

Title: Traceable AFM measurement capability

Abstract

Scanning probe microscopes (SPM) and atomic force microscope (AFM) are widely used in dimensional metrology. There are many commercial AFMs but in order to ensure traceability at a higher level, several NMIs have developed metrological AFMs.

Regulatory purposes, such as the expected regulation on nanoparticles for human safety and the environment, require the use of traceable measurement techniques. Therefore the availability of traceable measurement facilities at the nanometre level in each European country or region will facilitate the implementation of safety regulation and the development of the nanotechnologies towards market.

There is therefore a need to turn existing and commercial AFMs into routinely available instruments which will provide traceable measurements for calibration purposes at the nanometre level but are also suitable for research requiring traceable measurements at nanoscale. The development of metrological AFM would require experience in the determination of uncertainties and metrological validation through comparisons and peer reviews.

Keywords

Nanometrology, atomic force microscope, AFM, traceability, uncertainty budget, capacity building

Background to the Metrological Challenges

Regulatory purposes, such as the expected regulation on nanoparticles for human safety and the environment, require the use of traceable measurement techniques. The EC-funded Co-NanoMet project, in agreement with EURAMET, has produced an analysis on the nanometrology requirements and future strategies in support of the development of the European nanotechnology. Among the different techniques evaluated for traceable measurement at the nanometre scale, Atomic Force Microscopy, was selected as good candidate because of its sub-nanometre resolution. Many commercial AFMs exist but in order to ensure traceability at a higher level, most NMIs have or are developing metrological AFMs. Currently there are about 17 NMIs worldwide with metrological AFM in use or in development. The largest NMIs have already developed second or third generation metrological AFMs [1-4], and some smaller NMIs, typically with more limited resources, have developed also metrological AFMs [5-8]. Different methods for the characterisation of the instruments have been developed [4, 9, 10]. Several international comparisons have been organised to date in nanometrology [12-15].

An NMI or DI wishing to establish a capacity in traceable nanometrology would do so through the design, construction and validation of their own metrological AFM. The design would build on the experience of more developed NMIs. The validation process would involve the NMI establishing the capability participating in comparisons and analysis of uncertainties with others establishing similar facilities and with those with long established facilities. The whole process would result in both the development of a facility, the development of the relevant staff and the development of relationships between the NMI establishing the capability and more experienced researchers in the field which would foster further joint research activities beyond the life of the project.

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 turning existing AFMs into routinely available metrological instruments capable of providing traceable measurements and the validation of the newly established capability.

The specific objectives are:

1. To evaluate the design of existing metrological AFMs and to assemble new designed elements currently under development in emerging NMIs into commercially available AFM heads. Specific validation tests should be developed and performance criteria defined;
2. To validate the metrological AFMs fit-for-purpose and to assess the final performance (comparisons, uncertainties, CMCs);
3. For each participant, to develop an individual strategy for the long-term operation including regulatory support, research collaborations, quality schemes and accreditation. They should also develop a strategy for offering calibration services from the established facilities to their own country and neighbouring countries. The individual strategies should be discussed within the consortium and with other EURAMET NMIs/DIs, to ensure that a coordinated and optimised approach to the development of traceability in this field is developed for Europe as a whole, with
 - the development of ready-to-use methodologies for the calibration of step height, line width, grating pitch and surface roughness parameters and the development of a methodology for general shape measurements of different objects (e.g. particles);
 - the study of the effects of data post-processing and the elaboration of good practice guides to minimise the influence of the operator on the results;
 - the preparation and the realisation of an interlaboratory comparison on step height and line width involving all interested European NMIs.

Proposers shall give priority to work that meets documented metrological needs and activities that will lead to an improvement in European metrological capability and infrastructure beyond the lifetime of the project.

Proposers should establish the relevant current capability for research, and explain how their proposed project will develop capability beyond this.

EURAMET has defined an upper limit of 500 k€ for the EU Contribution to any project in this TP, and a minimum of 100 k€

EURAMET also expects the EU Contribution to the external funded partners to not exceed 10 % of the total EU Contribution to the project. Any deviation from this must be justified.

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,
- 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 or protection of the environment,
- Transfer knowledge to the nanotechnology sector and the metrology community.

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.

Additional information

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

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