European Partnership on Metrology
Call 2025 – Health, Integrated European Metrology, Regulation and Research Potential

Selected Research Topic number: **SRT-r01**
Version: 1.0

Title: Nanometrology development for emerging NMIs

Abstract

The significant progress in recent years in the field of nanotechnologies often involves the production and use of measurement systems whose macroscopic functional properties are determined by phenomena occurring in structures the size of a few nanometres. Advanced measurement systems for measurement of dimensional, electrical and mechanical properties based on techniques such as scanning probe microscopy (SPM), feature complex traceability routes and data processing that require significant expertise to implement them properly. This expertise is not always available in many national metrological institutes and designated institutes (NMIs/DIs). Proposals addressing this topic should focus on the development of nanometrology capabilities of NMIs and DIs that do not yet have the appropriate expertise in the field, and where there are clearly identified stakeholder needs within their countries.

Keywords

Nanometrology, atomic force microscopy (AFM), scanning probe microscopy (SPM), nano-standards, nano-positioning, traceability

Background to the Metrological Challenges

Nanotechnology and nanometrology are developing very rapidly, driven by requirements in industries such as automotive, civil engineering, construction, solar technologies, environmental applications, medicine, transportation, agriculture, food processing and textiles. The European Commission has defined strategies and policies to support areas of research and innovation that will be essential for the creation of wellbeing, prosperity and jobs across Europe. Some of these policies focus on areas, such as advanced manufacturing and advanced materials, which naturally require appropriate and reliable measurement systems on a nanoscale level. The Consultative Committee for Length (CCL) defined one of the main challenges as nanometrology in its Strategy for 2018-2028 [1]. The European Metrology Network (EMN) for Advanced Manufacturing has identified nano- and microtechnology as a key industrial sector, and has laid out the goal not only to develop measurement systems and metrological methods, but also consequently to improve the quality of production processes [2]. In order to support those European industries that require developed nanometrology infrastructure and expertise, a more even distribution across European counties is needed. One tool to achieve this goal is by knowledge transfer and accessibility which has been highlighted as a cross-cutting theme, which focuses on the requirements for the transfer of metrology knowledge and skills into industrial applications and the metrology community.

The projects NEW05 MechProNO, SIB61 CRYSTAL, 15SIB09 3DNano, 20IND08 MetExSPM funded under European programmes EMRP and EMPIR, provided in recent years, an opportunity to expand measurement capabilities in the fields of nanotechnology and nanometrology. Whilst many NMIs and universities took advantage of the opportunities in these projects, some were not able to participate due to a lack of relevant experience or an appropriate measurement set-up. Currently, only a selection of NMIs and DIs have measurement equipment and expertise that ensures measurement traceability in surface geometry measurements at the nanoscale level. Advanced measurement techniques, such as scanning probe microscopy (SPM), are furthermore capable of measurements of other properties beyond dimensional properties e.g. electrical, magnetic, mechanical or thermal properties. The traceability routes for many of these techniques have already been explored scientifically, but they are far from simple and not standard to use. Significant expertise and experience are needed to be able to perform such measurements. The more complex

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the SPM measurements, the higher is the risk of introducing human errors when setting up the measurement conditions or performing the data processing.

There is therefore a need for a wider range of NMIs/DIs to develop or increase measurement capabilities in nanometrology with a specific focus on identified stakeholders' needs. This requires the development of traceable and cost-effective measurement capabilities for the calibration of nano-positioning systems, nano scale standards, SPM, tactile, optical or laser interferometer systems, and depending on the capabilities required the measurement techniques, might be based on atomic force microscopy (AFM). It is important that efficient use is made of existing nanometrology capabilities, competence, knowledge and limited resources, in the development of measurement methods and metrology services in emerging NMIs/DIs. In addition, the sources of measurement uncertainty for the newly developed nanoscale measurements, nano positioning systems and nano standards, need to be determined, and the new capabilities validated via an interlaboratory comparison as preparation for the submission of Calibration and Measurement Capabilities (CMCs) to the BIPM KCDB.

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 protocol.

The proposal shall focus on the development of metrology capability for nanoscale measurements in NMIs/DIs that are newcomers to this technology, with the aim of supporting the emerging needs of stakeholders.

