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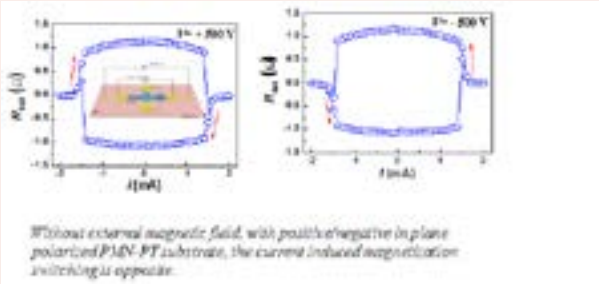
Control ferromagnets at room temperature without external magnetic field

Electrically controlling the spin in solids is the core of spintronics. We investigated that Spin Hall effect controls the magnetization switching in heavy metal/ferromagnet/heavy metal multilayers and also piezo voltages control the magnetization switching of Heusler alloy CoFeAl. By designing the device structure, we demonstrate a strong damping-like torque from the Spin Hall effect and unmeasurable field-like torque from Rashba effect. The spin-orbit effective fields due to the Spin Hall effect were investigated quantitatively and were found to be consistent with the switching effective fields after accounting for the switching current reduction due to thermal fluctuations from the current pulse. The spin-orbit torque switching controllably in above structures have to have the assistant of the external magnetic field. Without breaking the symmetry of the structure of the thin film, we realize the deterministic magnetization switching in a hybrid ferromagnetic/ferroelectric structure with Pt/Co/Ni/Co/Pt layers on PMN-PT substrate. The effective magnetic field can be reversed by changing the direction of the applied electric field on the PMN-PT substrate, which fully replaces the controllability function of the external magnetic field. We also investigated the planar Hall effect devices based on the tunability of the planar Hall resistance in ferromagnetic Co_2FeAl devices solely by piezo voltages. The room temperature magnetic NOT and NOR gates have been demonstrated based on the Co_2FeAl planar Hall effect devices without external magnetic field.



Without external magnetic field, with positive/negative in plane polarized PMN-PT substrate, the current induced magnetization switching is opposite.

Biography

Kaiyou Wang, PhD, Professor in Institute of Semiconductors in Chinese Academy of Sciences, Deputy Director of State Key Laboratory for Superlattices & Microstructure, obtained his PhD in 2005 at School of Physics & Astronomy, University of Nottingham. He worked as a Researcher Assistant from March to the end of May/2005 in University of Nottingham. He then worked as a Researcher in Hitachi Cambridge Laboratory from June/2005 to the end of March/2009. During his stay in UK, he had twice short visits to Institute of Physics, Poland and also a short visit to Niels Bohr Institute, Copenhagen. He joined State Key Laboratory for Superlattices & Microstructure, Institute of Semiconductors in CAS as a member of "100 Talent Program". In 2012, he has been awarded the "National Outstanding Youth Foundation" from NSFC. In 2014, he was selected to be excellent in the "100 Talent Program" final assessment. His current research interests include: (1) spintronic devices; (2) physical properties based on low dimensional nano-electronic devices.

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