RK13

Ultrafast magneto-acoustic pulses in a nickel film

Jiwan Kim, Mircea Vomir and Jean-yves Bigot*
Physics, IPCMS, CNRS, France

We report about the ultrafast magnetization dynamics induced by magneto-acoustic pulses in a 200-nm-thick Ni film generated with femtosecond laser pulses. The magneto-acoustic pulses result from the coupling between the magnetization and the acoustic waves generated by the laser pulses. In order to distinguish between dynamical magnetic effects induced either by the thermal excitation or by the magneto-acoustic pulse, the spin dynamics is measured from both the front and rear sides of the film via the magneto-optical Kerr technique. It is found that the acoustic pulses excite the magnetization on both sides of the film and the perturbation of the magnetization is very efficient at the rear side (10% of the static one). Using a detailed modeling of magneto-acoustic pulses combining the concepts of acoustic pulse propagation and ultrafast magnetization dynamics, we reproduce the magnetization dynamics on both sides of the film. In addition, our results imply that the magnitude of magneto-acoustic pulses can be controlled and maximized by selecting proper substrates with same ferromagnetic materials. We forecast that our results will have a strong impact for making ultrafast magneto-acoustic devices, with the capability of sensing the magnetization at relatively long distances from acoustic pulses generated by the laser pulses.

RK14

Minimal precessional and switching currents for relaxing-precessional magnetization reversal within a spin valve

Jui-hang Chang*, Hao-hsuan Chen and Ching-ray Chang
Physics, National Taiwan University, Taiwan

The relaxing-precessional magnetization reversal [1] is studied from the point of view of nonlinear dynamics. The solution of the Landau-Lifshitz-Gilbert equation with spin-transfer toque [2] shows that there are two critical values, α_{cs} and α_{cp}, for the damping constant, and $\alpha_{cs} < \alpha_{cp}$. Above α_{cs} the minimal switching current a_s is the same as the modified Stoner-Wolfarth (SW) limit [3] a_{cs} for the switching, and above α_{cp} the minimal precessional current a_p is the same as the modified SW limit a_{cp} for the onset of precession. For a given magnetic anisotropy and an arbitrary in-plane bias field, condition $a_s < a_{cs} < a_p < a_{cp}$ always happen, where a_s, a_p are functions of α_s, α_p, respectively. These investigations will be of importance for the design of spin-torque-transfer magnetic random access memories [4] and nano oscillators [5].

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RK15

Time dependent dichroism induced near the surface plasmon of Au nanoparticles

Jean-Yves Bigot[1]* and Minji Gwon[2]
[1] *Institute de Physique et Chimie des Materiaux de Strasbourg, CNRS, Universite de Strasbourg, Korea*
[2] *Ewha Womans University, Korea*

We have studied the Surface Plasmon (SP) dynamics of Au Nanoparticles, with a diameter of 50 nm, excited by circularly polarized femtosecond laser pulses. We report about a new effect observed in a time resolved pump-probe experiment, analyzing the polarization state of the probe pulses. It manifests as a circular dichroism and an optical rotation induced in the vicinity of the SP when pumping with left (σ+) or right (σ-) circularly polarized pulses. We attribute this effect to a time dependent change of the orbital momentum of conduction electrons as the effect is more pronounced when the nanoparticles are excited with a pump wavelength -pump = 800 nm as compared to 400 nm. Indeed, in that case the interband transitions from the d-band to the conduction band are minimized with respect to the Drude electrons. The induced dichroism is resonant on the SP (560 nm). Its lifetime is comparable to the energy relaxation time of the quasiparticles to the lattice. It suggests that the electron-phonon interaction is the main mechanism for the dissipation of this pump induced orbital momentum. The detailed behavior of the SP dynamics as a function of probe wavelength, pump polarization and pump-probe delay will be discussed.

RK16

The effect of surface anisotropy on the switching of a particle magnetic moment

Shuang Guo and An Du*
Physical department, Northeastern University, China

The effect of surface anisotropy on the switching of a particle magnetic moment Shuang Guo, An Du* College of Sciences, Northeastern University, Shenyang 110004, China * Corresponding author(du_an_neu@126.com) The dynamic precession of the moment for a spherical particle in a microwave field was studied by using Landau-Lifshitz-Gilbert (LLG) equation. The spins inside the particle have single-ion anisotropy and the ones on the surface of the particle have the surface anisotropy normal to the surface. The switching field threshold was calculated for different surface anisotropy with definite microwave frequency. It is found that the surface anisotropy influences the switching field threshold, with the increase of the surface anisotropy, the threshold increases, the switching speed of the magnetic moment increases obviously.

