Nanoobjects microscopy

Metrological aspects of atomic force spectroscopy

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From the viewpoint of using scanning probe microscopy for maintenance of up-to-date nanotechnologies, metrological traceability of measurements is very important. While 3D topography analysis is dominated applications of atomic force microscopy (AFM), the physics of probe-sample interactions and quantitative analyses of adhesive and mechanical properties have become of increasing interest in recent years. Practical applications of force spectroscopy measurements are ranged from single molecular interactions to tribology and mechanics of nanoobjects and advanced materials.

However, to verify and calibrate AFM force measurements, one should use common unified approaches that could provide worldwide comparability of measurement results and metrological traceability. Up to date, about a dozen of international normative documents are under development or nearing completion, for example [1,2]. Those, the refinement of physical models for tip/sample interaction and development of calibration techniques and suitable models for uncertainty evaluation is an actual problem.

We report developed and tested techniques for calibration of the AFM probes force constants. Peculiarities of different physical approaches were analyzed including, both stationary and dynamic modes. We suggest using combination of dimensional models for express predicting cantilever spring constants basing on optical measurements of cantilever geometry and frequency of mechanical resonance. Static deflection measurements of cantilever spring constants using etalon lever is quite convenient too. However, carrying out these measurements recommended after high-resolution surface force mapping to prevent possible tip apex damages. The thermal tune method was selected from variety of dynamic deflection measurements of cantilever spring constants. Specificity of thermal noise data collection, their statistical treatment and fitting was investigated. It was shown that this technique should be successfully realized in AFM with electronic bandwidth starting from 31 kHz and applied to calibration of soft levers (~ 0.2 N/m). A corresponding analysis of measurement uncertainties and calibration of sets of AFM probes with elastic constants in the range of 0.2 - 50 N/m will be reported.

1. ISO/DIS 11775 Determination of cantilever normal spring constants.
2. ISO/WD TR 13096 Guidelines for the description of AFM probe properties