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Traceable Dimensional Metrology of Nanoparticles and Nanostructures

Luigi Ribotta (1), Roberto Bellotti (1), Andrea Giura (1), Massimo Zucco (1)
(1) Nanometrology Group, Applied Metrology and Engineering Division, Istituto Nazionale di Ricerca Metrologica (INRIM), Strada delle Cacce 91, 10135, Turin, Italy

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Abstract
Nanometrology covers a wide range of techniques for enabling characterization and measurement of materials at the nanoscale. In particular, metrological Atomic Force Microscopes (mAFMs) are the workhorse of the dimensional nanometrology, since they use interferometers to traceable measure the tip–sample relative position.

In this study, INRIM mAFM is used to quantitatively study nanoparticles (NPs) and nanostructures of different shapes.

While AFM height measurements can be achieved with sub-nanometer accuracy and high resolution, lateral resolution is influenced by several factors, the most impacting is the tip shape. Bio-based nanostructures (Tobacco Mosaic Virus) are used as calibrator for reconstructing the dilation caused by the tip in lateral measures, since TMV cross-sectional diameter has a stable value [1].

Nowadays, quasi-spherical NPs are measured sufficiently accurately by AFM, through the determination of the mean diameter as the top-height of the cross-section profile. Since industrial nanomaterials have shapes much more complex than the spherical one, traceable measurement of non-spherical shapes and sizes requires the development of new measurement methods. AFM measurement of complex shape NPs represents a challenge, because their particular geometries emphasize the limitations associated with finite tip size. Through new geometrical approaches which consider the nominal crystal structure and the conditions in which the particles have been synthesized, we robustly and accurately reconstructed critical sizes and morphological parameters of TiO₂ anatase bipyramids and nanosheets NPs. These complex shape NPs can be applied as candidate reference materials in dimensional nanometrology, because of their critical sizes which are stable and have a monomodal distribution [2].

Each measurand reported in this study is quantitatively determined along with its uncertainty, with a relative combined standard uncertainty of the mean less than 10%.

References
Corresponding author: Luigi Ribotta
phone: +39 011 3919 960
e-mail: l.ribotta@inrim.it
address: Strada delle Cacce 91, 10135, Turin
institution: Istituto Nazionale di Ricerca Metrologica (INRiM)
address: Posta Elettronica Certificata: inrim@pec.it
invoicing data: Codice Univoco Ufficio per fatturazione elettronica: UFPQ1O
VAT Number: 09261710017