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RK17

Magnetization dynamics of GdFeCo nanostructures revealed with PEEM

Souliman El Moussaoui[1]*, Loic Le Guyader[1], Michele Buzzi[1], Elena Mengotti[1], Laura J. Heyderman[1], Frithjof Nolting[1], Thomas A. Ostler[2], Joe Barker[2], Richard F. L. Evans[2], Roy Chantrell[2], Arata Tsukamoto[3], Akiyoshi Itoh[3], Andrei Kirilyuk[4], Theo Rasing[4] and Alexey V. Kimel[4]
[1] *Paul Scherrer Institut, Switzerland*
[2] *Department of Physics, University of York, United Kingdom*
[3] *Nihon University, Japan*
[4] *Radboud University Nijmegen, Institute for Molecules and Materials, Netherlands*

The manipulation of spins is a very exciting topic from fundamental point of view as well as for practical applications. Combining experiments and simulation, we have been able to demonstrate that a fs-optical excitation is sufficient to trigger magnetization reversal in GdFeCo nanostructures on very short timescales. Employing a photoemission electron microscope (PEEM) at the SIM beamline, we have proved that we can manipulate the magnetization of nanostructures by using a heat pulse only. Performing time resolved X-ray magnetic circular dichroism (TR-XMCD) measurement we have observed that the magnetization reversal within the structures occurs on a timescale faster than 100 ps and evidenced that the reversal occurs against an external applied magnetic field. In our experiment the reversal happens only by heating the system on the time scale of the exchange interaction of the two sublattices and does not require any other external stimulus.

'Ultrafast heating as a sufficient stimulus for magnetization reversal' T. A. Ostler, J. Barker, R. F. L. Evans, R. Chantrell, U. Atxitia, O. Chubykalo-Fesenko, S. El Moussaoui, L. Le Guyader, E. Mengotti, L. J. Heyderman, F. Nolting, A. Tsukamoto, A. Itoh, D. Afanasiev, B. A. Ivanov, A. M. Kalashnikova, K. Vahaplar, J. Mentink, A. Kirilyuk,Th. Rasing and A. V. Kimel, Nature Comm. 3, 666 (2012).

RK18

A study of magnetic domain and magnetization reversal in L-shaped Py

S.S. Lee, Wondong Kim, Byong Sun Chun and Chanyong Hwang*
Korea Research Institute of Standards and Science, Korea

The evaluation of characteristic of nanometer-sized magnetic domain is one of the most important issues in the fields of spintronics. We made the Py stripe with and without the L-shaped edge structure. First, magnetic domain and its reversal reversal behavior were simulated with the use of OOMMF program. Depending on the thickness, width of this L-shaped structure, magnetic domain and its reversal behavior could be classified in several groups. We also used scanning electron microscope with polarization analysis(SEMPA, or spin-SEM) to probe the magnetic domain pattern predicted in the simulation.

POSTER PRESENTATION

July 12 (Thu)

RK19

Ultrafast dynamics of ferromagnetic copd thin film by various polarized probe beam

S. H. Jung[1], M. H. Jung[1], Jin Pyo Hong[2], Won Dong Kim[3], Chanyong Hwang[3]* and Joo In Lee[3]
[1] *Department of Physics, Sogang University, Korea*
[2] *Department of Pysics, Hanyang University, Korea*
[3] *Center for Nano-imasing Technology, Korea Research Institute of Standards and Science, Korea*

We study ultrafast dynamics of the ferromagnetic CoPd thin film by using time-resolved magneto-optical Kerr effect. In the case of using linearly polarized probe beam, the spin precession is observed in the frequency of about 14 GHz in the range of large time scale. On the other hand, when the probe beam changes to circular polarization, the large time scale precession disappears, and ultrafast precession (~100GHz) is observed in short time scale. We suppose that these result from the momentum change of probe beam from 0 to 1, and the ultrafast precession is related to interaction between spin and circularly polarized photon.

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RK20

Low temperature time domain THz spectroscopy of terbium gallium garnet crystals

Rostislav V. Mikhaylovskiy*, Euan Hendry, Feodor Y. Ogrin and Volodymyr V. Kruglyak
School of Physics, University of Exeter, United Kingdom

We have used the terahertz (THz) time domain spectroscopy to study high frequency magnetic excitations in terbium gallium garnet (TGG) crystals cut along <111> and <001> crystallographic planes. We demonstrate that a THz bandwidth transient electromagnetic pulse can efficiently couple to magnetic moments in TGG. By comparing the spectrum of the pulse before and after transmission through the crystal, we are able to isolate the absorption corresponding to magnetic resonance modes of TGG. We measure and discuss the dependence of the observed modes upon the temperature and the strength and orientation of the bias magnetic field with respect to the crystallographic axes of the crystals. The magnetic modes are present at temperatures above the Neel point, which is interpreted in terms of the field-induced magnetic ordering. The illumination of the crystal with intense optical pulses with wavelength close to the TGG absorption band destroys the magnetic ordering. Thus, the light induced demagnetization of TGG is observed. Our findings demonstrate that the time domain THz spectroscopy can be a powerful tool by which to study high frequency properties of dielectric magnetic materials.

