Nanomaterials
Room Hau - Session NM-MoM

Magnetic Properties

Moderator: Yoshiaki Nakamura, Osaka University, Japan

8:20am **NM-MoM2 Effect of Segregation of sp-Impurities on Surface and Grain Boundary Magnetism in Nanocrystalline Nickel and Cobalt***, **Mojmir Sob**, M. Vsianska, H. Vemolova,* Masaryk University, Czech Republic

We present a systematic ab initio study of segregation of 12 non-magnetic sp-impurities (Al, Si, P, S, Ga, Ge, As, Se, In, Sn, Sb and Te) at Σ5(210) grain boundary (GB) and (210) free surface (FS) in fcc nanocrystalline ferromagnetic cobalt and nickel and analyze their effect on structure, magnetic and mechanical properties. In nanocrystalline nickel, most of the above impurities nearly kill or substantially reduce the magnetic moments at the FS and, when segregating interstitially (i.e. Si, P, S, Ge, As, Se), also at the GB so that they provide atomically thin magnetically dead layers which may be very desirable in spintronics. We demonstrate that the existence of magnetically dead layers is a common phenomenon at the sp-impurity-decorated GB and FS in nickel. It is caused by a strong hybridization of sp states of the impurities with the d states of nickel and a redistribution of electron states in both majority and minority bands. Reduction of magnetic moments at the Σ5(210) GB in fcc nanocrystalline cobalt is, in absolute values, very similar to that in nickel. However, as the magnetic moment in bulk cobalt is higher, we do not observe magnetically dead layers here. It turns out that by focused impurity segregation we can generate atomically thin magnetic layers with tailored magnetization, which can contribute to a new development of technologically important materials.

8:40am **NM-MoM3 Reversible Single-Molecular Manipulations of Spin Trans-Effect in Co-porphryin/Au(111) with Conserved Spin Moment***, M.H. Chang,* Korea University, Republic of Korea*; Y.H. Chang,* orea Advanced Institute of Science and Technology (KAIST), Korea*; H. Kim,* Korea University, Republic of Korea*; S.-H. Lee,* Korea University*; Y.-H. Kim,* Korea Advanced Institute of Science and Technology (KAIST), Korea*; **Se-Jong Kahng**,* Korea University, Korea

Controlling spin interactions in magnetic-molecules/metal is essential for spintronic molecular device applications. It has been considered that small molecule coordination to magnetic-molecules/metal can be used to reset molecular spins from 1/2 to zero and from zero to 1/2. However, the study on the control of spin interactions without changing spin moment of magnetic-molecules has been rare. Here, we demonstrate that spin interactions in Co-porphyrin/Au(111) can be controlled while spins being conserved, by coordination and de-coordination of small gaseous molecules, using scanning tunneling microscopy and spectroscopy (STM and STS). With small moleculecoordination, we observed that a zero-bias peak at Co-porphryin, a signature of Kondo effect in STS, remained but was clearly showed reduced width i.e. Kondo temperature, and that it could be reversibly retrieved by single molecular STM manipulations. Based on our density functional theory calculation results, the reduced Kondo temperature is explained with the relocation of unpaired spins in d_z2 orbitals of Co-porphyrin by vertical coordination of small molecules. Our study shows that with conserved spin moment in magnetic-molecules/metal, spin version of trans-effect can be directly probed through Kondo effect with STS.

9:00am **NM-MoM4 Current-induced Magnetic Domain Wall Motion and its Application***, **Teruo Ono**,* Kyoto University, Japan **INVITED**

Current-induced magentic domain wall motion has been attracted much attention both from scientific and technological points of view [1]. When a magnetic DW is driven by electric current via adiabatic spin torque, the theory predicts a finite threshold current even for a perfect wire without any extrinsic pinning [2]. We have shown that this intrinsic pinning determines the threshold current, and thus that the adiabatic spin torque dominates the DW motion resulting in DW motion along electron flow direction, in a perpendicularly magnetized Co/Ni system sandwiched by a symmetric capping and seed layers [3-9]. On the other hand, current-induced DW motion against electron flow direction has been observed in ultrathin magnetic films in which the structural inversion symmetry (SIA) was broken [10, 11]. Recently, this DW motion against electron flow direction has been explained by the combination of a chiral DW and spin Hall torque [12, 13].In this presentation, I will show the systematic investigation by changing thickness of Co/Ni layer and discuss the contribution of adiabatic spin transfer torque, and spin Hall torque in the current-induced DW motion. I will also discuss possible applications using the current-induced DW motion.

