Standards for Nanotechnology from Elsewhere

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Contents:

•Examples of Standards from Elsewhere
– CIPM CCL WGDM 7, ISO TC 213, ASME B46, ASTM E42.14

•Observations
-Proliferation and Context
-Formats and Data Modeling
-Publishers and Copyright

CIPM Consultative Committee for Length, WG on Dimensional Metrology Discussion Group on Nanometrology (WGDM7), Meeting-25 June 1998

"Conclusion 1 - Working Definition of Nanometrology:
Nanometrology is the science of measurement of the dimensions of objects or object features, separations or displacements in the range from 1 nm to 1000 nm."

The National Nanotechnology Initiative Strategic Plan, December 2004, p iii.

"What is Nanotechnology?
Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nm, where unique phenomena enable novel applications."

The American Society of Mechanical Engineers

AN AMERICAN NATIONAL STANDARD

SURFACE TEXTURE (SURFACE ROUGHNESS, WAVINESS, AND LAY)

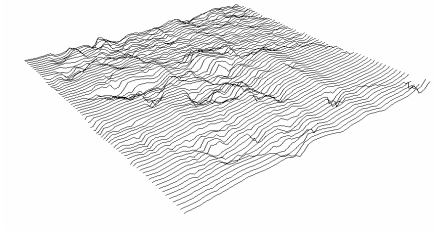
Terms Related to Surface Texture
Classification of Instruments for Surface Texture Measurement
Terminology and Measurement Procedures for Profiling, Contact, Skidless Instruments
Measurement Procedures for Contact, Skidded Instruments
Measurement Techniques for Area Profiling
Measurement Techniques for Area Averaging
Filtering of Surface Profiles
Specifications and Procedures for Precision Reference Specimens
Specifications and Procedures for Roughness Comparison Specimens

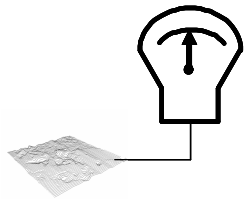
ASME B46.1-1995
(Revision of ANSI/ASME B46.1-1985)

The 2002 edition contains sections on

- **nanometer-level surface texture measurement with stylus**
- **Nanometer-level surface texture measurement with phase shifting interferometry**

Classification of Methods for Measuring Surface Texture From ISO 25178-6 (TC213/WG16)





Line Profiling,
Senses *Z(X)*

Areal Topography,
Senses *Z*(*X*,*Y*) or
Z(*X*) as a function of *Y**

Area-Integrating

Contacting Stylus,
Phase Shifting Interferometry,
Vertical Scanning (White Light) Interferometry,
Focus Sensing Confocal Microscopy,
Chromatic Length Aberration Confocal Microscopy,
Structured Light and Triangulation,
SEM Stereoscopy,
Scanning Tunneling Microscopy,
Atomic Force Microscopy,
Optical Differential Profiling,
Angle Resolved SEM

Total Integrated Scatter,
Angle Resolved Scatter,
Parallel Plate Capacitance,
Pneumatic

Contacting Stylus,
Phase Shifting Interferometry,
Circular Interferometric Profiling,**
Optical Differential Profiling

*The accuracy of *Z*(*Y*) profiling depends on the method and should be ascertained for each method

**Relies on circular scanning to produce a *Z*(*?*) profile

DRAFT INTERNATIONAL STANDARD ISO/DIS 25178-6

ISO/TC 213	Secretariat: DS
Voting begins on: 2007-09-18	Voting terminates on: 2008-01-18

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION - МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ - ORGANISATION INTERNATIONALE DE NORMALISATION

Geometrical product specifications (GPS) — Surface texture: Areal —

Part 6: Classification of methods for measuring surface texture

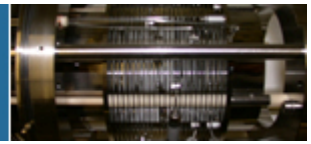
Spécification géométrique des produits (GPS) — État de surface: surfacique —

Partie 6: Classification des méthodes de mesurage de l'état de surface

3.3.14
atomic force microscopy (AFM), scanning force microscopy (SFM)
surface topography measurement method whereby the surface height is sensed from the mechanical force of attraction or repulsion between a probe tip and a surface

NOTE STM, AFM, and SFM are three methods that may be classified as scanned probe microscopies (SPM), which also encompasses near field scanning optical microscopy (NSOM), scanning capacitance microscopy (SCM) and others. The development of certain standards related to these techniques falls under the scope of ISO/TC 201/SC 9 on *Scanning Probe Microscopy*.

