Traceable Dimensional Nanometrology by Metrological AFM

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Nanometrology plays a key role in nanoscience and nanomanufacturing, since it allows to produce traceable and accurate results, ensuring the quality of products down to the nanoscale. Developments in nanomanufacturing, particularly in the nanoelectronics industry, pose increasing challenges in measuring nanostructures with ever smaller sizes and more complex 3D shapes.

Nanometrology encompasses a wide range of techniques for characterizing and measuring materials and devices at the nanoscale. In particular, metrological Atomic Force Microscopes (mAFMs) are the workhorse of the dimensional nanometrology, since they use interferometers to carry out traceable measurements of the tip–sample relative position.

3D nanometrology can support nanoscience and nanotechnologies by developing new measurement methodologies and data processing. Furthermore, the development of candidate reference nanomaterials for dimensional nanometrology will lower uncertainties and improve the traceability.

For this purpose, by using INRiM metrological atomic force microscope (mAFM) two main studies are performed:

(i) while AFM height measurements can achieve sub-nanometer resolution and accuracy, lateral resolution is affected by errors due to the probe shape and size. Tobacco Mosaic Viruses (TMVs) are used as calibrator for reconstructing the dilation caused by the tip in lateral measurements, since TMV cross-sectional diameter has a stable value;

(ii) since industrial nanomaterials have shapes much more complex than the spherical one, traceable measurements of non-spherical shapes and sizes require the development of new measurement methods. Complex shape inorganic nanoparticles are studied as candidate reference materials in dimensional nanometrology, because of their critical sizes which are stable and have a monomodal distribution.