

COordination of NANOMETrology in Europe

Reporting

Project Information

CO-NANOMET

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[Project website](#) 

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Final Report Summary - CO-NANOMET (Coordination of nanometrology in Europe)

Nanometrology in Europe

Executive summary:

To allow for the formulation of a European strategy for nanometrology, a comprehensive review of national and European nanotechnology related foresight activity has been completed to identify associated nanometrology needs. Following this review, a nanometrology consultative Paper has been published setting out future needs and opportunities within Europe for nanometrology. This document was circulated widely for comment and has subsequently been submitted to nanotechnology journal as a review paper.

To address the requirement for focused activity in Europe, 5 nanometrology action groups have been formed addressing the areas of engineered nanoparticles, nanobiotechnology, thin films and structured surfaces, critical dimensions and scanning probe techniques, modelling and simulation. In year one, each of the groups brought together key stakeholders and developed a discussion paper reviewing the current status, future needs and opportunities arising in their expertise area. In year 2, to build on the valuable work and outputs of these groups, dedicated workshops were implemented by each of the groups addressing:

1. 'Instruments, standard methods and reference materials for traceable nanoparticle characterisation'.
2. 'Measurement needs and opportunities in nanobiotechnology'.
3. 'Critical dimensions, scanning probe techniques and thin film metrology'.
4. 'Modelling and simulation at the nanoscale'.

Proceedings of the workshops have been compiled and provide a valuable resource to the community. The output of these workshops has also provided expert input to the strategic review completed of European nanometrology needs and opportunities.

As a result of the work of the critical dimensions and scanning probe techniques action group a German DIN national committee on 'Surface chemical analysis and scanning probe microscopy' has been established. As a consequence, Germany is now able to vote in the international organisation for

standardisation (ISO) technical committee 201 (surface chemical analysis) as a member body. This elevated national status for Germany allows the interests of European industry and national metrology institutes to be more fully supported at an international level. The activities of the engineered nanoparticles action group has also directly resulted in a new United State / European Union (US / EU) collaboration of further benefit to the nano standards community.

A review of current training in nanometrology across Europe has been completed. A subsequent training needs analysis has been implemented to ensure that the development of educational resources is suitably focussed to deliver the skilled workforce required to meet the needs of the nanotechnology community.

An 'Introductory guide to nanometrology' has been compiled. The guide provides a very valuable tool to the nanometrology community, increasing awareness of nanometrology and establishing a common metrological frame of reference.

A pan-European overview of organisations and associated capabilities in nanometrology has been provided in the form of a Capabilities Directory. Building on this, a gap analysis was completed and a scoping paper on priority areas for future infrastructural integration and development delivered.

To facilitate communication to and engagement with key stakeholders, a European nanometrology web portal has been established. This portal provides a central communications point highlighting capability within Europe and developments within the field. Key outputs of the programme have been communicated through this portal to a contact base of over 3 000. Targeted communication to two European countries (Ireland and Portugal), identified as having limited activity and knowledge in the field of nanometrology, has also been implemented to support nanotechnology development in these regions.

Based on the outputs of the above activities, a European strategy for nanometrology has been formulated. As a strategic guidance, this document contains a vision for European nanometrology 2020; future goals and research needs, building out from an evaluation of the status of science and technology in 2010. It incorporates concepts for the acceleration of European nanometrology, in support of the effective commercial exploitation of emerging nanotechnologies.

Overall the project has delivered significant benefit to the development and coordination of European nanometrology.

Project context and objectives:

Metrology, from the Ancient Greek metron (measure) and logos (study of), is the science of measurement. Nanometrology is a subfield of metrology, concerned with the science of measurement at the nanoscale level.

Today's global economy depends on reliable measurements and tests, which are trusted and accepted internationally. As such, metrology is a natural and vital part of our everyday life: coffee and planks of wood are both bought by weight or size; water, electricity and heat are metered. The quantity of active substances in medicine and the effect of the surgeon's laser must also be precise if patients' health is not to be jeopardised.