E42 on Surface Analysis



SubCommittee **E42.14 on STM/AFM**

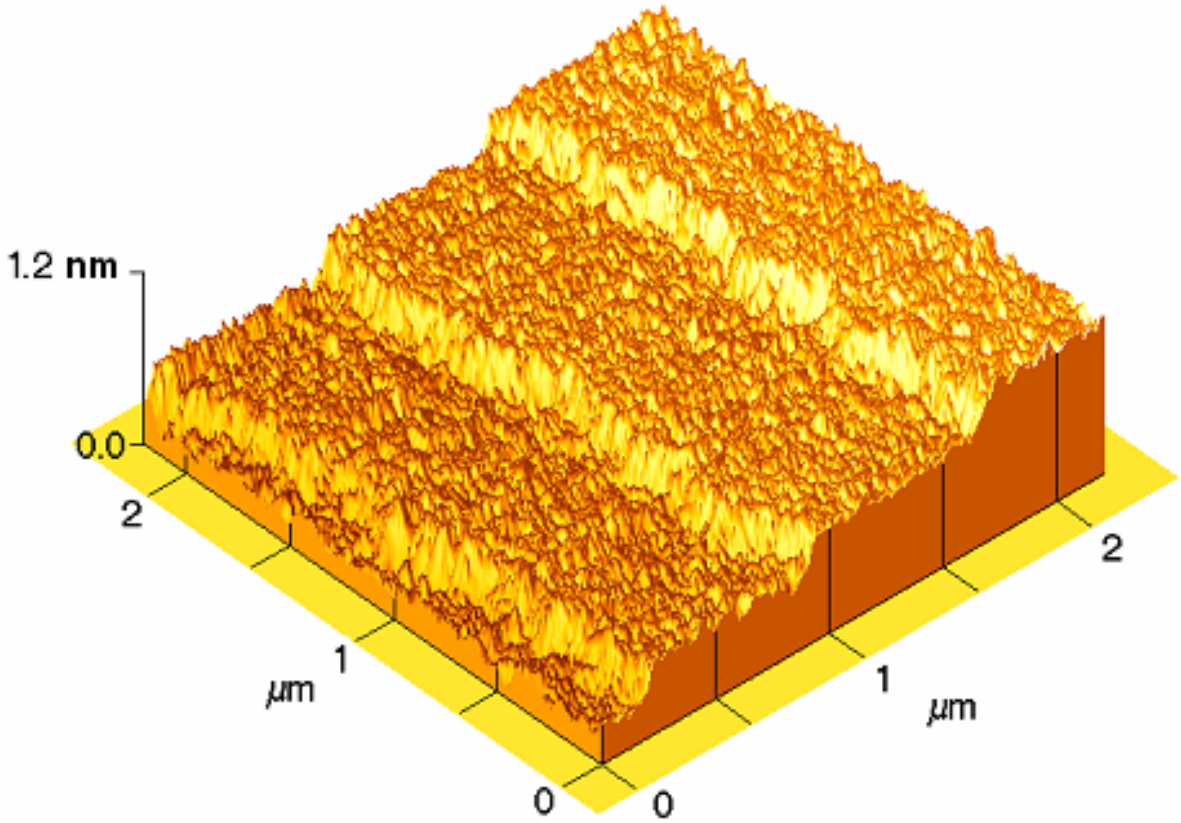
ACTIVE standards under the jurisdiction of E42.14

E1813-96(2007) Standard Practice for Measuring and Reporting Probe Tip Shape in Scanning Probe Microscopy

