Symposium Tailoring magnetism in $L1_0$-ordered nanostructures: Perspectives for magnetic recording beyond 1 Terabit/in^2 (SYTM)

jointly organized by
the Magnetism Division (MA),
the Metal and Materials Physics Division (MM), and
the Thin Films Division (DS)

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Overview of Invited Talks and Sessions

(lecture room H 0105)

Invited Talks

SYTM 1.1	Mon	9:30–10:00	H 0105	**Thermally Assisted Magnetic Recording at 620 Gb/in^2 using Granular $L1_0$ FeCuPtAg-X Media** — •D. Weller, O. Mosendz, S. Pisana, T. Santos, G. Parker, J. Reiner, B. C. Stipe
SYTM 1.2	Mon	10:00–10:30	H 0105	**Large-area hard magnetic $L1_0$-FePt and composite $L1_0$-FePt based nanopatterns** — •Dagmar Goll, Thomas Bublat
SYTM 1.3	Mon	10:30–11:00	H 0105	**Electric field control of magnetic exchange coupling in FePt / Fe-O thin fims** — •Karin Leistner
SYTM 1.4	Mon	11:00–11:30	H 0105	**FePt-based exchange coupled composite media** — •Manfred Albrecht
SYTM 1.5	Mon	11:30–12:00	H 0105	**Optimization of FePt films for recording applications by micromagnetic modeling** — •Josef Fidler, Jehyun Lee, Barbara Dymerska, Dieter Suess

Sessions

SYTM 1.1–1.5	Mon	9:30–12:00	H 0105	**Tailoring magnetism in $L1_0$ ordered nanostructures: Perspectives for magnetic recording beyond 1 Tb/in^2**

SYTM 1: Tailoring magnetism in $L1_0$ ordered nanostructures: Perspectives for magnetic recording beyond 1 Tb/in^2

Time: Monday 9:30–12:00 Location: H 0105

Invited Talk SYTM 1.1 Mon 9:30 H 0105
Thermally Assisted Magnetic Recording at 620 Gb/in^2 using Granular $L1_0$ FeCuPtAg-X Media — •D. Weller, O. Mosendz, S. Pisana, T. Santos, G. Parker, J. Reiner, and B. C. Stipe — Hitachi Global Storage Technologies, San Jose Research Center, San Jose, CA USA

Highly $L1_0$-ordered FeCuPtAg-X (X=C, BN, ...) nano-granular thin films as potential thermally-assisted magnetic recording (TAR) media have been studied. These films are fabricated in a flexible sputter system allowing deposition of appropriate adhesion, heat sink and structural seed layers before growing FeCuPtAg-X at elevated temperature to induce chemical $L1_0$ ordering and to optimize grain size, grain distribution and texture. Typical seed layers are 5-10 nm thick MgO (002) with rocking curve widths of FWHM ~4 deg. Granular FeCuPtAg-X films with thickness of ~7 nm and well isolated grains have room temperature coercivities up to ~5 T, depending on growth temperature and grain isolation. The Curie temperature is reduced to 600-650K by adding about 10 at% Cu, which is used to adjust (lower) the heating power needed during recording. So far, static tester experiments on our best optimized media using a TAR head demonstrate areal densities up to AD~620-650 Gbits/in^2. The goal is to optimize media and extend AD beyond Tb/in^2, which is one of the key projects going forward.

While the focus of this talk is on heat assisted magnetic recording (HAMR or TAR), we will also mention alternative technologies to move beyond the superparamagnetic limit of today's perpendicular magnetic recording (PMR). These include Shingled Write Recording (SWR), Microwave Assisted Magnetic Recording (MAMR) and Bit Patterned Magnetic Recording (BPMR).

Invited Talk SYTM 1.2 Mon 10:00 H 0105
Large-area hard magnetic $L1_0$-FePt and composite $L1_0$-FePt based nanopatterns — •Dagmar Goll[1] and Thomas Bublat[2] — [1]Hochschule Aalen, Institut für Materialforschung, Aalen — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart

