MA 24: FV Internal Symposium in honour of Nobelprice 2007 to Peter Grünberg and Albert Fert

Time: Thursday 9:30–11:30 Location: EB 301

Invited Talk MA 24.1 Thu 9:30 EB 301

Physics and applications of tunneling magnetoresistance effect — •Shinji Yuasa — National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki 305-8568, Japan

A magnetic tunnel junctions (MTJ), which consists of an ultra-thin insulator (a tunnel barrier) sandwiched by two ferromagnetic electrode layers, exhibits tunneling magnetoresistance (TMR) effect due to spin-dependent electron tunneling. Since the discovery of room-temperature TMR effect in 1995, MTJs with an amorphous Al-O tunnel barrier have been extensively studied and are currently used in magnetoresistive random-access-memory (MRAM) and read head of hard disk drive (HDD). These conventional MTJs show magnetoresistance (MR) ratios of up to about 70% at room temperature. However, MTJs with much higher magnetoresistance are desired for next-generation MRAM and HDD. In 2001, first-principle theories predicted the MR ratios above 1,000% in epitaxial Fe(001)/MgO(001)/Fe(001) MTJs with a crystalline MgO(001) tunnel barrier as a result of coherent spin-dependent tunneling. In 2004, giant MR ratios of about 200% at room temperature (RT) were experimentally achieved in fully epitaxial MgO-based MTJs and (001)-oriented poly-crystalline (textured) MgO-based MTJs. Novel CoFeB/MgO(001)/CoFeB MTJ structure, which is highly compatible with mass-manufacturing processes of MRAM and HDD read head, was also developed, and giant MR ratios above 200% up to 500% at RT have been achieved. Giant TMR effect in MgO-based MTJs is of great importance not only for developing various spintronic devices but also for clarifying the physics of spin-dependent tunneling.

Invited Talk MA 24.2 Thu 10:00 EB 301

From giant magnetoresistance to current-induced magnetic switching: theoretical aspects — •Jozef Barnas — Department of Physics, Adam Mickiewicz University, Poznań, Poland

The presence of two well-defined and strongly spin-dependent transport channels in ferromagnetic metals leads to the phenomenon of giant magnetoresistance (GMR) in magnetic layered structures. The discovery and successful applications of GMR led to a new branch of mesoscopic electronics, called spin electronics or briefly spintronics. Some basic theoretical aspects related to the GMR in magnetic multilayers as well as those related to semiconductor and molecular spintronics will be briefly discussed. Another consequence of the presence of two spin channels for electronic transport (and also of the discovery of GMR) is the phenomenon of current-induced magnetic switching (CIMS) due to spin torque. The latter is a consequence of spin transfer from conduction electrons to local magnetic moments. The spin torque can generate transitions between different local (quasi)equilibrium states. At some conditions, however, the spin-transfer torque may cause transition to dynamical states of microwave frequency, where the energy is pumped from a voltage source to the magnetic system. Of particular interest are structures, in which the microwave precessional states can be induced in the absence of external magnetic field.

Invited Talk MA 24.3 Thu 10:30 EB 301

Magnetoresistive Sensors and Magnetic Nanoparticles for Biotechnology — •Günter Reiss, Andreas Hütten, Inga Ênnen, Alexander Weddemann, Andy Thomas, and Jan Schmalhorst — Bielefeld University, Physics Department, P.O. Box 100131, 33501 Bielefeld, Germany

Detection as well as manipulation of biomolecules on one technological platform is important for both basic research as well as for numerous applications. The discovery of the Giant Magnetoresistance enabled the vision of a magnetoresistive Biochip: The detection of small magnetic carriers1 with tailored magnetoresistive sensors can create a completely electronic (bio-) chip capable of detecting antibodies or DNA fragments2. Moreover, this system would be compatibel with important developments in microelectronics, namely read heads and MRAM. Different configurations are discussed and the results for GMR sensors are compared to an analysis of the same systems marked with fluorescence dyes. This shows, that down to a low concentration of, e.g., DNA molecules, the magnetoresistive technique is competitive to nowadays standard analysis methods. The capability of the Tunneling Magnetoresistance sensors to detect even single markers as well as on chip manipulation of the carriers are additionally demonstrated.

1 G. Reiss, A. Hütten, Nature Materials News and Views, 4 (2005) 725

2 W. Schepper et.al., Physica B-Condens. Mat. 372 (2006) 337

Invited Talk MA 24.4 Thu 11:00 EB 301

Status and Future of Magnetic Recording — •Dieter Weller — Seagate Technology, 47010 Kato Rd, Fremont, CA 94538

The areal density in magnetic recording continues to grow at 40% per year. This growth is fueled by advancements in recording heads and media as well as improvements in the systems architecture and channels electronics. Perpendicular magnetic recording (PMR) was introduced in 2005 at 130 Gbit/in^2 and is now deployed across all product lines at densities up to 250 Gbit/in^2. Laboratory demos show that 520 Gbit/in^2 in PMR and 602 Gbit/in^2 in Discrete Track Recording (DTR) [Western Digital and TDK in October, 2007] are possible. Component technologies are tunneling magneto-resistance (TMR) heads and granular CoCrPt based perpendicular media with soft underlayers. Discrete tracks help to reduce the adjacent-track erasure effect and allow for higher track density. It is expected that a combination of PMR and DTR will enable Tbit/in^2 densities by 2010. At that point major changes in the heads and media are needed to support further extensions. The two vital options are (1) to scale the media to smaller grain size but use harder magnetic materials, which require write assist to allow recording in Heat Assisted Magnetic Recording (HAMR) and (2) to lithographically make thermally stable islands and record one bit on each one of them in Bit Patterned Media (BPM).