Seminars on Magnetism and Spintronics

Date: 3 July 2015, Friday
Time: 2.30pm – 5.00pm
Venue: Hilbert Space (PAP-02-02)
Host: Assoc Prof S.N. Piramanayagam

2.30pm– 3.15pm

Hybrid CMOS/Magnetic integrated electronics - Dr Ricardo Sousa, Spintec, France

Dr Ricardo Sousa is a Research Engineer and MRAM group leader at Spintec, and received his Ph.D. degree in Applied Physics from the Instituto Superior Técnico in Lisbon, Portugal, for his work on MRAM based on spin dependent tunnel junctions in 2002. His experience on MTJs and MRAM spans over 10 years working on two MRAM related EU contracts (ESPRIT No. 28229 TJMRAM and IST-2001-37334 NEXT). Project NEXT specifically targeted TA-MRAM and was awarded the European Descartes Prize 2006. He has been leading the MRAM group at Spintec since 2007, coordinating 2 French research agency (ANR) funded projects RAMAC (2007-2010) and PATHOS (2010-2013). He is the local coordinator of the bilateral Research & Development collaboration between Spintec and Crocus.

3.15pm – 4.00pm

Nano-Spintronic Devices - Dr Atsufumi Hirohata, Department of Electronics, University of York, UK

Dr Atsufumi Hirohata is a Professor at the Department of Electronics in the University of York. He has over 10 years of experience in spintronics, ranging from magnetic-domain imaging to spin-current interference. Before coming to York in 2007, he was a researcher at RIKEN, a Japanese governmental research institute, where he designed a spin-current interference device. He was before working at Tohoku University and Massachusetts Institute of Technology. He received his PhD in Physics at the University of Cambridge in 2001. He was originally graduated from Keio University for his BSc and MSc studies in Physics.

4.00pm – 4.45pm

Addition of perpendicular magnetic anisotropy to Heusler alloy films for spintronic device applications - Prof. Shigeki Nakagawa, Dept. of Physical Electronics, Tokyo Institute of Technology, Japan

Prof. Shigeki Nakagawa received B.S. and M.S degree in electrical engineering from Kanazawa University, Japan, in 1983 and 1985, respectively. He joined Tokyo Institute of Technology as a Research Associate of Department of Physical Electronics. He received Ph.D from Tokyo Institute of Technology in 1994. He joined to University of Minnesota as a Visiting Researcher in 1995. He promoted to Associate Professor in 1996. He is now Professor of the Department of Physical Electronics, Tokyo Institute of Technology. He engaged in research on magnetic thin films used in perpendicular magnetic recording and spintronics devices. He received the best paper awards at the 5th, 6th and 8th International Conference on Ferrites, and the best paper award of the Japan Society of Powder and Powder Metallurgy. Prof. Nakagawa was a chair of Japan chapter of IEEE Magnetics Society. He is a member of many academic societies, such as IEEE, the Japan Society of Applied Physics, the Institute of Electrical Engineers of Japan, the Magnetic Society of Japan, the Surface Finishing Society of Japan and the Japan Society of Powder and Powder Metallurgy.

4.45pm – 5.00pm

Informal discussions among speakers and participants
Hybrid CMOS/Magnetic integrated electronics

By
Dr Ricardo Sousa
Spintec

Date: 3 July 2015, Friday
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Abstract

Magnetic Random Access Memories combine non volatility, high speed, moderate power consumption, infinite endurance and radiation hardness, all at low cost and easy to embed. Since its inception in the late 90’s, however, and despite numerous promising announcements from laboratories, large corporations and start-ups, MRAM has yet to fulfil its expectations. Large volume applications are still not in production, with only Toggle switching-based standalone products currently available, at 180nm technology node. The recent advent of spin transfer torque, however, has shed a new light on MRAM with the promises of much improved performances and greater scalability to advanced technology nodes. Magnetic Tunnel Junctions (MTJ) with Perpendicular Magnetic Anisotropy (PMA) are possibly the best option achieve the smallest cell dimensions in magnetic random access memories.

