

Magnetic Interfaces and Nanostructures Division Room Union Station B - Session MI-ThP

Magnetic Interfaces and Nanostructures Poster Session

MI-ThP1 Room Temperature Skyrmion in Alternative Layer Molecular Beam Epitaxial Grown B20 Fe-rich Fe_{1.2}Ge Films, *Tao Liu, R. Bennett, S. Chen, A. Ahmed, R. Kawakami*, The Ohio State University

Magnetic Skyrmions are localized, topological spin textures that arise from competition between exchange interaction and Dzyaloshinskii-Moriya interaction (DMI) in magnetic materials with broken inversion symmetry. Their topological stability, small size, and the ability to be very energy efficiently written, read and manipulated, put them at the forefront of candidates for next generation storage technology. However, it is still challenging to find a material which can achieve skyrmion at room temperature with size no more than 10 nm, which has already become a major bottleneck of their developments. In order to realize this goal, it requires strong exchange interaction strength J , which sets the temperature scale, and a large DMI strength D that determines skyrmion stability and size, Ja/D (a is the atomic lattice spacing). Current skyrmion research is focused on two classes of materials: metallic multilayers and B20 crystals. Neither of them can meet this challenge. Metallic multilayers can meet the criteria of room temperature operations, but with small DMI arising from surface inversion symmetry broken. B20 crystals have a large bulk DMI and nanoscale skyrmions with sizes down to 3 nm, but cannot achieve room temperature operations.

In this work, we successfully synthesized Fe-rich Fe_{1.2}Ge films by alternative layer molecular beam epitaxy at room temperature and adding extra Fe atoms at the Fe-sparse atomic layers. As shown in figure 1, the cross sectional TEM result indicated that the Fe-rich Fe_{1.2}Ge film is B20 structure. Its XRD peak position shift to a lower angle relative to FeGe film, which might be good evidence indicating the extra Fe atoms went into the B20 structure rather than formed another structure phase. The Curie Temperature of the Fe-rich Fe_{1.2}Ge film has been pushed above room temperature (RT), and the observing of clear topological Hall resistance with maximum value around $H=\pm 1.5$ kOe could be the result of stabilization of RT skyrmion.

MI-ThP2 Investigation of Exchange Bias in L1₀-MnGa/θ-MnN/MgO Bilayers, *Sneha Upadhyay*, Ohio University; *K. Meng, F.Y. Yang*, The Ohio State University; *D. Ingram, A.R. Smith*, Ohio University

Exchange bias, a shift in the center for the magnetic hysteresis loop of a magnetic material, has gained a lot of attention due to its application in spintronics. Generally, exchange bias is observed in layered magnetic structure like antiferromagnetic/ferromagnetic bilayers. In this work, the L1₀ MnGa ($T_c=590$ K) / θ-MnN ($T_N=660$ K) bilayer on MgO substrate was studied for the investigation of exchange bias motivated by the recent report of giant exchange bias using MnN as the antiferromagnet.[1]

These bilayers were prepared using molecular beam epitaxy, and the growth was monitored by *in-situ* RHEED. Three samples were grown with MnN thickness of 47 nm while L1₀ MnGa thicknesses were varied from 15nm, 3nm and 1 nm. During the growth, RHEED images were taken which showed some disorder and roughness on the surfaces especially for thinner ones. In order to observe exchange bias, these samples were field cooled through the Néel temperature and the hysteresis was taken at a specific applied field using SQUID. The measurements showed the presence of a small but finite exchange bias in the case of the 3 nm L1₀ MnGa/θ-MnN sample in the *in-plane* direction only, and the amount of loop shift from the origin was estimated to be 300 Oersted. The results were compared with the recent publication for the case of CoFeB/θ-MnN which showed giant exchange bias (3600 Oersted).

Although the field cooling procedure is important to observe exchange bias, in our previous measurements, we were unable to field cool through the high Néel temperature of MnN. Currently, we are working on a new field cooling capability in our MBE chamber and further plan to study the sample using *in-situ* spin-polarized scanning tunneling microscopy under an applied magnetic field. We also plan to repeat the SQUID measurements as well with the high-temperature, field-cooled sample.

[1] P. Zilske, D. Graulich, M. Dunz, and M. Meinert, "Giant perpendicular exchange bias with antiferromagnetic MnN," *Appl. Phys. Lett.* **110**, 192402 (2017).

