NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Date of Issue:
28 May 2025

Standard Reference Material® 2323
Step Height Standard for Areal Surface Topography Measurement

Serial Number: SAMPLE

CERTIFICATE

Purpose: This Standard Reference Material (SRM) is intended for use as a calibration standard for the measurement of the Z-axis (vertical) amplification coefficient (scale) and linearity deviation [1] of areal three-dimensional (3D) surface topography measurement microscopes utilized in forensic toolmark analysis. The SRM addresses challenges of some microscopes in the measurement of calibration standards that have highly reflective surfaces or features with vertical or steep slopes. Intended applications of SRM 2323 include 1) measurement statistical process control [2] in a quality control scheme and 2) calibration, adjustment, or verification of a surface topography microscope (either by a forensic laboratory, qualified third party, or microscope manufacturer).

Description: An SRM 2323 is an aluminum cylindrical step height standard with three nominal steps of 10 µm, 50 µm, and 100 µm. Each unit has a nominal diameter of 21.5 mm and a height of 25 mm. The steps are realized by four nominally flat and parallel measurement areas (pads), each approximately 3 mm x 3 mm, machined into the top surface of the standard. Adjacent pads are vertically offset creating a step height and are connected by a sloped surface at an angle of nominally 18 degrees. The surfaces of the standard have been chemically etched to facilitate measurement by instruments that require a minimum level of surface roughness. The top of the cylindrical base is threaded to receive a nylon cap to protect the step height surfaces when not in use.

Certified Values: The certified step height values and estimated uncertainties for the three step heights in the table are based on measurement results obtained from traceable non-contact areal surface topography measurements and an areal step height analysis [3]. The measurements were performed using a coherence scanning interferometric (CSI) microscope. For every certified standard, a total of 10 repeat step height measurement values were obtained for each of the three steps. The mean of these 10 repeat measurements is reported as the certified value. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of uncertainty have been considered [4]. Step height values and corresponding uncertainties are provided in micrometers. The measurand is the offset between two parallel planes that are a least-squares best fit to the surface measurements of adjacent pads. The certified step height values are reported at 20 °C. Measurement traceability is to the International System of Units (SI) for length (meter).

For all measurements, the quoted expanded uncertainty U is equal to the combined standard uncertainty u_c times a coverage factor ($k = 2$). The combined standard uncertainty u_c is the root of the quadratic sum of the measurement system standard uncertainty and the statistical variation of the step height measurement values. The statistical variation is derived from a gauge repeatability and reproducibility study conducted on one step height sample over a period of seven days, described in the accompanying SP 260-249 document [3]. The measurement system standard uncertainty is primarily derived from the calibration uncertainty of the CSI microscope's z-scan axis [3].

Nominal Step Height (µm)	Measured Step Height (µm)	Step Height Uncertainty (µm)
10	SAMPLE	0.0084
50	SAMPLE	0.038
100	SAMPLE	0.062

Period of Validity: The certified values delivered by **SRM 2323** are valid within the measurement uncertainty specified until **01 October 2034**. The certified values are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified.

Maria E. Nadal, Chief
Sensor Science Division

Steven J. Choquette, Director
Office of Reference Materials

Maintenance of Certified Values: NIST will monitor this SRM over the period of its validity. If substantive technical changes occur that affect the certification, NIST will issue an amended certificate through the NIST SRM website (https://www.nist.gov/srm) and notify registered users. SRM users can register online from a link available on the NIST SRM website or fill out the user registration form that is supplied with the SRM. Registration will facilitate notification. Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (https://www.nist.gov/srm).

Safety: There are no safety hazards associated with the use of SRM 2323 to calibrate and verify performance of optical areal surface topography microscopes.

Storage: There are no specific temperature or humidity requirements for storage. End users should avoid environment conditions leading to condensation formation on the machined surfaces.

Use: Rubber or vinyl gloves should be worn when handling the SRM. Caution should be exercised not to breathe, sneeze, or cough directly on the machined surfaces. The nylon safety cap should be removed and replaced carefully to avoid touching the machined surfaces. Surfaces should be inspected for dust or other contamination. The sample should be mounted securely on the microscope to ensure it does not move or rock during measurement. After mounting, let the sample sit for a few minutes to thermally equilibrate before beginning measurement.

Additional Information: Additional information is provided in Appendix A.

REFERENCES

[1] ISO 25178-600:2019; *Geometrical Product Specifications (GPS)– Surface Texture: Areal – Part 600: Metrological Characteristics for Areal Topography Measuring Methods*; International Organization for Standardization (ISO), Geneva (2019).

