EMRP Call 2010 - Industry & Environment

Topic number: SRT-12i

Title: Electromagnetic characterisation of materials for industrial applications up to microwave frequencies

Abstract

Traceable electromagnetic (EM) characterisation of new materials designed for advanced high-speed electronics industry and ICT applications is essential if their performance is to be optimised. Novel materials present problems even for macro-scale measurements, but measurement at ever-smaller scales and ever-higher frequencies (up to 80 GHz) is required. The metrology of dielectrics and *actively controlled* materials: ferroelectrics, ferrites, magnetoelectrics, multiferroics, piezoelectrics, 'High-K' materials and semiconductors - needs to be advanced at macro- and microscales and for thin films in order to meet future requirements of a healthy EM-based European industry. This topic addresses the most urgent EM materials metrology requirements.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008, section on "Industry" related "Metrology R&D for applied and fundamental metrology", section Electricity and magnetism (page 10) and "Metrology for New Materials", page 42.

Keywords

Dielectrics, ferroelectrics, piezoelectrics, ferrites, magnetoelectrics, multiferroics, complex-permittivity, complex-permeability, thin-films, Scanning Microwave Microscopes (SMMs).

Background to the Metrological Challenges

The future of the European electronic components industry depends on innovation and upon its ability to manufacture novel advanced high added-value products. Impending limitations on the development of CMOS technology are encouraging industry to seek to develop new materials technologies to maintain progress in miniaturisation and increased functionality. These pressures for technological advance must embrace the requirements for efficiency, sustainability and flexibility both in the products and in the manufacturing processes.

A number of new materials technologies are emerging that will fuel these developments and new applications in the medium to long term. Examples include frequency-agile dielectric resonator filters (e.g. for use in mobile comms); new fast electronically-controlled actuators for piezoelectric tuning, on-wafer thin-film circuitry (often based on co-planar waveguide (CPW)) for tuning but also for switching and for sensor applications; ferroelectrics for novel memory devices and tuning; magnetoelectrics and multifunctional electromechanical actuators and sensors; higher frequency ultrasound medical imaging, where a lack of accurate measurement limits the uptake of new materials and designs. New traceable metrology is required to support industry in the development of all of these disruptive new technologies. EM materials' property characterisation thus needs to be extended beyond state-of-the-art methods (largely targeted at bulk-dielectric and conventional semiconductor applications) to new materials, device sizes, frequencies and modalities.

While adequate, well-characterised measurement techniques arguably exist for some (but by no means all) bulk dielectric and conventional semiconductor applications, the traceable characterisation of new materials in the small scales and geometries required for fast electronics has barely begun. In all cases the development of traceable methods will be the key to more effective and cost-effective

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industrial solutions. Development of the required metrology represents a major challenge, which will best be achieved by an all-embracing metrology-centred approach in collaboration with industrial partners. In this way lessons learnt in one area (e.g. thin-film metrology) can be applied effectively in another (e.g. near-field probe metrology).

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 focus of this topic is to provide metrological tools and methods for the traceable electromagnetic characterisation of new materials designed for advanced high-speed electronics industry and ICT applications at the macro-, micro- and nanoscale.

The specific objectives are:

1. To develop the metrological tools for characterising both passive and 'functional' EM materials to enable a step-improvement in EM materials performance for fast electronics applications from LF up to 80 GHz
2. To develop traceable methods for complex permittivity and permeability, magnetoelectric coefficients, coupling efficiencies in multiferroic and magnetoelectric materials and systems (charge, strain, stress, fields) at relevant frequencies up to 80 GHz
3. To develop improved traceable techniques for thin-film, bulk and meta- materials and for surface scans of EM property variations using scanning microwave microscopes (SMM)s or other probing and/or non-contact methods
4. Specifically, to achieve traceable (quantitative) measurements (dimensional and electrical) with the SMM technique by providing tip-sample interaction models, calibration standards and optimized specific calibration procedures
5. To establish and metrologically evaluate and validate cost-effective and easy-to-use sample preparation and calibration methods in order to encourage uptake by industry

Proposers shall give priority to work that meets documented industrial needs and that which supports transfer into industry e.g. by cooperation and/or 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 standards through appropriate standards bodies
- transfer knowledge to the user community.

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.