EDITORIAL

Nanoscale metrology

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Instrumentation and measurement techniques at the nanoscale play a crucial role not only in extending our knowledge of the properties of matter and processes in nanosciences, but also in addressing new measurement needs in process control and quality assurance in industry. Micro- and nanotechnologies are now facing a growing demand for quantitative measurements to support the reliability, safety and competitiveness of products and services. Quantitative measurements presuppose reliable and stable instruments and measurement procedures as well as suitable calibration artefacts to ensure the quality of measurements and traceability to standards.

This special issue of Measurement Science and Technology presents selected contributions from the Nanoscale 2008 seminar held at the Istituto Nazionale di Ricerca Metrologica (INRIM), Torino, in September 2008. This was the 4th Seminar on Nanoscale Calibration Standards and Methods and the 8th Seminar on Quantitative Microscopy (the first being held in 1995). The seminar was jointly organized by the Nanometrology Group within EUROMET (The European Collaboration in Measurement Standards), the German Nanotechnology Competence Centre ‘Ultraprecise Surface Figuring’ (CC-UPOB), the Physikalisch-Technische Bundesanstalt (PTB) and INRIM.

A special event during the seminar was the ‘knighting’ of Günter Wilkening from PTB, Braunschweig, Germany, as the 1st Knight of Dimensional Nanometrology. Günter Wilkening received the NanoKnight Award for his outstanding work in the field of dimensional nanometrology over the last 20 years.

The contributions in this special issue deal with the developments and improvements of instrumentation and measurement methods for scanning force microscopy (SFM), electron and optical microscopy, high-resolution interferometry, calibration of instruments and new standards, new facilities and applications including critical dimension (CD) measurements on small and medium structures and nanoparticle characterization.

The papers in the first part report on new or improved instrumentation, details of developments of metrology SFM, improvements to SFM, probes and scanning methods in the direction of nanoscale coordinate measuring machines and true 3D measurements as well as of progress of a 2D encoder based on a regular crystalline lattice. To ensure traceability to the SI unit of length many highly sophisticated instruments are equipped with laser interferometers to measure small displacements in the nanometre range very accurately. Improving these techniques is still a challenge and therefore new interferometric techniques are considered in several papers as well as improved sensors for nanodisplacement measurements or the development of a deep UV microscope for micro- and nanostructures. The tactile measurement of small structures also calls for a better control of forces in the nano- and piconewton range. A nanoforce facility, based on a disk-pendulum with electrostatic stiffness reduction and electrostatic force compensation, is presented for the measurement of small forces.

In the second part the contributions are related to calibration and correction strategies and standards such as the development of test objects based on 3D silicon structures, and of samples with irregular surface profiles, and their use for calibration. The shape of the tip and its influence on measurements is still a
contentious issue and addressed in several papers: use of nanospheres for tip characterization, a geometrical approach for reconstruction errors by tactile probing. Molecular dynamical calculations, classical as well as \textit{ab initio} (based on density functional theory), are used to discuss effects of tip–sample relaxation on the topography and to have a better base from which to estimate uncertainties in measurements of small particles or features. Some papers report about measurements of air refractivity fluctuations by phase modulation interferometry, angle-scale traceability by laser diffractometry, and an error separation method. The development of 3D surface roughness measurement standards from scratches is considered in one contribution. Here a 2D autoregressive model was used to generate the software gauge data, which were used as a base for the manufacturing process by diamond turning.

Contributions in the third part deal with applications including CD measurements on small and medium structures, the characterization of nanoparticles with a diameter less than 200 nm by electron microscopy, chemical nanoscale metrology by TXRF and a study of the strength of nanotube bundles.

We would like to thank all the authors for their contributions, and the referees for their time spent reviewing all the papers and for making their valuable and helpful comments. Additional thanks are extended to all involved in the production of this issue for their help and support.