E2382-04 Guide to Scanner and Tip Related Artifacts in Scanning Tunneling Microscopy and Atomic Force Microscopy

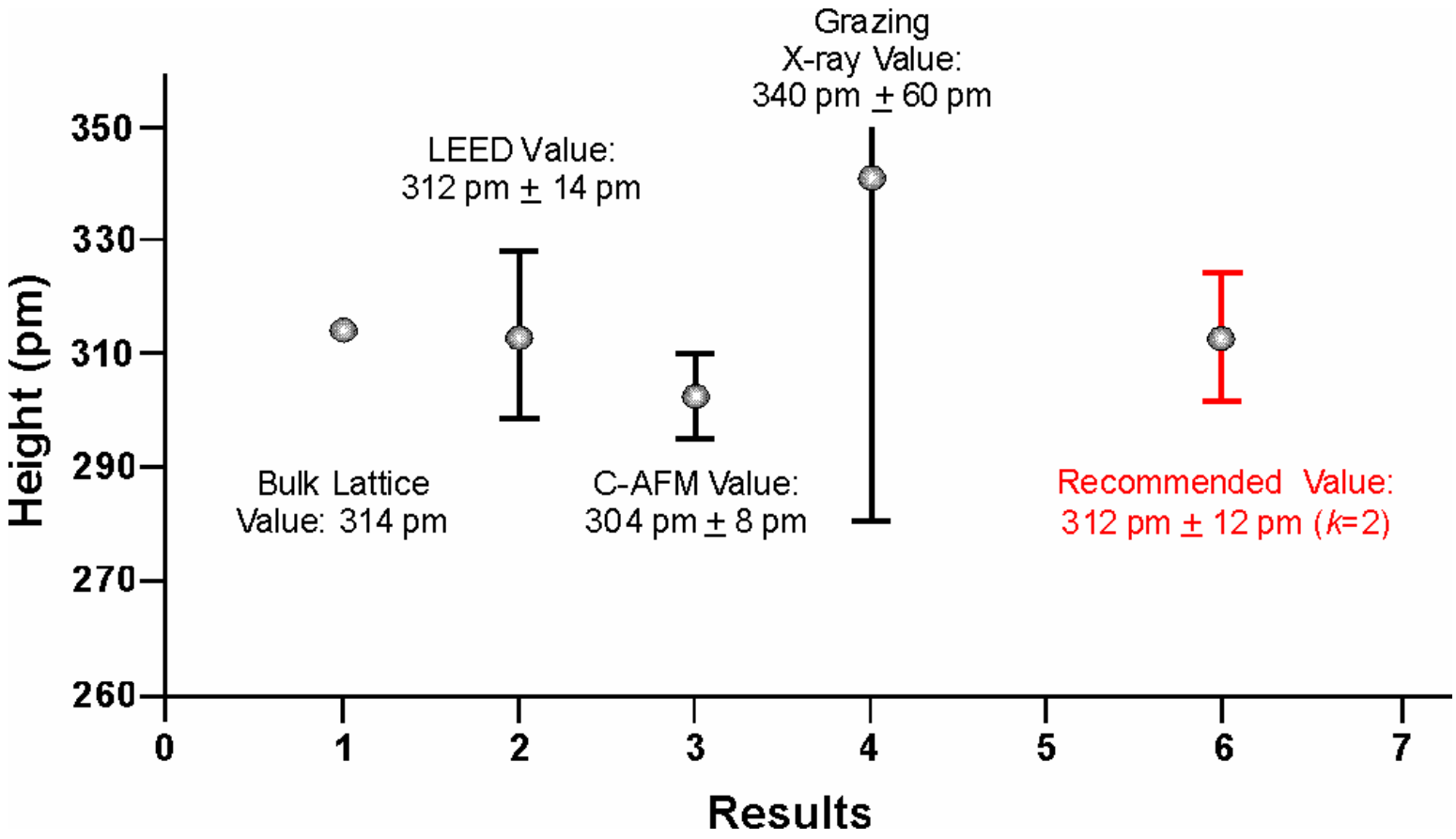
E2530-06 Standard Practice for Calibrating the Z-Magnification of an Atomic Force Microscope at Subnanometer Displacement Levels Using Si(111) Monatomic Steps

AFM image of silicon (111) atomic step specimen with native oxide



See N.G. Orji et al. *Wear* **257**, 1264 (2004).