The specific objectives are

1. To study existing SPMs, nano-standards, software and calibration procedures used within NMIs/DIs with developed capabilities to ensure traceability of measurements for nanometrology and to transfer this theoretical and experimental knowledge to the less experienced institutes. In addition, to establish collaborations between NMIs/DIs and universities or research organisations to enable efficient use of existing nanometrology capabilities, competencies and limited resources in the development of measurement methods and metrology services, including the use of SPMs for dimensional measurements and to investigate the possibility of characterisation of electrical, mechanical and thermal properties.
2. To develop traceable and cost-effective measurement capabilities for the calibration of nano-positioning systems (e.g. SPMs, photomasks, Piezo Displacement Generators), probe systems (e.g. AFM, tactile) and calibration standards used in nanometrology based on stakeholders' requirements in the respective countries.
3. To characterise and quantify the sources of measurement uncertainty for nano-positioning systems, probe systems and nano-standards calibration (e.g. line width, height, pitch, grating, nanoparticles). The uncertainty evaluation should be performed for each new capability developed
4. To perform an interlaboratory comparison to validate the newly developed nanoscale measurement capabilities and to prepare the basis for future new or improved Calibration and Measurement Capabilities (CMC) in this field for the participating laboratories.
5. To facilitate the take up and long-term operation of the capabilities, technology and measurement infrastructure for nanoscale measurements developed in the project, by the measurement supply chain (NMIs/DIs, calibration and testing laboratories), and end users (e.g. industry, instrument manufacturers, regulators). The approach should be discussed within the consortium and with other EURAMET NMIs/DIs, e.g. via EURAMET TC-L and EMN Advanced Manufacturing, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole.

Joint Research Proposals submitted against this SRT should identify

- the particular metrology needs of stakeholders in the region,
- the research capabilities that should be developed (as clear technical objectives),
- the area for which the capabilities will be built (Green Deal, Digital Transformation, Health, Integrated European Metrology, Industry, Normative or Fundamental Metrology) and in which future main call the developed research capabilities are planned to be employed,
- the impact the developed research capabilities will have on the industrial competitiveness and societal needs of the region,
- how the research capability will be sustained and further developed after the project ends.

Where relevant, proposals are encouraged to build on, or seek collaboration with, existing projects and develop synergies with other relevant European, national or regional initiatives and funding programmes. In particular, links are encouraged with (i) the projects funded under earlier relevant topics of the Horizon Europe programme; or (ii) other relevant European Partnerships.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMRP and EMPIR projects NEW05 MechProNO, SIB61 CRYSTAL, 15SIB09 3DNano, 20IND08 MetExSPM and how their proposal will build on those.

The development of the research potential should be to a level that would enable participation in other TPs.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.7 M€ and has defined an upper limit of 0.9 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 20 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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 proposal's results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Provide a lasting improvement in the European metrological capability and infrastructure beyond the lifetime of the project,
- Facilitate improved industrial capability or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the advanced manufacturing and nanotechnology sectors and the metrology community.

You should detail other impacts of your proposed JRP as specified in the document "Guide 4: Writing Joint Research Projects (JRPs)"

You should also detail how your approach to realising the objectives will further the aim of the Metrology Partnership 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.

Timescale

The project should be of up to 3 years duration.

Additional information

The links provided in this section are only correct at the time of publication up until the end of the Call year.

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

[1] *Strategy 2018-2028, Consultative Committee for Length (CCL)* https://www.bipm.org/documents/20126/2070984/CCL+Strategy.pdf/0f4af537-1729-b44a-e39e-f0023e439435

[2] *EMN Advanced Manufacturing Strategic Research Agenda*
https://www.euramet.org/european-metrology-networks/advanced-manufacturing/strategy/strategic-research-agenda

[3] *Recommendations of CCL/WG-N on: Realization of SI metre using height of monoatomic steps of crystalline silicon surfaces*
https://www.bipm.org/documents/20126/41489670/CCL-GD-MeP-3.pdf/5240b431-730f-3daf-4d8a-be590de99cdb

These references have been provided by EURAMET.

[4] *European Commission – strategies and policies supported by EU research and innovation*
https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation_en