## Magnetic Interfaces and Nanostructures
## Room 304A - Session MI-WeM

### Magnetic Nanostructures

**Moderator:** R.A. Lukaszew, University of Toledo

8:20am **MI-WeM1 Structural and Magnetic Properties of Ultrathin Co Film Grown on Pt(100)***, M.H. Pan, K. He, L.J. Zhang, J.F. Jia, Q.-K. Xue,* The Chinese Academy of Sciences, China*; **W.D. Kim,*** Univ. of California at Berkeley and KRISS, Korea*; Z.Q. Qiu,* Univ. of California at Berkeley

Ultrathin Co films were deposited on Pt(100) at room temperature in ultrahigh vacuum, and investigated in situ by Low Energy Electron Diffraction (LEED), Scanning Tunneling Microscopy (STM), and Surface Magneto-Optiic Kerr Effect (SMOKE). The Co film was grown into a wedged shape to provide a continuous change of the film thickness. We find that the Co film forms single crystal ultrathin films at least up to 5ML. For as grown films, we observe only in-plane magnetization. After annealing the film, the Co film develops a perpendicular magnetic anisotropy, leading to a spin reorientation transition at 2.7 ML Co thickness. STM measurements were performed at room temperature both before and after annealing the film. We found very different surface morphology and alloy formation after the film annealing, and attribute the perpendicular magnetic anisotropy to the formation of the Co-Pt alloy layer at the Co/Pt(100) interface.

8:40am **MI-WeM2 Structure and Magnetic Anisotropy of Ultrathin Co Films on Au(111) Vicinal Substrates***, **A. Tejeda**, G. Baudot,* Université Paris 7, France*; A. Coati,* Université Paris XI, France*; Y. Garreau,* Laboratoire Utilisation Rayonnement Electromagnetique, France*; Y. Girard,* Université Paris 7, France*; J.P. Jamet,* Université Paris XI, France*; V. Repain, S. Rohart, S. Rousset,* Université Paris 7, France

Nanostructured systems with magnetization along the surface normal are of technological interest for magnetic storing devices. We have studied ferromagnetic films of Co as they exhibit a strongly enhanced magnetic anisotropy with an easy axis perpendicular to the surface plane. Vicinal surfaces are a system model to control the roughness of the ferromagnetic films. We have deposited Co ultra-thin films on vicinal substrates of Au(111) in order to study the relationship between structure and magnetic properties. STM and Grazing Incidence X-ray Diffraction studies have been performed to determine the surface structure. X-ray diffraction shows that the vicinality of the substrate strongly modifies the Co film structure. While Co/Au(111) presents hcp structure, fcc Co is found on Au(233). Growth on an intermediate surface as Au(788) originates a structure with stacking faults. In a second part, we report on a magneto-optical study of the magnetic properties of these cobalt ultrathin films. In vicinal surfaces, the transition of the magnetisation from out-of-plane to in-plane orientation as a function of Co coverage appears in a more progressive way and at lower coverages than in Co/Au(111). Ex-situ measurements on samples passivated with a gold layer show an helicoidal reorientation transition. The easy axis of the magnetization changes from out-of-plane to in-plane, step parallel orientation. These results will be discussed in the light of the precise structural knowledge of these films.

9:00am **MI-WeM3 Growth and Magnetic Properties of Co Quantum-Platelets on Si(111) Surface***, **Q.-K. Xue,*** The Chinese Academy of Science **INVITED**

Self-organized Co platelets with a singular height and of equilateral triangular shape are fabricated on a Si(111)-7Ã-7 surface pre-decorated with an periodic array of Al magic nanoclusters, as observed using the scanning tunneling microscopy. The selection of such a singular height is attributed to the suppression of chemical reaction between Co and Si by the Al nanoclusters, and the corresponding improved confinement in the motion of the conduction electrons within the Co platelets. Such quantum platelets exhibit intriguing magnetic properties in the hysteresis loop, which is shown to reflect a synergism between magnetic dipole interactions and magneto-crystalline anisotropy of the platelets. The present study demonstrates a promising pathway to directly integrate magnetic nanostructures with Si-based electronic devices. @FootnoteText@ In collaboration with Ming-Hu Pan, Hong Liu, Jun-Zhong Wang, Jin-Feng Jia, Xiang-Rong Wang, J. T. Markert, C. K. Shih, Zi-Qiang Qiu, and Zhenyu Zhang.