This measurement infrastructure must be extended into the nanoscale and beyond, to bring nanotechnology based products or manufacturing processes successfully and safely into the market place. It must provide the ability to measure in three dimensions with atomic resolution over large areas. For industrial application this must also be achieved at a suitable speed / throughput.

Measurements in the nanometre range should be traceable back to internationally accepted units of measurement (e.g. of length, angle, quantity of matter, and force). This requires common, validated measurement methods, calibrated scientific instrumentation as well as qualified reference samples. In some areas, even a common vocabulary needs to be defined. Given the speed and breadth of nanotechnology development, in only a few special cases has a traceability chain for the required measurements in the nm range been established.

Funded under the European Commission (EC)'s Seventh Framework Programme (FP7) CO-NANOMET is a programme of work which has addressed the need within Europe to develop the required measurement framework to successfully support the development and economic exploitation of nanotechnology.

By bringing together industry, research institutes, national metrology institutes, regulatory and standardisation bodies across Europe, it has coordinated ongoing activity, defining needs and uniting the infrastructure, people and capability, required to meet this challenge. A common strategy for European nanometrology has been defined such that future nanometrology development in Europe will build out from our many current strengths. In this way, European nanotechnology may be supported to reach its full and most exciting potential.

Specific project objectives were defined as follows:

- Objective 1: To define a European strategy for nanometrology - to provide a suitable measurement framework for the effective commercial development of nanotechnology. Definition of industrial needs will be achieved through review of national and European foresight and road mapping activities carried out to date. A pan-European coordinated response of the National Metrology Institutes to these defined needs will be formed in consultation with key stakeholders. Priority areas will be agreed which reflect both European strengths and emerging legislative requirements for nanoproducts.

- Objective 2: To identify and coordinate leading Nanometrology activity across Europe- with the aim to align the activities of the National Metrology Institutes, research institutes, equipment suppliers, end users and high-tech Small and medium-sized enterprises (SMEs) and build a dissemination path of traceability to national standards.

The field of nanotechnology covers a breadth of markets and applications each of which has specific and varying metrological needs. To this end, 5 European nanometrology action groups (ENAGs) will be established focussing on a set of core technology fields (engineered nanoparticles, nanobiotechnology, thin films and structured surfaces, critical dimension and scanning probe techniques, as well as modelling and simulation). Each action group will address the process chain for dissemination of metrology techniques as well as traceability to national standards and internationally harmonised methods.

- Objective 3: To coordinate European training and education of scientists, engineers and end-users in nanometrology - with the aim to provide an effective training infrastructure through which developments in measurement standards and techniques may be driven out from the National Metrology Institutes and research institutes through to industry. A review of current training and education programmes will be made and a training needs analysis completed. A training directory will be established for the community and recommendations on future curricular needs defined. To stimulate the development, use and promulgation of European and International standards, based on robust nanometrology, training on standards exploitation will be delivered. An introductory guide to nanometrology will also be developed establishing basic concepts for both new and expert workers in the field of nanotechnology.

- Objective 4: To create a central hub that builds on, coordinates and provides visibility to new and existing activities across Europe - with the aim to raise awareness of European capability and infrastructures in nanometrology and hence to encourage its effective exploitation by the nanotechnology community. This hub will be used to provide a European nanometrology capabilities directory; report on the activities and developments within the European action groups; to deliver information on available training; as well as to

call for input and disseminate the European Strategy for Nanometrology. In this way it will provide a valuable information service for industry and particularly SMEs in which the activities of leading centres are consolidated.

