EMPIR Call 2014 – Industry and Research Potential

Selected Research Topic number: **SRT-i01**
Version: 1.0

Title: Advanced 3D chemical metrology for innovative technologies

Abstract

“Faster”, “smarter” and “cheaper” demands from consumers are driving innovation in high value-added manufacturing. To achieve this, industry is increasingly using 3D architectures, additive manufacturing and a rapidly expanding library of materials. This is equally the case for devices based on organic materials, such as smart optical films and advanced coatings, as it is for inorganic nanolayered high-density 3D-devices (such as FinFETs). In many technologies, e.g. sensors and semiconductors, the interface between organic and inorganic materials causes severe measurement issues. This creates an urgent need for beyond state-of-the-art capabilities to measure chemical composition and interfacial properties with 3D-spatial resolution.

Keywords

Phase separation, heterogeneous materials, 3D printing, additive manufacturing, nanotechnology, buried layers, beyond Moore’s law, beyond CMORE, self-healing technologies, light management films

Background to the Metrological Challenges

Multi-layered devices, used in LCD display, are high-value (> $3 billion global annual sales) however a major issue with these devices are defects and void formation at buried interfaces. The current state-of-the-art techniques/methods for industrial analysis have a mass resolution ~10,000 and mass accuracy of 30 ppm. These need to be improved to > 100,000 and 500 ppb respectively in order to identify unknown defects, identify similar classes of materials in different phase domains or identify low-level chemical additives.

The chemical, automotive, steel and aerospace industries growth is driven by the exploitation of innovative organic and inorganic materials and a major challenge is characterising the expanding these library of novel and exotic materials with non-destructive techniques at both R&D and production sites.

For aerospace and medical engineering 3D printing and production services are growing rapidly (29 % in 2012 to €2.2 billion) and there is an urgent need to measure the complex heterogeneous chemistry of these printed devices (with voids and organic-organic, organic-inorganic and inorganic-inorganic interfaces).

For the microelectrics industry, block-copolymers self-assembly is considered an extremely promising technology, to overcome the limitations of the conventional photolithography technique. These materials need to be characterised with super-resolution chemical imaging techniques; IR scanning near-field optical microscopy (IR SNOM) has great potential. Modelling is required to decouple chemical and topographic effects and in order to be used in bench-top instruments a metrological framework is required with a high-performance synchrotron light source.

In the semiconductor, steel and energy storage industries, analysts are faced with challenges to measure the chemical composition of inorganic devices or heterogeneous systems containing organic/inorganic layers and interfaces. The emerging technology of atom probe tomography (APT) is a major contender to meet characterisation targets. However, it lacks standardisation which leads to multiple distortions and metrology with well controlled reference devices and layer structures is urgently required to fulfil industry needs and begin development of international standards.

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 traceable measurement and characterisation of chemical composition and interfacial properties in 3D-spatial resolution

The specific objectives are

1. To develop measurement techniques for chemical and compositional 3D imaging of organic and heterogeneous devices with high-resolution chemical identification of phase separated and buried domains. A mass resolution of >100 000 should be achieved with sampling from sub-micron areas.
2. To develop metrology for reliable and traceable detection, identification, localisation, molecular orientation and quantification of chemical components in the depth of organic layers as required in the manufacture of innovative devices including novel metrological methods for 3D chemical imaging of irregular devices and complex organic-inorganic interfaces.
3. To develop methods for accurate 3D reconstruction and quantification. This should include the development of atomic resolution 3D elemental imaging techniques for inorganic devices and the improvement of tomographic methods, by the development and quantification of 3D nano structured reference materials.
4. To develop traceable methods for quantifying mass depositions and element depth profiles in 3D structured nano-layered devices. Essential calibration standards, 3D nano-structured reference materials, with a high control of shape and size using organic domain structures ranging from 10 nm to 100 nm, should be developed in order to transfer traceability to online analytical instrumentation.
5. To engage with industry to facilitate the take up of the technology and measurement infrastructure 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 and JRP IND56 Q-AIMDS, IND07 Thin Films and ENG53 ThinErgy.

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 nanotechnology sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing a 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.