9:40am **MI-WeM5 Ferromagnetic Stability in Fe Nanodot Assemblies on Cu(111) Induced by Indirect Coupling through the Substrate***, **M.A. Torija**[1],* Oak Ridge National Laboratory, University of Tennessee, Knoxville*; J.P. Pierce,* Oak Ridge National Laboratory, Sandia National Laboratories*; Z. Gai,* Oak Ridge National Laboratory, Peking University, China*; E.W. Plummer,* Oak Ridge National Laboratory, University of Tennessee, Knoxville*; J. Shen,* Oak Ridge National Laboratory

To first order, assemblies of nano-scale magnetic dots are superparamagnetic. In these systems, thermal energy, which causes fluctuation of the dots' magnetic moments, becomes significant enough to overcome the anisotropy energy barrier and randomize their orientation at the so-called blocking temperature. This typically occurs far bellow room temperature. In real nanodots assemblies, it has been generally recognized that the magnetic dipole-dipole interaction can affect the barrier height for flipping the spin of each individual dot as well as the collective magnetic behavior of the dot assembly. In this work, we report collective ferromagnetic behavior in two- dimensional Fe dot assemblies on the Cu(111) surface that persists above room temperature. Our ability to tune the average size and spacing of the dots enables us to investigate the relative contributions of the mechanisms that support this unexpectedly robust magnetic order. Our experimental results and simulations indicate that the high-Tc ferromagnetism cannot be explained by either magnetic anisotropy or dipolar interaction. Direct comparison of the Curie temperatures (Tc) of similar dots prepared on vaious substrates including Cu(100) and Ge(111) allows us to conclude that the observed high-Tc ferromagnetism for Fe dots on Cu(111) is a result of an indirect exchange interaction via the surface states of Cu(111) substrate.

10:00am **MI-WeM6 Exploring New Magnetic Properties in Coupled Magnetic Nanostructures***, **C. Won**, Y.Z. Wu,* University of California at Berkeley*; A. Scholl, A. Doran,* Lawrence Berkeley National Laboratory*; N. Kurahashi,* University of California at Berkeley*; H. Zhao,* 3 International Center for Quantum Structures, China*; Z.Q. Qiu,* University of California at Berkeley

Interaction between different magnetic entities in a magnetic nanostructure creates new properties that are not available in single phase bulk materials. In order to study how the magnetic interaction at nanometer scale generates new magnetic behaviors, we applied photoemission electron microscopy (PEEM) to investigate coupled magnetic nanostructures. The unique element-specific capability of PEEM allows the measurement of different magnetic species separately, thus enabling the identification of new magnetic properties caused the magnetic coupling. Several systems have been investigated by our group in the last a few years. In this talk, I will first give an overview of the research topics that we studied using PEEM. Then I will focus on a particular topic of magnetic phase transition in coupled magnetic layers. Co/Cu/Ni/Cu(100) and Co/Fe/Ni/Cu(100) are fabricated using epitaxial growth in which the Cu and Fe spacer layers controls the interlayer coupling between Co and Ni films. Element-specific measurements are performed to monitor the ferromagnetic to paramagnetic phase transitions of the Co and Ni films separately. Our results show that the interlayer coupling couples the magnetic fluctuations of the Co and Ni films to result in three types of magnetic phase transitions. A complete phase diagram is constructed in the Co-Ni thickness plane and a Monte Carlo simulation explains the conditions of having these three types of transitions.

