EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-x01**
Version: 1.0

Title: Spintronic and spin-caloritronics in magnetic nanosystems

Abstract

In the rapidly evolving field of magnetic nanodevices, the understanding and control of novel effects are instrumental for the development of future spin-based applications. For example, the control of magnetic domain walls in magnetic nanostructures may lead to new applications ranging from local field sensing to high-density storage. Furthermore, thermal gradients may provide a new understanding for the manipulation of spins in magnetic nanostructures allowing new applications like the control of the heat flow by magnetic fields. Such novel aspects of spintronics and spin-caloritronics in magnetic nanosystems should be addressed by this JRP.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 9 and 25.

Keywords

Spintronics, spin-caloritronics, magnetic nanosystems, magnetic domain walls, magneto Seebeck effect

Background to the Metrological Challenges

The field of nanotechnology has a strong impact on global economy [1] with a global market of $15.7 billion in 2010, growing to approximately $26.7 billion by 2015, with a compound annual growth rate of 11.1 %.

One very important field of nanotechnology has developed from the convergence of electronics and magnetism based on the understanding and precise control of effects associated with the spin degree of freedom of the charge-carrying electrons. This field of spintronics [2] has led both to highest level scientific discoveries (like the *giant magnetoresistance* awarded by the Nobel Prize 2007) and to highly important industrial applications such as ultra-sensitive nano-scale magneto resistive read heads used in today’s hard disk drives. Spintronics based sensors are also successfully applied in metrology, e.g. for non-destructive material testing or for localised stray field sensing in the bio-medical field.

Domain wall devices allow novel metrological applications ranging from highly localised field and moment detection (e.g. for quantifiable bio-molecular sensing) to calculable nano-scale stray field standards for traceable magnetic imaging. But, the reliable traceable determination of critical domain wall device and material parameters requires new measurement tools and methods to underpin future research. Optimised domain wall nanodevices will enable a wealth of promising applications. For example, low power magnetic logic devices will allow a significant increase of the efficiency of ICT devices compared to today’s CMOS logic [3], and highly integrated magnetic domain wall based magnetic storage architectures are being developed [4].

Spin-caloritronics [5] is a new branch of spintronics that combines fundamental concepts from thermo-electricity (i.e. electronic and heat transport in the presence of thermal gradients) and spintronics. Coupling heat transport and heat driven transport with spintronics allows new device concepts such as innovative spin sources [6,7], thermally driven magnetization reversal by thermal spin transfer torque [8], magnetic heat valves [9], or magnetically switchable cooling [10]. However, many of these concepts are still waiting for their first experimental realisation.

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Scientific and Technological Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the JRP-Protocol.

The JRP shall focus on enabling a fundamental understanding of new effects emerging in the field of spintronics and spin-caloritronics in magnetic nanosystems. The understanding and control of these effects will allow promising future applications in metrology, science and ICT and other industries and will pave the way towards future standardisation of spintronic and spin-caloritronic measurements, materials, and devices.

The specific objectives are to:

1. Develop, realise, and investigate magnetic nanodevices allowing the detection, manipulation, and control of individual magnetic domain walls in advanced magnetic materials with perpendicular magnetic anisotropy.
2. Develop, realise, and investigate new functional magnetic nanodevices exploiting the interplay of spin-polarized transport and thermal gradients.

Proposers shall give priority to work that enables new metrological methods and techniques in the future through excellent science. The project need not address metrology directly.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

The total eligible cost of any proposal received for this SRT is expected to be around the 1.8 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 84 months of effort.

Potential Impact

The project should be designed to bring together the best scientists in Europe and beyond whilst exploiting the unique capabilities of the National Metrology Institutes and Designated Institutes. Significant non-NMI/DI and international participation in the projects is expected and proposers should make full use of the larger budget for Research Excellence Grants available for this SRT.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] http://www.bccresearch.com/ and BCC Research NAN047B, Published: January 2011

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[6] Uchida, K. et al. Observation of the spin Seebeck effect. Nature 455, 778–781 (2008).

[7] Le Breton, J-C. et al. Thermal spin current from a ferromagnet to silicon by Seebeck spin tunneling. Nature 475, 82–85 (2011)

[8] Hatami, M. et al. Thermal spin-transfer torque in magnetoelectronic devices. Phys. Rev. Lett. 99, 066603 (2007).

[9] Heikkila, T. et al. Spin heat accumulation and its relaxation in spin valves. Phys. Rev. B 81, 100408(R) (2010)

[10] Slachter, A., et al. Modeling of thermal spin transport and spin–orbit effects in ferromagnetic/nonmagnetic mesoscopic devices. Phys. Rev. B 84, 174408 (2011)