- Objective 5: To signpost, network, and recommend the development of new nanometrology infrastructures across Europe - with the aim to improve access to existing facilities and coordinate future development. With the increasing capital costs and the multi-disciplinary approach of nanotechnology, access to large and or specialised infrastructures is crucial for efficiency. Larger facilities offer unique opportunities to investigate dynamic phenomena at the nanoscale, they also offer the engineering tolerances required to work at these levels with confidence i.e. vibration control and temperature stability. The project will look at existing infrastructures and define emerging requirements. There is also synergy with the capabilities directory that will signpost available facilities to a public audience. Integration and enhancement of existing activities to provide for new 'poles of excellence' as called for in the EC nanosciences and nanotechnology action plan will be addressed. This objective will be pursued in coordination with the European metrology research programme (EMRP) that has recently been launched as an ERA-NET PLUS activity.

Potential impact:

Future nanometrology capacity development in Europe must build out from a clear and common understanding of current capabilities and competence as well as emerging future needs. To address this: A pan-European overview of organisations and associated capabilities in nanometrology has been provided in the form of a capabilities directory.

Building on this, a scoping paper on priority areas for future infrastructural investments was produced to inform subsequent discussions to be held with key stakeholders (to include EC, National Metrology Institutes, Metrology Services Governments and key EU infrastructures).

Publication of the capabilities directory to the nanotechnology community will also help to improve industry exploitation of current infrastructures.

The level of technological innovation across Europe in nanotechnologies is variable across the member states. The most advanced states are those predominately in the north west of Europe that have been well established innovators of new technologies since the formation of the EEC. With the advent of enlargement incorporating new states from central and Eastern Europe a new skills base has been incorporated into the research landscape. To address this:

- A review of current training in nanometrology across Europe and subsequent training needs analysis has been implemented to ensure that the development of educational resources is suitably focussed to deliver the skilled workforce required to meet the needs of the nanotechnology community.
- In addition, the transfer of knowledge from the National Metrology Institutes and the academic sector into the industrial arena has been enabled through direct engagement of industry in the European action groups plus the wider dissemination of reports and workshop proceedings of these bodies. In this way industry has been kept abreast of latest metrological developments to support their activities.

It is essential that all stakeholders are made aware of and engaged in the definition of capacity requirements. To this end, this programme of work has:

- Draw on the large body of work carried out to date defining the needs of nanotechnology such as national foresight studies and the nano aspects of the micro-nano manufacturing road maps developed under the European projects.

Improved Reliability of Measurement and Analysis at the Nano-Level

Public acceptance of emerging nanotechnologies is essential to enable it to reach its full commercial potential. Lessons may be learnt in this area from former emerging technologies such as nuclear power technology or Genetically modified organisms (GMO). Experience from these areas shows that citizens' expectations and concerns as well as perceptions of risk and benefits must be taken into account as they may critically impact on acceptance of new technologies in the market and hence determine market success or failure.

Key to the public acceptance of nanotechnologies is the existence of a robust and qualified system of measurement, control and regulation. In the field of nanoparticles, the required measurement frameworks are yet to be implemented. This programme of work will supported improved reliability of measurement and analysis through:

- A dedicated European nanotechnology action group on engineered nanoparticles addressing requirements for classification and measurement methods, instrumentation, standards and reference materials. In this way a more positive public interaction may be created and public confidence increased.
- The implementation of four further European NAGs (covering nanobiotechnology, thin films and structured surfaces, critical dimension and scanning probe techniques, and modelling and simulation). Each group has addressed the requirements in their given field to establish a dissemination process for traceability to National Standard from the National Metrology Institutes through to the product manufacturing process.

Support to the development of new nanotechnology based products and industrial processes, to their reliability, safety and future commercialisation on the global market.

Maintaining competitiveness in product development and commercial processes today requires ongoing and rapid innovation. To quote Lord Kelvin 'If you cannot measure it, you cannot improve it'. Optimisation of the performance and reliability of nano enabled products, systems and processes requires effective measurement of critical nanoscale properties, standardised testing configurations and methodologies. Moreover, qualification of the performance enhancement of nano products requires an understanding and quantification of the link to the underlying key nanoscale structure / composition.