10:20am **MI-WeM7 Self-assembled Ferroelectric/Ferrimagnetic BaTiO@sub3@-CoFe@sub2@O@sub4@ Nanostructures***, **H. Zheng**[2], J. Wang, Z. Ma, L. Mohaddes-Ardabili, T. Zhao, S.R. Shinde, S.B. Ogale, M. Wuttig, A. Roytburd, L. Salamanca-Riba,* University of Maryland, College Park*; S.E. Lofland,* Rowan University*; D. Viehland,* Virginia Tech*; D.G. Schlom,* Pennsylvania State University*; R. Ramesh,* University of California Berkeley

Ferroelectric/ferrimagnetic BaTiO@sub3@-CoFe@sub2@O@sub4@ (BTO-CFO) nanostructures have been synthesized by pulsed laser deposition using a single Ba-Ti-Co-Fe-Oxide ceramic target. Spinel CFO and perovskite BTO phases spontaneously separated during heteroepitaxial growth on single crystal SrTiO@sub3@ (001) substrates. It is shown that films are epitaxial in-plane as well as out-of -plane, with CFO nano-pillar arrays embedded in a BTO matrix. CFO pillars have uniform size and spacing. As the substrate temperature increases from 750 °C to 950 °C, the average lateral size of the pillars increases from ~9 nm to ~70 nm. Magnetic

[1] **Falicov Student Award Finalist**

[2] **Falicov Student Award Finalist**

measurements exhibit that all the films have a large uniaxial magnetic anisotropy with an easy axis normal to the film plane. It is calculated that stress anisotropy is the main contribution to the anisotropy field. We measured the ferroelectric and piezoelectric properties of the films, which correspond to the present of BTO phase. The temperature dependent magnetic measurements illustrate a coupling between the two order parameters of polarization and magnetization by a change in magnetization at the ferroelectric Curie temperature. This approach to the formation of self-assembled ferroelectric/ferromagnetic nanostructures is generic and manifests itself in other such spinel-perovskite systems, thus making it of great interest and value to a broad materials community. This work is supported by the NSF-MRSEC under contract No. DMR-00-80008.

10:40am **MI-WeM8 Artifically and Self Organized FePd(001) Nanoparticles: Fabrication, Magnetic and Magneto-Photonic Properties***,* ***A. Cebollada****,* IMM (CNM-CSIC), Spain*; C. Clavero, A. Bengoechea,* IMM (CNM-CSIC) Spain*; J.L. Costa Kramer, A. Garcia-Martin, J.V. Anguita, G. Armelles,* IMM (CNM-CSIC), Spain*; Y. Huttel,* ICMM (CSIC), Spain*; L.l. Balcells,* ICMAB (CSIC), Spain*; V.F. Puntes,* Univ. de Barcelona, Spain **INVITED**

The fabrication and investigation of ordered arrays of high anisotropy and magneto-optic activity L10 FePd nanoparticles is reported. These arrays of particles are grown in 2 and 3 dimensions and embedded on single crystalline MgO(001) substrates and matrices. The deposition conditions are optimised to obtain the chemically ordered L10 phase. Several approaches are followed to obtain two dimensional nanostructured arrays: self organization, artificial generation of nucleation centres prior to growth and post growth patterning using e-beam lithography and nano-masks. The deposition of an epitaxial MgO matrix that conformally covers the FePd islands allows the subsequent growth of further FePd nano-particle layers, obtaining a 3D array of single crystalline high anisotropy particles embedded in an insulating matrix. The magnetization reversal, inter-particle magnetic interactions and magnetic anisotropies are studied in both 2D and 3D arrays, with special emphasis on the role that the reduction in dimensionality and the chemical and spatial order play in the magnetic properties. The characterization of the magneto optic and magneto photonic properties of these new materials is also performed in the same context.

11:20am **MI-WeM10 Properties of Magnetic Wires, Dots, and Dot Chains Fabricated via Epitaxial Growth***,* ***D. Li,*** Argonne National Laboratory **INVITED**

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