MI-ThP3 Investigating a Possible Kondo Resonance for Iron-induced Islands on Chromium Nitride (001), *K. Alam, Y. Ma, Shyam Chauhan, S.R. Upadhyay, A.R. Smith*, Ohio University

Chromium and iron surfaces have been of intense interest due to their high technological importance. Stroschio *et al.* investigated the electronic states of Fe(001) and Cr(001) surfaces using room temperature scanning tunneling spectroscopy, finding surface state peaks at +170 meV and -50 meV, respectively, relative to the Fermi level and enabling a chemical identification of surface elemental species in FeCr alloys.[1] Later, Hanke *et al.* measured the temperature-dependent spectroscopy on Cr(001) surfaces and found that both orbital Kondo effect and single-particle models could be used to reasonably interpret the observed temperature-dependent Cr(001) surface peak seen at 20 meV above E_F. [2]

Recently, we have carried out a study of Fe on CrN(001) surfaces exhibiting a step-terrace morphology as grown by molecular beam epitaxy. These CrN samples are antiferromagnetic below 270 K.[3] We performed STS spectroscopy on, and between, nanometer-sized islands resulting from sub-ML Fe deposition. Spectroscopy on the clean CrN regions displays a broad dip near E_F and a peak at 125 meV, similar to the oxygenated Cr surface reported by Hanke *et al.* Whereas spectroscopy on the islands displays sharp spectral features exactly at, or within a few meV of, E_F. We make a case for interpreting these spectra in terms of a Kondo resonance.

[1] Stroschio *et al.*, *Phys. Rev. Lett.* **75**, 2960 (1995).

[2] Hanke *et al.*, *Phys. Rev. B* **72**, 085453 (2005).

[3] Alam *et al.*, *Phys. Rev. B* **96**, 104433 (2017).

MI-ThP5 Characteristics of a Single Molecule Magnet on Graphene: A DFT Study, *Rainier Berkley, Z. Hooshmand, T.S. Rahman*, University of Central Florida

Single-molecule magnets (SMMs) are molecules that function as nanoscale magnets below their blocking temperature. These systems have become of increasing interest due to their potential applications for magnetic technologies, since they display many unique quantum phenomena and their structures can be tuned to modify their magnetic and quantum properties. However, in order for SMMs to be applicable for magnetic technology they must retain stability both in their structures and their magnetic moments during and after the deposition process. Due to the complicated nature of magnetic interactions with substrates, the effects of magnetic materials on substrates are not fully understood. Therefore, in order to fully understand these systems a study of the interactions between a well-characterized SMM and substrate at the most fundamental level is required. For this purpose, we have studied the interactions of a [Mn₃]₂ dimer with graphene using Density Functional Theory (DFT) calculations. The [Mn₃]₂ dimer can exhibit two different ground states: ferromagnetic (FM) and anti-ferromagnetic (AFM). Our calculations for the spin of both the FM and AFM configurations of the isolated [Mn₃]₂ dimers in gas phase, agree with experimental results ($S=12$ and 0 respectively) only when the dimers are charged (+2). More importantly, our calculations reveal that graphene is inert; thus, hardly affecting the magnetic properties of the FM and AFM dimers and that both dimers display the same spin as in their isolated gas phase structures after deposition. These results are further confirmed by charge redistribution analysis in which there are no strong charge distribution from/to molecules to/from graphene and the spin density remains almost intact after interactions of molecules with substrate. Our results provide insights into the design of coupled SMM/substrate systems, namely [Mn₃]₂ dimer on graphene.

1 Nguyen *et al.* *J. Am. Chem. Soc.* 2015, 137, 7160–7168.

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MI-ThP6 Molecular Conductivity Switching via Voltage Controlled Spin Crossover at a Ferroelectric Interface, *Aaron Mosey*, Indiana University-Purdue University Indianapolis; *G. Hao*, University of Nebraska-Lincoln; *A.T. N'Diaye*, Lawrence Berkeley National Laboratory; *A.S. Dale*, Indiana University-Purdue University Indianapolis; *U. Manna*, Illinois State University; *P.A. Dowben*, University of Nebraska-Lincoln; *R. Cheng*, Indiana University-Purdue University Indianapolis

The scale of new micro and nano magneto-electronic devices is bounded by thermal and quantum constraints as predicted by Moore's Relation. This necessitates a push into the limits of harnessable natural phenomena to facilitate a post-Moore's era of design. Thermodynamic stability at room temperature, fast (Ghz) switching, and low energy cost narrow the list of candidates. Molecular electronic frontier orbital structure of Fe ions in octahedral fields will split in response to the local energetic environment, giving rise to the e_g and t_{2g} orbitals. The energetic scale between these

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two orbitals as a result of this deformation yields a low spin diamagnetic state or an $S=2$ high spin paramagnetic state. Spin crossover complex $[\text{Fe}(\text{II})(\text{H}_2\text{B}(\text{pyz})_2(\text{bipy}))_2]$ will show locking of its spin state well above the transition temperature, with an accompanied change of conductivity, when placed in a polar environment. Here we show voltage controllable, room temperature, stable locking of the spin state, and the corresponding conductivity change, when molecular thin films of $[\text{Fe}(\text{II})(\text{H}_2\text{B}(\text{pyz})_2(\text{bipy}))_2]$ are deposited on a ferroelectric polyvinylidene fluoride hexafluoropropylene substrate. This opens the door to the creation of a thermodynamically stable, room temperature, multiferroic gated voltage device.

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