Comparison of Silicon Step Height Results



Typical Area Selection for Step Height Analysis on Si (111)
What is the expected variability for a user

scan size is 1.44 µm

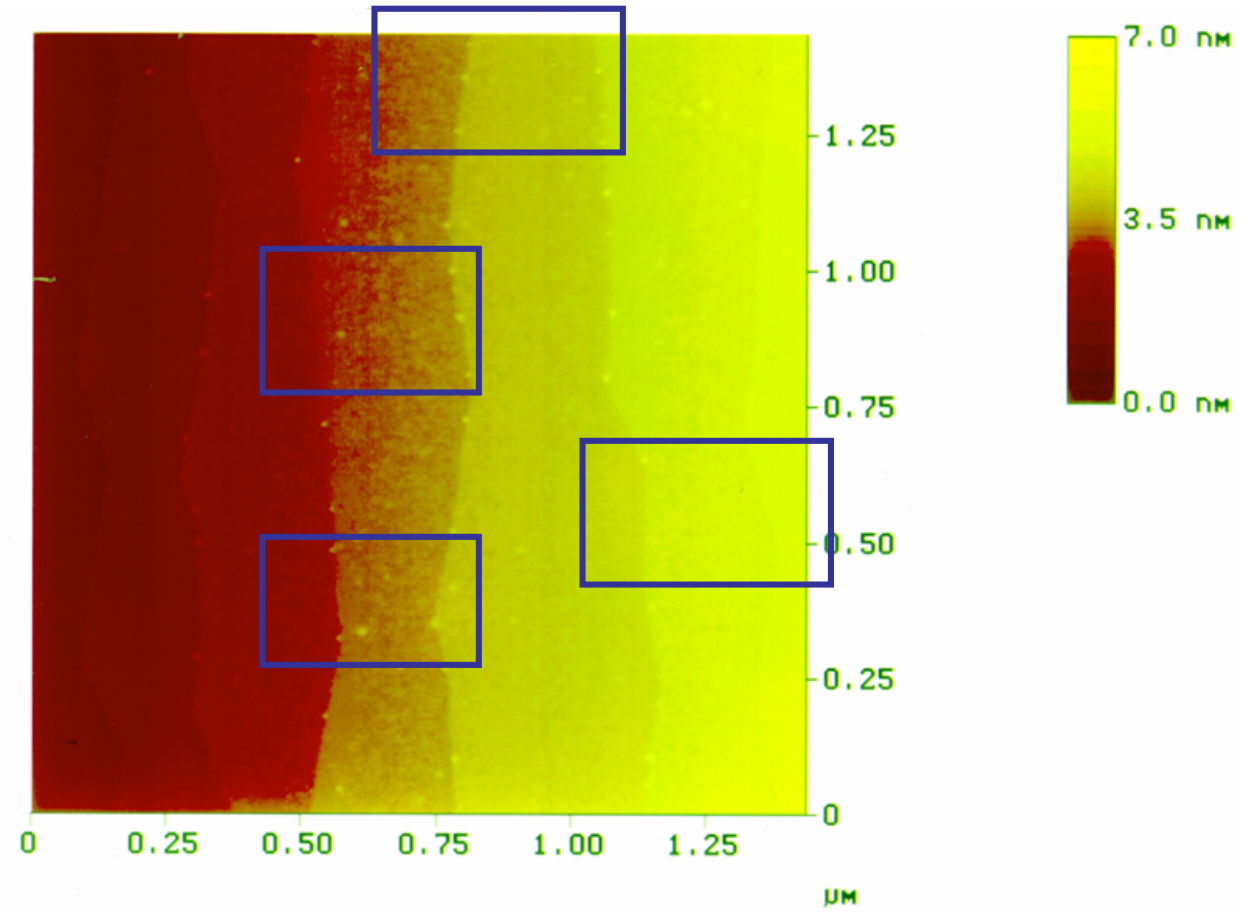