A recent report from ITRS ERD/ERM working group has identified STT MRAM and Redox RAM as the most promising candidates for emerging scalable and manufacturable non-volatile memories. This work also shows how thermal assistance [1] can be implemented in field induced switched MTJ to enhance the reliability, the power consumption and the scalability of MRAM. A new self-referenced reading scheme was implemented in these cells to obtain a Magnetic Logic Unit (MLUTM) that present new logic functionalities compared to standard MRAM. The presentation will also cover spin transfer torque switching of perpendicular cells aimed at sub-20nm cell sizes. Several approaches, including electric field [2] and heat, have been proposed to use the spin torque current in a way that it reduces the perpendicular anisotropy and stability of the cell during the write operation. In heat assisted magnetic reversal a temperature increase is used to lower the write energy, while information is retained at a standby temperature where the anisotropy is high. Ultimately, thermal assistance can be implemented in MTJ with perpendicular magnetization [2]. In that case, thermally induced anisotropy reorientation (TIAR) can be used to decrease the switching power consumption, increase the writing reliability and improve further the scalability of TA-MRAM to sub-20nm technological node.


Short Biography

Dr Ricardo Sousa (43 years old) is a Research Engineer and MRAM group leader at Spintec, and received his Ph.D. degree in Applied Physics from the Instituto Superior Técnico in Lisbon, Portugal, for his work on MRAM based on spin dependent tunnel junctions in 2002. His experience on MTJs and MRAM spans over 10 years working on two MRAM related EU contracts (ESPRIT No. 28229 TJMRAM and IST-2001-37334 NEXT). Project NEXT specifically targeted TARMRAM and was awarded the European Descartes Prize 2006. He has been leading the MRAM group at Spintec since 2007, coordinating 2 French research agency (ANR) funded projects RAMAC (2007–2010) and PATHOS (2010–2013). He is the local coordinator of the bilateral Research & Development collaboration between Spintec and Crocus.

He has worked on the development of several MRAM concepts, including thermally assisted, precessional switching and self-reference read-out in-plane cells and more recently in perpendicular anisotropy MRAM devices in conventional STT cells and thermally assisted perpendicular concept. All these concepts resulted in successful demonstrations and some are still being developed. In 2011 he was nominated CEA Expert in the domain of: Materials and solid-state physics, with a specialty in “Concept and fabrication with expertise in Spintronics, MRAM and Non-volatile memories”.

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PAP Seminar Announcement

Nano-Spintronic Devices
By
Dr Atsufumi Hirohata
Department of Electronics, University of York

Date: 3 July 2015, Friday
Time: 3.15 pm – 4 pm
Venue: Hilbert Space (PAP-02-02)
Host: Assoc Prof S.N. Piramanayagam

Abstract

Recent advancement in nanofabrication and growth allows the utilisation of spin-polarised electrons in transport and dynamics, resulting in the development of spintronic devices [1]. In the spintronic devices, the key technologies are injection, manipulation and detection of spin-polarised electron in a non-magnetic media with high efficiency. Conventionally such a spin-polarised electron current has been injected into a non-magnetic material by flowing an electrical current through a ferromagnetic layer. However, its spin polarisation is dependent upon the interfacial properties, such as conductance matching, junction resistance and interfacial resonant states. We recently succeeded to fabricate an abrupt Fe/GaAs(001) interface for the first time and have demonstrated reproducible spin transport across the interface [2]. This system offers an ideal junction to form a spin-polarised field effect transistor for example. We also demonstrated spin-current amplification in a lateral spin-valve (LSV) using a geometrical ratchet effect [3]. Two Py nanowires were designed to be 30 nm thick and 200 nm wide bridged by a Cu nanowire (70 nm thick and 100 nm wide). Here, the central part of the Cu wire was modified into the following geometrical ratchet shapes with allowing 50 nm separation between the Py wires and the ratchets. We measured over 700% spin-current amplification for the right-angled triangles with 100 nm base and 60 nm height.

