

## Nano-material properties

Nano materials are inspiring a new generation of products; chains of molecules acting as wires in ever smaller electronics, nano-films creating future flexible unbreakable phones, membranes with nano-holes filtering sea water into drinking water. However, their small scale means they behave in a fundamentally different way to the bulk material. To reap the benefits of new innovations, methods are needed for measuring nano-scale material properties.

### **Europe's National Measurement Institutes working together**

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

# Challenge

Introducing innovative products such as novel optoelectronics based on quantum dots, nanowires and nanorods or wear resistant coating using new nanostructures relies on having confidence in how these materials behave at the nano-scale.

Understanding the strength of materials at the nano-scale as opposed to in bulk is essential. Atomic interactions may dominate nano-scale properties and being only a few atoms thick may make a material very delicate to handle. Before the world's most innovative manufacturers can start using nano-materials, they need to reliably measure nano-scale material properties.

Miniaturised materials and objects need miniaturised test methods. Atomic Force Microscopy (AFM) is a popular method for measuring nano-properties such as elasticity. It works by applying a load to a probe tip and measuring how much it sinks into the material. The tip is held in place by a tiny piece of material called a cantilever. Unfortunately cantilevers flex and compromise measurements by reducing the applied force. Greater accuracy in measuring cantilever stiffness and determining how much of the applied load is transferred to the test material are needed for calibrations of AFM used for measuring nano-material properties.

# Solution

The EMRP project, *Traceable measurement of mechanical properties of nano-objects*, looked at methods for determining cantilever stiffness.

The project developed well defined nano-objects with known response to loads and used these to compare different AFM calibration methods, determining which factors have the greatest effect on measurement accuracy and how improvements can be made. Cantilever vibrations were analysed to simplify their contributions to complex calculations of the forces applied during AFM testing. The acquired measurement data was then compared to precise computer models. This allowed verification of proposed new corrections and the achievement of greater calibration accuracy for AFM measurements of nanoscale material strength.

# Impact

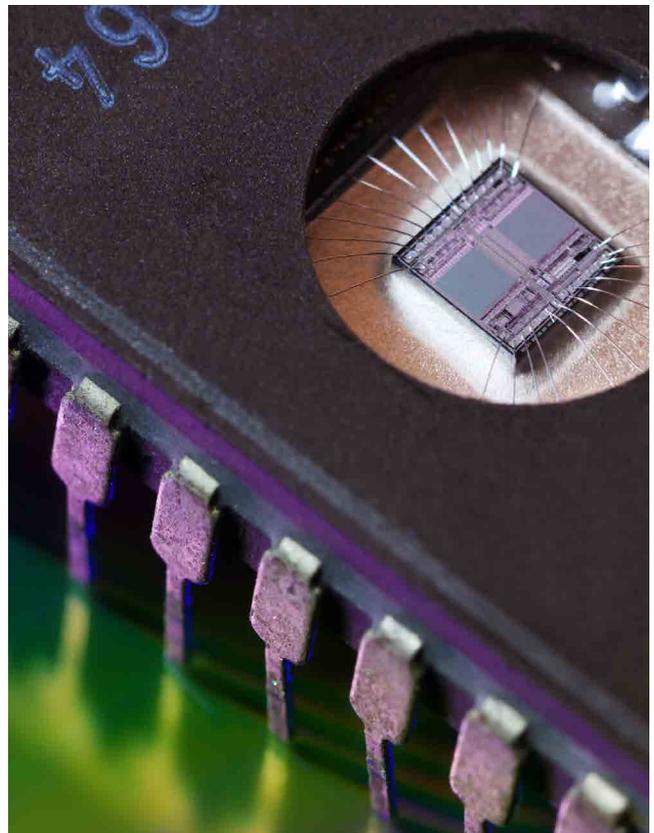
NanoWorld AG, a leading manufacturer of high quality probe tips for AFM and similar measurement technologies, used the cantilever stiffness calibration method developed by the project to bring traceability to their own CalibLever reference cantilevers.

NanoWorld's certified cantilever enables SI traceability for their own in house calibration methods, confirming the stiffness uncertainty of their commercially available AFM cantilevers, and allowing them to offer a calibration service to users. As a result, NanoWorld has increased sales of cantilevers with measured force constants to customers around the world.

Improved robustness for AFM measurements of elasticity at the nanoscale is increasing our understanding of nanomaterial behaviour in situ, so providing greater confidence in the use of nano-wires and other nano-structure innovations in new products.

## Introducing traceability for nano-mechanical properties

Conventional bulk material measurement techniques cannot be used to assess nano-material properties, and existing nano-scale measurement methods lack rigour impeding uptake of novel nano-materials into new innovative products. The EMRP project *Traceable measurement of mechanical properties of nano-objects* developed methods for nano-sized specimen preparation and compared existing and novel nano-measurement techniques leading to increased traceability for nano-material mechanical properties. As a result atomic force microscopy can be confidently used to determine the strength of nano-materials and a new scanning electron microscopy tool enables users to view sub-nano mechanical testing as it's performed.



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## EMRP

European Metrology Research Programme  
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The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

[www.euramet.org/project-NEW05](http://www.euramet.org/project-NEW05)

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