Tools and Metrology at the nanoscale

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Abstract

The continuous development of instrumentation and measurement techniques has opened up new insights in the knowledge of the property of matter and processes at the nanoscale. Innovative instrumentation plays a crucial role for measuring, manipulating and machining of material, including new measurement needs from the modern production of semiconductor and integrated devices [1]. Nanotechnology is now facing a growing demand of quantitative measurements and traceable standards to support the reliability, safety and competitiveness of products and services [2,3]. This requires the definition of protocols and methods to ensure the quality of measurements and traceability to standards, as well as the adoption of an agreed standardization framework supported by pre-normative research. Several projects have been carried out by national Metrology Institutes and other labs to extend traceability and to improve the measurement capabilities at the nanoscale. The achieved steps and consistency of measurements have been demonstrated by several inter-laboratory comparisons.

This contribution aims to address tools, capabilities and standards in nanometrology, with emphasis on dimensional and surface measurements for characterization and design of materials, structures and devices, including linewidths, gratings, grids, step-height standards and particles. The state of the art of standards available for surface metrology is presented together with a few example of applications. A description of the instrument design and calibration of a metrological scanning force microscope is given. Measurement needs for precise positioning and control of tip/sample displacements are discussed together with recent achievements in high-resolution optical interferometry.

Quantitative measurements rely on traceable standards, calibrated instruments and a consistent estimation of the uncertainty. A detailed description of the uncertainty budget as estimated in a case of study at the nanoscale is given.

References

[1] International Technology Roadmap for semiconductor – 2011 Edition – Metrology http://www.itrs.net/Links/2011ITRS/2011Chapters/2011Metrology.pdf.

[2] National Nanotechnology Initiative – Strategic Plan (2011) http://www.nano.gov/node/581

[3] European Commission – Nanotechnology http://ec.europa.eu/nanotechnology/index_en.html