frontiers in Nanotechnology

EDITORIAL
published: 18 March 2022
doi: 10.3389/fnano.2022.863388

Editorial: Intelligent Spintronics: From Hybrid Materials to Integrative Devices and Computing Architectures

Ping Kwan Johnny Wong[1,2]*, *Wen Zhang*[1,2]*, *Andrew T. S. Wee*[3], *Stéphane Mangin*[4,5] and *Sandrine Heutz*[6]

[1]School of Microelectronics, Northwestern Polytechnical University, Xi'an, China, [2]NPU Chongqing Technology Innovation Center, Chongqing, China, [3]Department of Physics, National University of Singapore, Singapore, Singapore, [4]Université de Lorraine, CNRS, Institut Jean Lamour, Nancy, France, [5]Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom, [6]Department of Materials & London Centre of Nanotechnology, Imperial College London, London, United Kingdom

Keywords: spintronics, hybrid materials, integrative devices, intelligent electronics, in-memory computing

Editorial on the Research Topic

Intelligent Spintronics: From Hybrid Materials to Integrative Devices and Computing Architectures

OPEN ACCESS

Edited and reviewed by:
Themis Prodromakis, University of Southampton, United Kingdom

***Correspondence:**
Ping Kwan Johnny Wong
pingkwanj.wong@nwpu.edu.cn
Wen Zhang
zhang.wen@nwpu.edu.cn

Specialty section:
This article was submitted to Nanodevices, a section of the journal Frontiers in Nanotechnology

Received: *27 January 2022*
Accepted: *03 March 2022*
Published: *18 March 2022*

Citation:
Wong PKJ, Zhang W, Wee ATS, Mangin S and Heutz S (2022) Editorial: Intelligent Spintronics: From Hybrid Materials to Integrative Devices and Computing Architectures. Front. Nanotechnol. 4:863388. doi: 10.3389/fnano.2022.863388

Our digital world, in particular, the information and memory segment, is now experiencing a major transform, driven by the rollout of 5G, AI, Big Data and IoT. This demands revolutionary new technologies with the potential of integrating, improving, or even replacing charge-based CMOS paradigm that has already been in place for several decades. To date, exploiting electron spin in tandem with charge in spintronics has gained considerable interest as a disruptive pathway to support this technology transform. This development is particularly driven, especially by the multitude of features endowed by the active use of spin—high integration density, non-volatility, ultralow power consumption and fast operation speed. All these features can be combined in a single device unit, depending on materials, integration strategies, and device architectures. These aspects represent three active lines of impactful research. It is the aim of this Research Topic to collect some of the most exciting advances along these lines.

One of the key challenges faced by today's information processing technologies concerns the memory bottleneck, as well as the high energy and speed costs associated with constant data movements between memory and processor, commonly referred to as the von Neumann bottleneck. Memristors, devices that shows a permanent change in resistivity upon a set of voltage- or current-driven processes, offer a straightforward solution to this issue, by acting as an ultrahigh-density memory unit that can be directly integrated on a processor chip. A magnetic tunnel junction (MTJ) can serve as a memristor, with the relative magnetization alignment of its two ferromagnetic electrodes giving either a high or low resistive state, depending on the external magnetic fields applied to the junction. A more recent focus involves using various types of current-induced torques to perform magnetic switching. Goossens et al. demonstrated the ability to control magnetic anisotropy of $SrRuO_3$ ferromagnetic layers by the choice of substrate, $SrTiO_3$(001) and (110) in this work. The tailored anisotropy can potentially allow for probabilistic or deterministic current-induced magnetization switching in $SrRuO_3/SrTiO_3$ heterostructures capped with a Pt layer with strong spin-orbit coupling. The different switching observed may emerge as ways to emulate neurons or synapses for neumorphic applications. This huge family of two-dimensional (2D) van der Waals materials and related heterostructures emerged over the past decade, and has considerably broadened the scope of spin-orbit torque (SOT) applications. Tian et al. reviewed the recent development of this line and highlighted the fresh concepts, new opportunities and challenges in 2D-SOT devices. Besides current-induced torques, Yamada et al. employed an all-optical approach to realize field-free, deterministic control of magnetization in a Pt/Co/Pt structure. The dual-pulse excitation method demonstrated represents a possible route towards ultrafast opto-magnetic writing in magnetic recording media.

As the field of intelligent spintronics is continuously expanding, the papers collected in this Research Topic can be considered a "taster" for what is yet to come. More interesting results are envisaged in the future. Many thanks to all authors who have contributed to this research topic.

AUTHOR CONTRIBUTIONS

PW and WZ drafted the editorial. AW, SM, and SH proofread it.

FUNDING

This work was supported by the Natural Science Foundation of Shaanxi (2021JM-042 and 2022JM-030), the Natural Science Foundation of Chongqing (sctc2021jcyj-msxm1568), China and the Leverhulme Trust.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.