By utilising these fundamental building blocks, we can also develop a large variety of new devices.

This work was partially supported by the EPSRC (EP/I000933/1 and EP/K03278X/1), Royal Society Industry Fellowship, EC (NMP3-SL-2013-604398) and JST-PRESTO.


Short Biography

Dr Atsufumi Hirohata is a Professor at the Department of Electronics in the University of York. He has over 10 years of experience in spintronics, ranging from magnetic-domain imaging to spin-current interference. Before coming to York in 2007, he was a researcher at RIKEN, a Japanese governmental research institute, where he designed a spin-current interference device. He was before working at Tohoku University and Massachusetts Institute of Technology. He received his PhD in Physics at the University of Cambridge in 2001. He was originally graduated from Keio University for his BSc and MSc studies in Physics.
Addition of perpendicular magnetic anisotropy to Heusler alloy films for spintronic device applications.

By
Prof. Shigeki Nakagawa
Dept. of Physical Electronics, Tokyo Institute of Technology
nakagawa@pe.titech.ac.jp

Date: 3 July 2015, Friday
Time: 4 pm – 4.45 pm
Venue: Hilbert Space (PAP-02-02)
Host: Assoc Prof S.N. Piramanayagam

Abstract

Addition of perpendicular magnetic anisotropy to the highly spin polarized half metallic films, such as Heusler alloy films, such as Co$_2$MnSi (CMS) and Co$_2$FeSi (CFS), is important to realize perpendicular magnetic tunneling junction (p-MTJ) with high MR ratio which is applicable for next generation MRAM. In order to induce perpendicular magnetic anisotropy to the Heusler alloy thin films, multilayers composed of Pd insertion layer and bilayered structure with MgO films is effective to attain PMA which is applicable to MRAM devices. We fabricated [CMS/Pd]$_n$ superlattice films on glass slides and on MgO single crystal substrates with (100), (110) and (111) crystals. It is confirmed that the crystal orientation of Pd and CMS bilayers were able to be controlled by changing the crystal orientation of MgO substrates. PMA was obtained in the [CMS (0.6 nm) / Pd (2 nm)]$_6$ superlattice film formed on MgO (111) substrates although other superlattice films prepared on MgO (001) and (110) substrates showed in-plane and isotropic magnetic anisotropy, respectively. An interfacial anisotropy constant $K$ per one CMS-Pd interface in the superlattice prepared on MgO (111) substrate was estimated to be 0.16 erg/cm$^2$. The origin of the PMA in the [CMS/Pd]$_n$ superlattice films on glass slides seems to be originated from the (110) crystalline component in the randomly oriented CMS layers. We have also confirmed the enhancement of PMA of CFS/MgO bilayered films when O$_2$ exposure was performed after the deposition of CFS film before MgO layer deposition on CFS layer. Interfacial magnetic anisotropy constant $K_s$ was enhanced by the O$_2$ exposure process up to $K_s$ of 0.9 erg/cm$^2$.

Short Biography

Shigeki Nakagawa received B.S. and M.S degree in electrical engineering from Kanazawa University, Japan, in 1983 and 1985, respectively. He joined Tokyo Institute of Technology as a Research Associate of Department of Physical Electronics. He received Ph.D from Tokyo Institute of Technology in 1994. He joined to University of Minnesota as a Visiting Researcher in 1995. He promoted to Associate Professor in 1996. He is now Professor of the Department of Physical Electronics, Tokyo Institute of Technology. He engaged in research on magnetic thin films used in perpendicular magnetic recording and spintronics devices. He received the best paper awards at the 5th, 6th and 8th International Conference on Ferrites, and the best paper award of the Japan Society of Powder and Powder Metallurgy. Prof. Nakagawa was a chair of Japan chapter of IEEE Magnetics Society. He is a member of many academic societies, such as IEEE, the Japan Society of Applied Physics, the Institute of Electrical Engineers of Japan, the Magnetic Society of Japan, the Surface Finishing Society of Japan and the Japan Society of Powder and Powder Metallurgy.