The establishment of European NAGs addressing the areas of measurement technologies; instrumentation; standardisation requirements traceability and equivalence and tools for the assurance of measurement quality has addressed these evolving requirements and so enabled the more rapid development of nano products through to the market place.

Reliability and safety of products and industrial processes are underpinned by the requirement for replication to within agreed tolerances. Once again this will be progressed through the work of both the action groups and the European strategy development on the implementation of a global measurement framework for nanotechnology.

Support to research and regulation

In line with public concerns in regard to nanotechnology detailed above, many regulatory bodies are considering the implications of this new area. As a novel technology area, adaption of current regulatory frameworks may not suffice in some areas and new approaches may be required.

The implementation of control procedures is implicit in regulatory requirements. The novel properties of nano enabled products result from the control of a 'critical dimension' of a specimen in the nanometre range. This same nanoscale feature which may add beneficial properties has the potential to introduce new risks to people and the environment.

This project of work has addressed the ability to measure key nanoscale properties in a verifiable manner, a pre requisite to the implementation of regulatory controls. Assessment of emerging regulations and their link to industry has fallen fall under the remit of the European nanometrology action groups.

Within research, once again, the ability to measure key properties at the nanoscale is necessary to specify novel effects and their link to underlying structural definition. This programme has created a central hub for nanometrology developments in Europe, whereby key development in measurement systems and methodologies may be effectively communicated to the research base.

sustainable development

Nanotechnologies offer a crucial contribution to sustainable development. EU research on clean technologies and industrial processes already helps minimise energy consumption, solve waste problems and stimulate responsible behaviour from both producers and consumers. Nanotechnologies will allow Europe to go one stage further - to do even more and better while using fewer resources.

Nanotechnology may enable the EU to meets its international commitments on sustainability issues, make its enterprises more competitive and contribute to fulfil the legitimate expectations of European citizens in terms of safety, security and quality of life. Nanometrology has a clear supporting role in this development.

In parallel with nanotechnology developments, coordination at the European level must be addressed, to prevent doubling-up of efforts among regions and member states. To this end, the programme has brought together multiple European players, public and private, and created new exploitation networks which allow the joining of forces and pooling of resources.

This coordination action has brought together the input from key players both in the overall definition of a European strategy plus in focused activity along specific technological themes. As such it has enabled the

potential benefits of nanotechnology for sustainable development to be realised.

Implementation of the EC's action plan for nanotechnology

To ensure that Europe best benefits from the opportunities provided by nanotechnologies, the EC's action plan for nanotechnology sets out the following needs:

to implement an integrated and responsible approach on nanotechnology at EU level;

- to join forces across disciplines, sectors and national borders;

- to coordinate actions, increase investment, create the necessary infrastructures and boost human resources to support research and foster innovation to properly address the societal concerns that come with the development of new applications.

These requirements pass directly though to Nanometrology. Details on the ways in which this programme has supported each of these requirements have been addressed above.

Infrastructure

World-class Research and development (R&D) infrastructure and 'poles of excellence' are essential for the EU to remain competitive in nanoscience and technology. Europe needs an appropriate, diverse but coherent system of infrastructure that comprises both 'single sited' (in one location) and 'distributed' (networked) facilities. However, due to its interdisciplinary, complex and costly nature, the infrastructure for R&D and innovation in nanotechnologies and nanosciences requires a critical mass of resources that are beyond the means of regional and often even national governments and industry.

The review of nanometrology capabilities carried out under this programme will map directly to and further inform the associated map of existing nanoscience and nanotechnology infrastructures to be developed at a European level. It will support transnational networking and integration of resources across National Metrology Institutes, universities, R&D organisations and industry as a means of assembling critical mass through 'distributed' poles of excellence. The European action groups established under this programme,

and the capabilities and infrastructures represented therein may be considered the forerunners to the formal formation of such poles of excellence in nanometrology.

List of websites: www.co-nanomet.eu www.euspen.eu/nanometrology

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