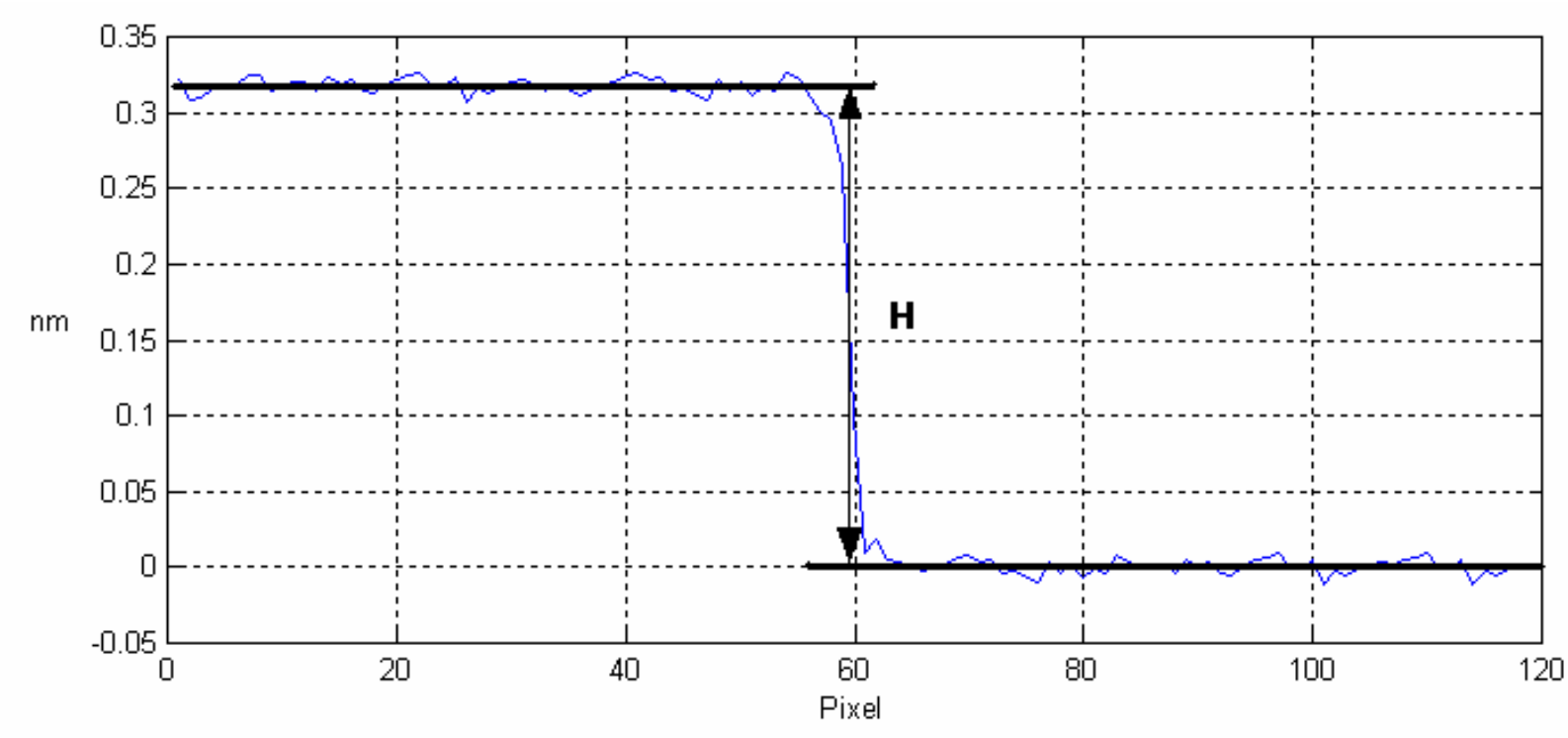


Illustration of Step Height Calculation for a Single Profile



Results of Industrial Measurement Comparison

Five participants, including NIST (using Nanoscope 3, not C-AFM)