This work was partly supported by a Grant-in-Aid for Scientific Research on Innovative Areas, Grant-in-Aid for Specially Promoted Research, and R & D Project for ICT Key Technology of MEXT.

[1] A. Yamaguchi et al., Phys. Rev. Lett. 92 (2004) 077205.

[2] G. Tatara & H. Kohno, Phys. Rev. Lett. 92 (2004)086601.

[3] T. Koyama et al., Nature Materials 10 (2011) 194.

[4] T. Koyama et al., Appl. Phys. Lett. 98 (2011) 192509.

[5] D. Chiba et al., Appl. Phys. Express 3 (2010) 073004.

[6] T. Koyama et al., Appl. Phys. Express 1 (2008) 101303.

[7] T. Koyama et al., Nature Nanotechnology 7 (2012) 635.

[8] Y. Yoshimura et al., Appl. Phys. Express 5 (2012) 063001.

[9] K-J. Kim et al., Nature Communications 4, (2013) 2011: doi:10.1038/ncomms3011.

[10] I. M. Miron et al., Nature Materials. 10, (2011) 419.

[11] T. Koyama et al., Appl. Phys. Express 6 (2013) 033001.

[12] S. Emori, et al., Nat. Mater. 12, (2013) 611.

[13] K. S. Ryu, et al., Nat. Nanotech. 8, (2013) 527.

9:40am **NM-MoM6 Reconfigurable Nano-Structured Magnetic Metamaterials for Magnonic Logic***, **Andrei Slavin**, I.V. Lisenkov, V.S. Tyberkevych,* Oakland University, USA

Artificial magnetic metamaterials formed by arrays of dipolarly coupled magnetic nanodots are promising candidates for applications in microwave signal processing. It has been shown recently, that an array of magnetic dots can be used as a reconfigurable magnonic metamaterial (RMM), since its metastable static state (and the corresponding microwave characteristics) can be switched by application of a pulse of a bias magnetic field [1-3].

In this work we present a theory of switching of a metastable static state in a magnetic metamaterial formed by an array of identical dipolarly coupled nanodots under the action of a short (duration of the order of 10-100 ns) magnetic field pulse. It is shown that a large array of magnetic dots cannot be switched into a perfect periodic antiferromagnetic state (AFM). Instead, the final state of an array after the end of the switching pulse comprises a set of clusters with the local AFM periodicity. The properties of the array's final state strongly depend on the duration of the trailing front τ_f of the switching field pulse. In particular, the average size of the AFM clusters in the final state increases as $A\sim \tau_f^{2/3}$. This increase in the regularity of a final state is limited by the thermally activated dot magnetization reversals that become possible if the switching field decreases too slowly. In particular, our results show that the distance of the signal propagation in a chain of magnetic dots may be increased by application of a clock pulse having a long trailing front. It is also demonstrated that using magnetic metamaterials it is possible to design of a magnonic phase shifter operating without an external bias magnetic field. The phase shifter uses a localized collective spin wave mode propagating along a domain wall "waveguide" in a dipolarly-coupled magnetic dot array with a chessboard antiferromagnetic (CAFM) ground state. It is also demonstrated numerically that the remagnetization of a single magnetic dot adjacent to the domain wall waveguide introduces a controllable phase shift in the propagating spin wave mode without significant change to the mode amplitude. Thus, it is possible to realize a logic XOR gate in the same system.

References:

1. J. Topp, et al., Phys. Rev. Lett. **104**, 207205 (2010).

2. S. Tacchi, et al., Phys. Rev. B **82**, 184408 (2010).

3. R. Verba, et al., Appl. Phys. Lett. **100**, 192412 (2012).

Author Index

Bold page numbers indicate presenter