Oral Session C2 (Thursday, February 15)

Chair: Cheng Song, Tsinghua University

Contributed Oral

10: 55 - 11 : 15

Anisotropic spin polarized current and magnetoresistance in an antiferromagnetic tunnel junction

Xianzhe Chen[1, 2], Tomoya Higo[1, 2], Katsuhiro Tanaka[2, 3], Takuya Nomoto[3], Hanshen Tsai[2], Hiroshi Idzuchi[2], Masanobu Shiga[1], Shoya Sakamoto[1], Hidetoshi Kosaki[1], Takumi Matsuo[2], Daisuke Nishio-Hamane[1], Ryotaro Arita[3, 4], **Shinji Miwa**[1, 5], and Satoru Nakatsuji[1, 2, 5, 6]

1. The Institute for Solid State Physics, The University of Tokyo, Japan
2. Department of Physics, The University of Tokyo, Japan
3. Research Center for Advanced Science and Technology, The University of Tokyo, Japan
4. Center for Emergent Matter Science (CEMS), RIKEN, Japan
5. Trans-scale Quantum Science Institute, The University of Tokyo, Japan
6. Institute for Quantum Matter, Johns Hopkins University, USA

Tunnel magnetoresistance (TMR) and spin-transfer torque (STT), due to longitudinal spin-polarized current, provide the read and write protocols for the two-terminal magnetoresistive devices. In addition to the well-established ferromagnetic spintronics, antiferromagnets have attracted considerable interest as next-generation active elements for further improvements in operating speed and integration density. Therefore, it is important to develop both TMR and STT using all-antiferromagnetic tunnel junctions. In principle, TMR effect in all-antiferromagnetic tunnel junction is feasible in terms of momentum-dependent spin polarization [1]. However, it is difficult to prepare such time-reversal odd and controllable spin state in collinear antiferromagnet. Therefore, no reports have been published on the TMR effect using an all-antiferromagnetic tunnel junction. In addition, the observation and manipulation of the longitudinal spin-polarized current is necessary as a basis for the design of the memory device based solely on antiferromagnets, but, again, it has never been carried out for antiferromagnets. In this talk, we show that high-quality epitaxial thin films of the Weyl antiferromagnet Mn_3Sn [2] could be prepared by molecular beam epitaxy [3]. We clarify the existence of anisotropic, longitudinal spin-polarized current [4] using Fe/MgO/Mn_3Sn-MTJ and achieve TMR in an all-antiferromagnetic tunnel junction comprising Mn_3Sn/MgO/Mn_3Sn [5].

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11: 15 - 11 : 35

First-principles study on tunnel magnetoresistance effect with antiferromagnets

Katsuhiro Tanaka[1], Takuya Nomoto[2], and Ryotaro Arita[2, 3]

1. Department of Physics, The University of Tokyo, Japan
2. Research Center for Advanced Science and Technology, The University of Tokyo, Japan
3. Center for Emergent Matter Science (CEMS), RIKEN, Japan

Recent studies have shown that the antiferromagnets macroscopically breaking the time-reversal symmetry can exhibit a finite tunnel magnetoresistance (TMR) effect [1–4]. Particularly, we have focused on Mn_3Sn, a noncollinear antiferromagnet whose time-reversal breaking magnetic structure can be regarded as the ferroic order of the cluster magnetic octupole moments [5]. We have shown that Mn_3Sn can have a finite TMR effect from first principles, and we have actually observed the TMR effect in experiments [3].

To understand the TMR effect with antiferromagnets more closely, we have dealt with simple lattice models with collinear magnets. We have found that the local density of states inside the tunneling barrier can be an easy probe to discuss the TMR effect qualitatively [6]. As its application to first-principles calculations, we will discuss the TMR effect with Cr doped RuO_2; the rutile-type RuO_2, an antiferromagnet, shows intriguing phenomena thanks to its magnetic structure [1, 7], and its magnetism is reinforced by doping Cr into RuO_2 [8].

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11: 35 - 11 : 55

Magnetic tunnel junction-based readout for spin Hall nano-oscillators

Akash Kumar[1, 2], Takaaki Dohi[2], Mohammad Zahedinejad[1], Roman Khymyn[1]
Shun Kanai[2], Shunsuke Fukami[2] and Johan Åkerman[1, 2]

1. Applied Spintronics Group, Department of Physics, University of Gothenburg, 41296 Gothenburg, Sweden
2. Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication, Tohoku University, Sendai, Japan

Since their demonstration, nano-constriction spin Hall nano-oscillators (NC-SHNOs) have gained substantial attention for their easy nano-fabrication, coherent signal, and large frequency-tunability[1]. Their superiority in mutual synchronization exhibited in both onedimensional chains [2,3] and two-dimensional arrays [4] positions these oscillators as building-blocks in diverse unconventional computing schemes, including reservoir/neuromorphic computing [4,5], and Ising machines [6]. Despite their potential, the low anisotropic magneto-resistance (AMR) of ferromagnetic materials limits their practical applications. Various efforts have been undertaken to enhance the output power of NC-SHNOs, such as incorporating large easy-plane anisotropy [7] and exploiting giant magneto-resistance [8].
This study introduces a groundbreaking approach by integrating a magnetic tunnel junction (MTJ)-based read-out for SHNO devices, resulting in MTJ-SHNOs with superior spectral characteristics. These devices exhibit large output power due to significant tunnelling magnetoresistance (>70%) while maintaining a low linewidth and preserving original magnetodynamical mode of SHNOs. Experiments demonstrate a remarkable 10^4 increment in output power (>5 nWs from 0.5 pW) without additional input. Moreover, the MTJ pillars provide a means for individual control of SHNOs through an additional current path and enable local probing/control within large chains or arrays. These advancements not only overcome NC-SHNOs' output power limitations but also enables additional control, facilitating their effective integration into practical applications.

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