Table I. Summary of Final Results for Silicon Step Height Samples

Participant	Number of Topographic Images	Average Step Height Value (pm)	One Standard Deviation (pm)	Average Number of Steps in Each Image	Number of Areas Measured
A	7	325	12	6	268
B	9	302	8	4	90
C	10	317	4	7	100
D	4	306	3	6	180
E	6	311	3	6	60

Reference: R. Dixson et al. *SPIE Proc.* **4344**, 157 (2001)

Designation: E 2530 – 06

Developed by ASTM SC E42.14, STM/AFM

Standard Practice for Calibrating the *Z*-Magnification of an Atomic Force Microscope at Subnanometer Displacement Levels Using Si *(111)* Monatomic Steps[1]

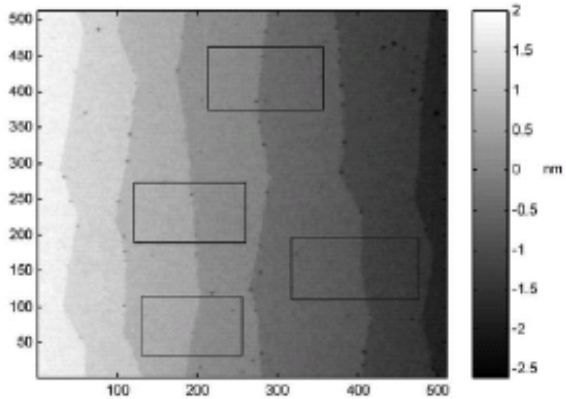


FIG. 2 Illustration of Selected Areas

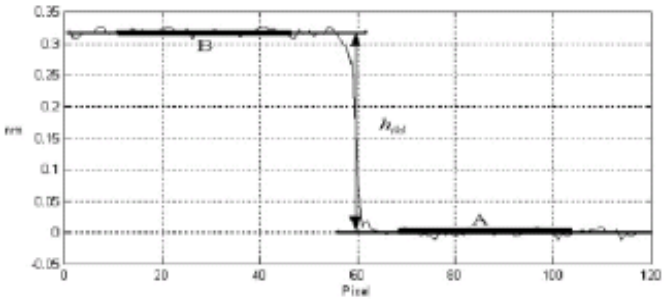


FIG. 3 Illustration of the Step-Height Algorithm Used

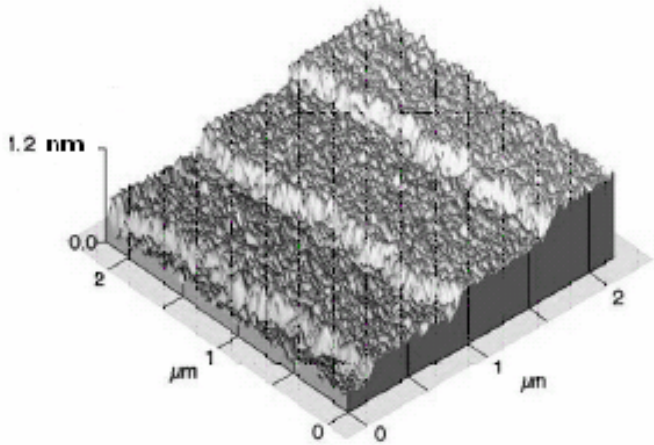


FIG. 1 Image of a Silicon Monatomic Stepped Surface

Observations (1):

The proliferation of standards results from differences in context.
Too hard to control, but maybe can be comprehended.

Northgeorgiasportsman.com/aspen_grove

Observations (2):

Implications for Computing and Automation

The modeling of information requirements in different fields leads to different neutral file formats:

ISO TC 182 / SC4 on Product Data Modeling – EXPRESS, XML

Surface Metrology: XML, SMD, SDF

Different Information Requirements in Reporting

Observations (3): Publishing and Copyright

The goal of standards committees to obtain universal agreement and adoption of standards among different groups.

is trumped by

The goals of standards publishers to protect and profit from the information they publish

» Standards published jointly by different committees are hard to find