[2] *NIST/SEMATECH e-Handbook of Statistical Methods;* available at http://www.itl.nist.gov/div898/handbook (accessed May 2025)

[3] Stocker, M.T.; Renegar, T.B.; Soons, J.A.; Griesmann, U.; Young, S.W.; Stoudt, M.R.; *Certification of Standard Reference Material 2323 Step Height Standard for Areal Surface Topography Measurement;* NIST Special Publication (SP) NIST SP 260-249; National Institute of Standards and Technology, Gaithersburg, MD (2024); available at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.260-249.pdf (accessed May 2025)

[4] Beauchamp, C.R.; Camara, J.E.; Carney, J.; Choquette, S.J.; Cole, K.D.; DeRose, P.C.; Duewer, D.L.; Epstein, M.S.; Kline, M.C.; Lippa, K.A.; Lucon, E.; Molloy, J.; Nelson, M.A.; Phinney, K.W.; Polakoski, M.; Possolo, A.; Sander, L.C.; Schiel, J.E.; Sharpless, K.E.; Toman, B.; Winchester, M.R.; Windover, D.; *Metrological Tools for the Reference Materials and Reference Instruments of the NIST Material Measurement Laboratory*; NIST Special Publication 260-136, 2021 edition; National Institute of Standards and Technology, Gaithersburg, MD (2021); available at https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.260-136-2021.pdf (accessed May 2025).

If you use this SRM in published work, please reference:

Stocker MT, Renegar TB, Soons JA, Griesmann U, Young SW, Stoudt MR, (2024) Certification of Standard Reference Material 2323 Step Height Standard for Areal Surface Topography Measurement. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) NIST SP 260-249. https://doi.org/10.6028/NIST.SP.260-249

Certain commercial equipment, instruments, or materials may be identified in this Certificate to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Users of this SRM should ensure that the Certificate in their possession is current. This can be accomplished by contacting the Office of Reference Materials 100 Bureau Drive, Stop 2300, Gaithersburg, MD 20899-2300; telephone (301) 975-2200; e-mail srminfo@nist.gov; or the Internet at https://www.nist.gov/srm.

* * * * * * * End of Certificate * * * * * * *

APPENDIX A

Shipping: During shipping, the sample should be stored with the protective cap in place, stored inside the wood box, and placed inside a sealed plastic bag with a desiccant.

Cleaning Protocols: Because aluminum is a relatively soft metal, the step surfaces are fragile. Surfaces should be cleaned with care, and only when contamination is observed. Surfaces should be inspected using a microscope before and after cleaning. There is an order of cleaning methods, described below, to employ to remove contamination from the step surfaces. The end-user should only use as many steps as necessary to clean the surface.

1. The first step is to use compressed air or nitrogen to blow off the contamination. It is best practice to use particulate and moisture filters on the compressed gas lines. When using compressed gas to remove contamination, let the air flow for a few seconds before showering the sample to minimize the chance of any residual contaminants in the gas line depositing on the sample. When using compressed air or nitrogen from a can, the end-user should ensure the contents of the can contain pure gas with no other chemical additives.

2. The second step is to use a commercial product called First Contact Polymer, which is a blended polymer and solvent cleaning solution. A few drops of the polymer-based cleaning solution is applied to the surface, allowed to dry, and peeled off to remove contaminants. The company website (https://www.photoniccleaning.com/Kits-s/112.htm) offers instructional videos for its use.

3. If steps 1) and 2) fail, move to using a reagent grade 200 proof ethanol from a glass bottle. Squirt the ethanol on the surface, let it sit for a few seconds, and then finish drying with compressed air or nitrogen to avoid spotting. If necessary, an ethanol-soaked pure 100% cotton ball (not a cotton swab) can be used to gently wipe the surfaces, followed by drying with compressed air or nitrogen.

4. If all the above methods fail, move to using a reagent grade acetone from a glass bottle. Squirt the acetone on the surface, let it sit for a few seconds, squirt 200 proof ethanol on the surface, and then finish drying with compressed air or nitrogen to avoid spotting. If necessary, an acetone-soaked pure 100 % cotton ball (not a cotton swab) can be used to gently wipe the surfaces. After gently wiping with the acetone-soaked cotton ball, immediately squirt 200 proof ethanol on the surface and then dry with compressed air or nitrogen to avoid spotting.

* * * * * * * * * * End of Appendix A * * * * * * * * * *