and @alpha@Fe@sub 2@O@sub 3@, which can only form the ferrimagnetic nickelferrite, NiFe@sub 2@O@sub 4@, by interdiffusion at the interfaces. The magnetism of this interlayer compound can be used as a local probe for the study of interdiffusion. Increasing the number of interfaces and hence the number of ferrimagnetic layers should lead to a regular increase of the total magnetic moment. Surprisingly, we observed a pronounced oscillation of the total magnetic moment with the number of interface layers.@footnote 1@ This oscillation can only be accounted for by assuming an antiparallel alignment of the moments of each interlayer with respect to the neighboring interlayers. The magneto-optical Faraday rotation was measured in the range from 1.5 eV to 3 eV on samples with a different number of interfaces. The ellipticity of the Faraday rotation shows a similar energy dependence when compared to Kerr spectra (rotation and ellipticity) of bulk NiFe@sub 2@O@sub 4@ taken from the literature. Especially two crystal field excitations at 2.3 eV at 2.8 eV appear in both spectra. However, normalization of the ellipticity by the number of interfaces doesn't show in the entire spectral range a unique dependence. At energies higher then ~2.1 eV a non - negligible difference can be observed in the normalized ellipticity for samples with different numbers of interface. @FootnoteText@ @footnote 1@N.Keller, M. Guyot, A. Das, M. Porte, R. Krishnan, Solid State Comm. 105 (1998) 333-337

11:20am **MI-FrM10 Magnetooptical Characterization of Layered Structures using Variable Angle of Incidence Generalized Magnetooptical Ellipsometry (VA-GME)***, **A. Berger**, M.R. Pufall,* University of California, San Diego

Recently, we have developed the technique of Generalized Magnetooptical Ellipsometry (GME) which allows a complete optical and magnetooptical characterization of a ferromagnetic bulk material.@footnote 1@ The technique combines the advantages of a generalized ellipsometric approach, enabling us to retrieve the maximum amount of information from a reflection experiment, with a high sensitivity measurement which allows for a precise determination of the relatively small magnetooptical material constants. In the present study, we have extended the concept of GME to multiple measurements with variable angle of incidence (VA). This not only allows for a consistency check of the previously performed magnetooptical bulk measurements, but in addition it enables us to characterize more complex layered structures by a simultaneous analysis of the VA-GME data sets. The experiments are performed with an experimental setup almost identical to the previously reported one, using a HeNe-Laser as a light source and 2 linear polarizers as the polarization sensitive elements.@footnote 1@ The sample orientation and the position of the detector arm of the ellipsometer are rotatable to allow for a variable angle of incidence. As a first test structure we have used a thick permalloy film with a SiO@sub 2@ overcoating. The magnetooptical structure analysis was then performed by a least square-fit procedure of the entire VA-GME data set. The consistency of the results was checked by a conventional ellipsometric measurement and by a self-consistent comparison of independently measured VA-GME data sets for different in-plane orientations of the magnetization. Our results clearly demonstrate the successful extension of GME to a variable angle of incidence measurement technique, which allows a complete optical and magnetooptical characterization of layered magnetic materials. This work has been supported by the ONR-N000-1495-10541, NSF-DMR-94-00439, and the CMRR at UCSD. @FootnoteText@ @footnote 1@A. Berger and M. R. Pufall, Appl. Phys. Lett. 71, 965 (1997)

11:40am **MI-FrM11 Magnetization Induced Optical Second Harmonic Generation as a Readout of Thin Film Magnetic Memories***, **T.V. Murzina**, A.A. Fedyanin, A.V. Melnikov, T.V. Misuryaev, O.A. Aktsipetrov,* Moscow State University, Russia

The search for new materials for the magnetic memory devices gives rise to the search for new nondestructive readout techniques. In the present paper magnetization induced second harmonic generation (MSHG) is suggested as a readout for thin magnetic film-based memories. The advantage of the MSHG probe is a high sensitivity of quadratic nonlinear-optical response to the magnetic properties of nanostructures and low-dimensional systems. The fundamental wavelength can be chosen far from electronic resonance. That makes the MSHG probe nondestructive, while the MSHG wavelength can be resonant and thus provide an effective MSHG output sensitive to the magnetic state of the memory. In this paper, the results of systematic MSHG studies in thin magnetic films are presented which demonstrate the potential of this probe as a readout for thin film-based magnetic memories. Three systems are studied: Gd-containing Langmuir-Blodgett (LB) films, rare-earth iron garnet films, and magnetic Co-Cu nanogranular films. The output of a Q-switched YAG:Nd@super +3@ laser at 1064 nm, a pulse duration of 15 ns and an intensity of about 1 MW/cm@super 2@ is used as a fundamental radiation. DC-magnetic field up to 1.5 kOe is applied to the films in a longitudinal NOMOKE configuration. The MSHG readout is shown to be based either on the magneto-induced rotation of the polarization of the second harmonic (SH) wave polarization or on the magnetoinduced changes in the SHG intensity and magnetoinduced changes of the SH wave phase. It is shown that in nonresonant conditions, i.e. as both the fundamental and SH wavelength is far from electronic resonance of a magnetic film, the probability of the misreading (readout error) is rather small. Apart from three magnetic systems studied, the MSHG readout can be potentially used for a wide variety of magnetic storages based on thin film structures.

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