RK21

Ferromagnetic resonance of a single micron dot using vector network analyzer

Kazuto Yamanoi[1], Satoshi Yakata[2], Takashi Kimura[2] and Takashi Manago[1]*
[1] *Department of Applied Physics, Fukuoka University, Japan*
[2] *Inamori Frontier Research Center, Kyusyu University, Japan*

Magnetization dynamics of small ferro-magnets in the gigahertz region have been investigated intensively for the applications in microwave devices. It is based on the precessional motion of magnetization and it is necessary to control one of each small magnets in devices. In this paper, we investigated ferromagnetic resonance (FMR) of a single miconscale dot of permalloy (Py) using a vector network analyzer (VNA). A micron-scale Py dot and a coplanar wave guide were fabricated using electron beam lithography, electron beam evaporation and lift off technique. The thickness of the Py dots was 30 nm, and the shapes were square and rectangle with a width and length of 1~10 um and 1~40 um, respectively. The FMR measurement was performed using the VNA and probe station. In the square shape dot of 10 um, the resonant frequency depends on magnetic fields, which was good agreement with the Kittel's equation of a thin film. In the rectangle shape dots, the resonant frequency shifted to higher frequency with increasing length. This tendency was remarkable for 1 um-width dots. It means that demagnetization effect becomes large when the width is less than 1 um for a thin film.

RK22

Relation between gilbert damping constants and perpendicular magnetic anisotropy in Ti buffered Co/Ni multilayers

Hyonseok Song[1], Kyeong-dong Lee[1], Jeong-woo Sohn[1], See-hun Yang[2], Stuart S.p. Parkin[2], Chun-yeol You[3] and Sung-chul Shin[4]*
[1] *Department of Physics and Center for Nanospinics of Spintronic Materials, KAIST, Daejeon 305-701, Korea*
[2] *IBM Research Division, Almaden Research Center, San Jose, California 95120, USA*
[3] *Department of Physics, Inha University, Incheon 402-751, Korea*
[4] *Department of Physics and Center for Nanospinics of Spintronic Materials, KAIST, Daejeon 305-701, Department of Emerging Materials Science, DGIST, Daegu 711-873, Korea*

Recently, there has been a growing interest in spin-transfer-torque magnetic random access memory utilizing perpendicularly magnetic anisotropy (PMA) materials in order to overcome thermal stability problems. Since the critical current density depends on the Gilbert damping parameter, it has been an important issue to understand and manipulate the Gilbert damping parameter in the PMA materials. In this work, we have investigated PMA [Co/Ni] multilayers with Ti buffer layers by an all-optical pump-probe time resolved magnetic optical Kerr effect (TR-MOKE). In particular, we have studied the variation of Gilbert damping constant (α) and PMA as a function of the thickness of Ti buffer layer thickness (t). Since the PMA and damping constant are strongly related with the spin-orbit coupling, both physical quantities must be correlated. Clear damped oscillations of the magnetization are observed in TR-MOKE measurements. After background subtraction, the signal is fitted with a damped harmonic function, from which the precession frequency (f) and the decay time (τ) are deduced. We obtained f and τ by fitting with Landau-Lifshitz-Gilbert equation, and we could be estimated α. We find that The α and PMA values increased monotonically with increasing of t. This result clearly shows close relationship between PMA and α.

RK23

Chaotic motion of magnetic domain structure under alternate field

Michinobu Mino* and Yousuke Yamamoto
Department of Physics, Okayama University, Japan

Magnetic domain motion in a garnet thin film under alternate magnetic fields up to 5000 Hz has been investigated at room temperature. Domain structures and motions are observed by using a high-speed video camera with the help of magneto-optical Faraday effect. When a field frequency is low, the magnetization changes periodically and a domain pattern has a labyrinth structure. By increasing the field amplitude and driving frequency, irregular oscillations of a magnetization appear. Under a rapidly oscillating field, chaotic motions of domain are observed. In this region, domain structures have a disk-like shape. These disks grow from some crystal defects. And a growing point shows a branch-like form.

RK24

Demagnetization dynamics observed by spin-resolved ultrafast x-ray photoemission

Thomas Michlmayr
Physics, ETH Zurich, Switzerland

We report on the experiment and the results of time- and spin-resolved photoemission. Ultrafast demagnetization was first observed by Beaurepaire et al. in 1996 and many approaches where done to support these findings. Our method allows for measuring the whole valence band mediated by the cascade electrons emerging from the sample and therefore gives a direct measure of the sample's magnetization. Ultrafast demagnetization is observed on thin films of Fe on W(110) by optical pumping at 800 nm and x-ray probing at 7 nm. The measured demagnetization time of 450 fs is limited by the experiment. Although space charge effects limits the photoelectron gain the measured spin asymmetry stays almost constant with increasing x-ray flux and only drops at very high x-ray fluxes (> 4 nJ/pulse). We also show the feasibility of single shot magnetic measurement. The experimental setup consists of a completely mobile two chambers ultra-high vacuum system (preparation and measurement chamber) with Mott-polarimeter which can be brought to the free electron laser FLASH, Hamburg.