Bit-patterned media is a very promising concept for next generation ultrahigh density magnetic recording. Large-area hard magnetic $L1_0$-FePt based nanopatterns with dot sizes between 40 nm and 100 nm and out-of-plane texture were fabricated by using a top-down approach [1,2]. For the fabrication process ultraviolet nanoimprint lithography in combination with inductively coupled plasma reactive Ar-ion etching has been used. By this technique continuous epitaxially grown $L1_0$-FePt films were nanostructured into a regular arrangement of nanodots over an area of 4 mm^2. In the as-etched state the morphology of the dots corresponds to the morphology of phase graded $L1_0$-FePt/A_1-FePt composite particles with coercivities up to 1.7 T at RT. After post-annealing the morphology of the dots is of pure $L1_0$-FePt resulting in coercivities up to 4.4 T. Within the framework of micromagnetism the magnetic reversal mechanism of the different types of nanodots has been analyzed from the temperature dependence and angular dependence of the reversal field. For the as-etched dots magnetization reversal takes place by a domain wall induced process and for the post-annealed dots by a uniform nucleation process. Additionally composite $L1_0$-FePt/Fe nanopatterns were produced from continuous bilayers and characterized. [1] T. Bublat, D. Goll, Nanotechnology 22 (2011) 315301. [2] T. Bublat, D. Goll, J. Appl. Phys. 110 (2011) 073908.

Invited Talk SYTM 1.3 Mon 10:30 H 0105
Electric field control of magnetic exchange coupling in FePt / Fe-O thin fims — •Karin Leistner — IFW Dresden, 01171 Dresden, Germany

Electric control of magnetism is a vision which drives intense research on magnetic semiconductors and multiferroics. Recently, also ultrathin metallic films were reported to show magnetoelectric effects at room temperature. Here we demonstrate much stronger effects by exploiting phase changes in a naturally grown oxide layer exchange coupled to an underlying ferromagnet. For the exemplarily studied FePt/iron oxide composite, a large and reversible change of magnetic moment and anisotropy is obtained. As the principle can be transferred to various metal/oxide combinations, this versatile approach represents a key step towards multifunctional materials, applicable in magnetic data storage and nanoactuators.

Invited Talk SYTM 1.4 Mon 11:00 H 0105
FePt-based exchange coupled composite media — •Manfred Albrecht — Institute of Physics, Chemnitz University of Technology, 09126 Chemnitz, Germany

In order to continue the areal density increase in magnetic hard disk drives, it is necessary to develop media that support very small bit sizes, while maintaining thermal stability as well as writability of the bits. One potential candidate as a recording layer are L10 chemically ordered FePt alloys which exhibit a huge magnetic anisotropy value. However, the magnetic field required to switch the magnetization of one individual FePt bit typically exceeds the maximum available write field. To solve this so called writability issue in magnetic data storage, a recording concept known as exchange coupled composite (ECC) media aiming to lower the switching field of individual bits was proposed. ECC films consist of a high anisotropy layer coupled to a low anisotropy layer and have been shown to combine both thermal stability and low coercivity for writability. Such ECC structures are also attractive for bit patterned media (BPM), where the bits are individual pillars of magnetic material that are defined by lithography.

In this presentation I will focus on L10 ordered FePt-based ECC thin films and nanostructures fabricated by nanoimprint lithography. Films were transformed to the L10 phase by rapid thermal annealing. I will show that the combination of ECC media with BPM reveals superior properties compared to single layer BPM, as it leads to a significant reduction in the switching field and a substantial narrowing of the switching field distribution.

Invited Talk SYTM 1.5 Mon 11:30 H 0105
Optimization of FePt films for recording applications by micromagnetic modeling — •Josef Fidler[1], Jehyun Lee[1,2], Barbara Dymerska[1], and Dieter Suess[1] — [1]TU Wien, Inst. für Festkörperphysik, Austria, — [2]Seoul National University, Rep Korea.

The ordered FePt/L10 phase with high magnetocrystalline anisotropy is a candidate for achieving an areal magnetic storage density beyond 1 Tbit/inch2. The switching field of individual grains and bits has to be reduced due to the limitations of the write head. Exchange coupled composite and graded media have been suggested to reduce the nucleation/coercive field and keeping the high thermal stability[1]. The present study will discuss the combination of the ordered fct FePt/L10 phase and the disordered fcc FePt/A1 phase[2]. TEM investigations revealed a complex transformation from the disordered to the ordered phase and a rough interphase including spikes/tips depending on the deposition temperature and cooling rate. Numerical FE micromagnetic simulations of such phase graded media show that the roughness strongly influences the domain wall propagation during the magnetic reversal process from the soft to the hard phase. As a result, the Hc of the phase graded media was reduced to 13 kOe which is 16% of FePt L10 single phase (79 kOe)[3].

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[1] D. Suess et al., Appl Phys Lett 87 (1), 012504 (2005). [2] V. Alexandrakis et al., J Appl Phys 109, 07B729 (2011). [3] J. Lee et al., Appl Phys Lett 98 (22), 222501 (2011).