

Title: High frequency and dynamic measurements of functional materials

Abstract

European ICT, high-speed electronics & aerospace industries are increasingly making use of functional electromagnetic (EM) materials which need to be reliably characterised if their performance is to be optimised. EM materials metrology is key to development of new forms of memory, high speed data storage, and energy efficient circuits among other applications. Measurements on both existing and novel materials at ever-faster speeds are required, and detailed metrological studies are needed if reliable characterisation is to be achieved. The EM metrology of functional materials, such as magnetics, ferroelectrics, multiferroics, non-linear dielectrics, etc., needs to be advanced to meet future requirements of these industries.

Keywords

Functional Materials, Multiferroic, Ferroelectric, Magnetic, Time Domain, Microwave, Dielectric,

Background to the Metrological Challenges

The tuning, switching and dynamic properties of functional EM materials offer a range of unique possibilities enabling them to be employed in the manufacture of novel devices deployable in many industries; these devices cannot be realised using just semiconductor materials. Functional Materials are generally well understood at low frequencies, <100 kHz, for low speed dynamic properties, risetimes of > 100 ns, and at bulk scales of 100 microns upwards. To realise the full potential of these materials, their relevant EM properties and performance need to be measurable at high frequency in a wide range of industries, not just elite universities and NMIs.

For instance, ferroelectric materials underpin many existing technologies, such as piezoelectric sensors, actuators and transducers, pyroelectrics and ferroelectric memory. Their ultra-fast processes are of direct technological interest for non-linear optics, photonics, and optical data storage. Currently, optical storage of information uses slow (>1ns) thermally-activated processes. Non-thermal, coherent, ultrafast, controllable switching of macroscopic ferroelectric domains would open a wide range of applications in information processing and optical communications and beyond. Similar opportunities exist to make use of the ultrafast processes exhibited by other functional materials, such as magnetics and multiferroics. Another class of functional material that needs to be addressed is composite materials based on inclusions in passive matrices that enable functional behaviour whilst preserving other properties such as strength.

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 proposal.

The JRP shall focus on the development of traceable measurement and characterisation techniques that enable the development of novel high speed electronics devices and computer memory/storage, based on the high frequency dynamic properties of Functional Materials.

The specific objectives are

1. To develop a suite of traceable Time Domain measurement techniques and modelling capabilities suitable for functional materials such as magnetic (non-metallic), ferroelectric and multiferroic. The techniques should target magnetic/electric/strain-related functional properties that are suitable for deployment by industry and should be capable of measuring materials down to 10 nm thickness with a range of timescales down to sub-ps.

2. To develop a suite of traceable Frequency Domain measurement techniques and modelling capabilities for the dynamic characterisation of functional materials such as non-metallic magnetic, ferroelectric and multiferroic. The techniques should target magnetic/electric/strain-related functional properties that are suitable for deployment by industry and should be capable of measuring materials down to 10 nm thickness at frequencies up to 50 GHz.
3. To develop a suite of traceable measurement techniques and modelling capabilities to characterise the non-linear behaviour of functional materials, including dielectrics. The techniques should target those materials that are required to operate in non-linear regimes necessitated by ever increasing pulse energy densities.
4. To develop and evaluate metrological methods and modelling capabilities to derive intrinsic key parameters (such as the intrinsic damping) of ferromagnetic thin films and multilayers from Time Domain or Frequency Domain measurements of the precessional magnetisation dynamics.
5. To engage with industry that manufactures or exploits functional materials in order to facilitate take up of the techniques developed by the project to support the development of new, innovative products thereby enhancing the competitiveness of EU industry.

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. Particular reference should be made to the JRP IND02 EMINDA funded by EMRP.

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,
- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the electronics sector.

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

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include 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 EURAMET Member States whose metrology programmes are at an early stage of development to be increased

- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.