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DEVELOPMENTS IN METROLOGY IN SUPPORT OF NANOTECHNOLOGY

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ABSTRACT:
Nanotechnology emerges out of fundamental science through capability for accurate, repeatable and reproducible measurements on the nanoscale which allows scientists and engineers to accumulate knowledge. Understanding the measurement science is the first step towards development of new ideas. This paper describes some research initiatives which underpin the development of nanotechnology. Programs underway at the National Research Council of Canada.Thia include development of metrological scanning-probe microscope instrumentation for dimensional calibration, materials characterization, development of artefacts designed specifically for dimensional calibration, investigation of metrology for application to soft materials and investigation of intrinsic length standards for realization of the SI metre at the nanoscale.

Key words: Nanotechnology, measurement, basis, procedures, technical

Introduction

Common terminology, standards and procedures form the basis of fair trade, technical competitiveness and product reliability. Accurate measurements are also important for the advancement of science and acquisition of knowledge as they allow comparability of measurements. Comparability and coherence with the fundamental constants is becoming increasingly relevant to industry as feature sizes diminish and quantum effects are exploited in new devices. This is best achieved through traceability to the SI, which provides a unified basis for measurements.

Metrology and international standards have an important role in taking proofof-concept ideas to commercialization and trade in our global marketplace. The June '07 Resolution of ISO/TC229 Technical Committee on Nanotechnologies calling for governments to invest in nanotechnology R&D is a testament to the acknowledged large-scale cooperative effort required to establish terminology and nomenclature, and measurement & characterization techniques − essential to our understanding of health, safety and environmental impacts of nanotechnologies. Consensus standards contribute in a fundamental way to the body of knowledge necessary for realizing benefits, such as predictive toxicology in the area of health and environment. Drawing further on this specific example, terminology, nomenclature and the specification of key physico-chemical properties of nanomaterials are topics of intense interest for the purpose of unique identification and characterization of nanomaterials. There are several lists of measurands deemed as essential currently under consideration by the science and technology community; work is ongoing to determine the most widely-accepted list, which in turn will influence nomenclature of new nano-objects and the development of metrology.

Reference materials are a necessary component of reliable measurements since they are used to calibrate instruments and compare testing procedures and measurement results between laboratories. The community of national metrology institutes are launching nanoscale reference materials and measurement protocols with the intention of providing guidance and benchmarks to nanotechnology users and ensuring commutability of measurement results. Evidence that more work is required to understand nanoscale objects and measurement methods is supplied by the case of nanoparticles: the specific value attributed to particle size is determined largely based on the measurement technique applied and end-use of the client.

The quality of the transfer of the definition the metre depends on the design, quality and measurement techniques used to calibrate reference standards. History demonstrates that economic benefit results from high quality manufacturing, which is in turn directly related to highest-level metrological standards that keep pace with the developments of competitive precision mechanics. Nanotechnologies pose new challenges to traditional metrology because our understanding of how nature behaves on nanoscale lengths is in development. This paper outlines the activities and progress of the National Research Council of Canada (NRC) program of research and development, in part drawing upon trusted strategies from macroscale measurements and applying them towards understanding behaviour, and developing new measurement techniques specifically to address nanoscale measurement problems. In the area of length metrology, projects focus on development of lengthcalibration artefacts, metrological scanning-probe microscope instrumentation for dimensional calibration, materials characterization and investigation of intrinsic length standards for realization of the SI metre at the nanoscale..

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Conclusions

This paper describes an NRC program of scientific research and development offering a unique opportunity for innovative design and fabrication of standards, development of metrological instrumentation and calibration procedures. Goals focus on length and force quantities; establishing a solid foundation for development of nanotechnologies which are expected to have powerful applications not only in physics and engineering, but also in chemistry and biology. Instrumentation and methods developed in this program will be validated via international inter-laboratory comparison experiments. Measurement comparisons offer the only opportunity for performance evaluation of measuring instruments at the highest metrological level, since instruments do not always perform to the specifications anticipated.]. They also uncover practical aspects of reference standard quality, longevity/durability, etc. Comparison results offer international peer review and validation of research-oriented instruments, and a quality check on production-based industrial instruments.

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