EMRP Call 2010 - Industry & Environment

Topic number: SRT-11i

Title: Metrology for advanced industrial magnetics

Abstract

Magnetic sensors can be found in a broad range of products in various fields of industry like consumer electronics, information and communication technology (ICT), and the automotive sector. The fast product development in these fields creates the need for advanced magnetic sensors having significantly improved specifications with respect to resolution, reliability, size, signal to noise ratio, and unit cost.

New magnetic materials will lead to more efficient electrical machines in industry but require knowledge-based tools in their design, based on the physical understanding and the traceable measurement of the properties of the core materials.

Joint Research Projects submitted for this topic should aim to provide the metrological framework to tackle the challenges in development, production, testing and calibration of advanced industrial magnetic sensors and materials. It should enable the European industry to play a leading role in future development, production and application.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on "*Grand Challenges"* related to *Industry* on page 32.

Keywords

Magnetic sensors, giant magneto resistance, tunnel magneto resistance, anisotropic magneto resistance, Hall effect, magneto electronics, spin electronics, magnetic thin films, magnetic multilayers, patterned magnetic materials, micromagnetic numerical models, spin injection, spin torque, low-loss magnetic materials.

Background to the Metrological Challenges

The world market for silicon-electronics based magnetic sensors is presently of the order of $1 bn and is projected to reach $1.4 bn in 2013 corresponding to a projected total of more than 5 billion shipped magnetic sensor IC units (not taking into account magnetic storage read heads) shipped per year. Magnetic sensors thereby represent one of the most pervasive types of sensors sold today. These devices are used in areas ranging from high-cost applications like industrial motors that require accurate knowledge of rotor position to control loads, to mid-priced automotive sensor ICs that measure rotation speed angle, and position, to low-cost consumer products.

One driving force for magnetic sensor development is the automotive sector as one of the most significant branches of European industry. Many sensors are needed in today's cars, and many more will be required in the future. The body and powertrain segments show the greatest potential for new magnetic sensor penetration and will be important target markets in the future. In the automotive body segment alone, the number of magnetic sensors and switches per car will grow from 6.7 on average in 2008 to 9.4 in 2013. These applications are still dominated by robust and cheap Hall sensors or anisotropic magneto resistance (AMR) sensors. More recently giant magneto resistance (GMR) sensors have also been used. In contrast, existing and emerging high tech applications like hard disk and magnetic tape read heads or bio-tech and pharmaceutical applications already rely on the high signal and sensitivity of advanced tunnelling magneto resistance (TMR) structures or even SQUID based sensors.

Downscaling of magnetic sensors allows higher integration and reduced unit costs. However, in very small structures new effects (like superparamagnetism, domain wall pinning, etc…) become apparent and have to be taken into account when evaluating the sensor function. On the other hand, some of those effects offer promising emerging applications. For example, the spin torque effect i.e. the magnetisation motion induced by a spin polarized current could allow a broad range of new industrial applications like tuneable high frequency oscillators and detectors for on-chip communication and new high density three-dimensional magnetic storage architectures.

The accuracy of any measurement and control utilising magnetic sensors is limited by the accuracy and response of the magnetic sensor itself. Hence the fast product development in these diverse fields of application creates the need for more advanced sensors having improved specifications with respect to e.g. resolution, reliability, size, signal-to-noise-ratio (SNR), and unit cost and requires new tools for their reliable characterisation.

Magnetic materials are at the core of all electrical devices and are the direct and indirect source of all electromagnetic losses. With novel and improved soft and hard magnets becoming available, machine designs have changed accordingly but optimal design requires improved and traceable measurements of magnetic properties. The data must be often determined under extreme conditions, typical of the final use of the device, and accurate characterisation is not supported by current documentary standards. Similarly, methods for the characterisation and modelling of the electric and magnetic properties of soft composites, which are used for machine cores, are not yet standardised.

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 aim of your JRP should be to provide the European industry with the metrological support for the development, the production and the testing and calibration of advanced magnetic sensors as well as for the characterisation of magnetic materials in complex industrial applications.

The specific objectives are:

1. Develop metrological tools and methods for industrial magnetic sensor development (traceable characterization of advanced materials, optimisation of sensor devices, emerging new concepts)

2. Develop metrological in-line tools and methods for sensor production (traceable measurement of magnetic parameters of devices such as thin films, multilayer stacks, patterned magnetic microstructures, individual magnetic microdevices etc)

3. Develop metrology for sensor testing and calibration (metrological chain including specific coil setups, reference and test magnetic materials, metrological tools for testing magnetic properties in HF range (GHz), stress and reliability properties).

4. Develop advanced metrological tools and methods for the characterisation of soft magnetic materials (such as used in power-generation) and of extra-hard rare-earth based permanent magnets.

The prioritisation of the developments shall strictly follow documented industrial needs. The project may include modelling and shall include measures to support transfer into industry by cooperation and by standardisation.

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

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

You should also detail other Impacts of your proposed JRP as detailed in the document “Guidance for writing a JRP”

You should detail how your JRP results are going to:

- feed into the development of urgent standards through appropriate standards bodies
- transfer knowledge to the industrial magnetics sector.

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. 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 3 years duration.