Surface Chemical Analysis

Technical Work Area 2

Call for Participation

Project A52

Method for AFM sub-nanometer z-linearity and z-calibration using stepped surfaces

Objectives

This project aims to assess the effectiveness of 6H-SiC(0001) stepped surfaces for atomic force microscopy (AFM) height calibration in the sub-nanometer to nanometer range. The results of this study will be used towards the initiation of an ISO NWIP for sub-nanometer range calibration of the z-piezo actuator of an AFM.

Background

Accuracy and precision in dimensional metrology in the nanometer and sub-nanometer range are crucial for various emerging applications in functional materials and fabricated structures. One of the most widely used techniques for imaging surface topographies and conducting dimensional measurements at this scale, both in research and industry, is AFM. Therefore, it is essential to ensure the proper calibration of the piezoelectric scanner in any AFM by periodically measuring features of known height, and that these features are sized appropriately to identify any potential drift, creep, and nonlinearities on the scale of the desired measurement. For sub-nanometer to nm scale calibrations use of 6H-SiC(0001) stepped surfaces for height calibration is proposed. Artifacts with this surface functionalization are commercially available and are user-friendly for direct topographical imaging with AFMs. Unlike single-defined height artifacts, the staircase step structure of these surfaces provide a continuous range of height calibration, from a single step (sub-nm range) to the height of multiple steps (to tens of nm).

Standardization Needs

There is a significant need to establish dimensional standardization for AFM to support sub-nanometer metrology and applications. The height calibration of an AFM instrument is currently determined using artifacts with height differences ranging from tens to hundreds of nanometers. There are no existing calibration artifacts or procedures that offer a reliable calibration specifically for the sub-nanometer to nanometer range.

Work Programme

Participants will be provided a draft measurement protocol, data analysis software package, and a 6H-SiC(0001) calibration artifact. Participants will be expected to measure the artifact and return both analyzed and raw data to the project leader. Statistical analysis of the results from participants will be conducted as consistent with ISO/TS 11308.

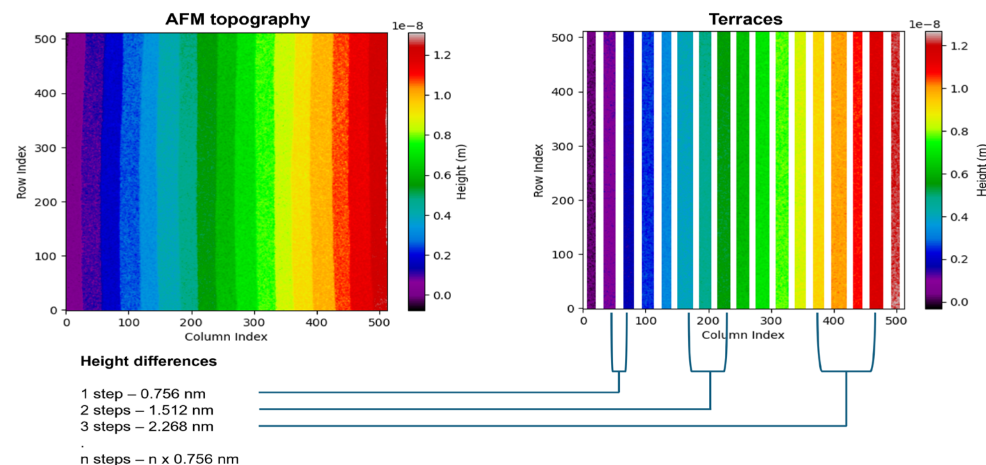

Figure: AFM topography (3 um x 3 um) of 6H-SiC(0001) stepped surface to extract various step heights by calculating the differences between the imaged terraces. The staircase heights are compared to multiples of the 6H-SiC(0001) crystallographic step height.

Deliverables and Dissemination

Results will be presented at annual ISO/TC201/SC9 (scanning probe microscopy) meetings, published in peer-reviewed journals, and used to develop an ISO standard for z-piezo AFM calibration and linearity.

Funding

Participants fund their own involvement in the project. Anticipated work is ≈ 3 days.

References

Python analysis script: https://github.com/usnistgov/AFM-Staircase.

Status: This project is set to start in April 2026.

For more information:

Project Leader:
Dr. Gheorghe Stan
National Institute of Standards and Technology (NIST), USA
Email: gheorghe.stan@nist.gov

TWA 2 Chair
Prof. Ian Gilmore
National Physical Laboratory, UK
Email: ian.gilmore@npl.co.uk

www.vamas.org
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