National Institute of Standards & Technology

Certificate

Standard Reference Material® 2073a

Sinusoidal Roughness Specimen

Serial No. Sample

Standard Reference Material (SRM) 2073a is a sinusoidal profile roughness specimen certified for roughness average, *Ra*, and surface spatial wavelength, *D*. The SRM is intended for use as a standard for the calibration of stylus instruments that are used to measure surface roughness. A unit of SRM 2073a is a steel block of nominal Knoop hardness (HK) 500 which has been coated by the electroless nickel deposition process. A sinusoidal roughness profile was machined onto the top surface of the specimen in a facing operation, using a single-point diamond tool on a numerically controlled lathe.

The certified *Ra* and *D* values and their associated expanded uncertainties ($k = 2$) for this specimen are:

Roughness Average (*Ra*), µm	Sample	±	0.050
Surface Wavelength (*D*), µm	99.099	±	0.041

(Note: the Ra values are quoted individually).

This SRM was originally calibrated and certified in October 1995 and was re-certified on November 23, 2009. From 1995 to 2008, the stability of the SRMs has been continually monitored by routinely measuring NIST check standard SRM 2073 Serial Number 1104 eighty-nine times. The NIST check standard SRM 2073 Serial Number 1104 is a sinusoidal profile roughness specimen with nominal values of $Ra = 3$ µm and $D = 100$ µm, which was also fabricated by diamond turning electroless nickel. A dynamic control chart [1] with both dynamic and fixed control limits is used for monitoring the long-term variation of the certified *Ra* and *D* values for the SRM specimens. Units of the other sinusoidal profile SRM check standards have been measured as well. The check measurement results have demonstrated high measurement reproducibility within the quoted uncertainty range, and no significant variations and drift have been observed.

Expiration of Certification: The certification of **SRM 2073a** is valid, within the measurement uncertainty specified, until **30 June 2024**, provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Handling, Storage, and Use"). The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

The technical direction and physical measurements leading to certification were provided by T.V. Vorburger, J.F. Song, T.B. Renegar, B.R. Scace, C.K. Rymes, A Zheng, and F.F. Rudder, Jr. of the NIST Precision Engineering Division.

Statistical analysis was provided by J.H. Yen of the NIST Statistical Engineering Division.

Michael T. Postek, Chief
Precision Engineering Division

Robert L. Watters, Jr., Chief
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Gaithersburg, MD 20899
Certificate Issue Date: 30 June 2010
See Certificate Revision History on Last Page

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

INSTRUCTIONS FOR HANDLING, STORAGE AND USE

Storage: SRM 2073a should be stored in its original wooden box in a clean dry environment at temperatures between 10 °C and 30 °C.

Handling and Use: The stylus contact force used for measurements should cause negligible damage to the hard metal surface, although faint stylus traces may be visible on the surface. Repeated use with stylus instruments can slowly degrade roughness specimens; however, the specimen is expected to maintain its calibration values provided these measurements are taken on clear, undamaged areas.

Source and Preparation[1]**:** The SRM specimens were machined by Colorado Precision Products, Inc. of Boulder, CO using a single-point diamond tool in a facing operation with a numerically controlled lathe. The surface profile is highly sinusoidal as shown in Figure 1. For certification measurements, the stylus force was approximately 4×10^{-4} N.

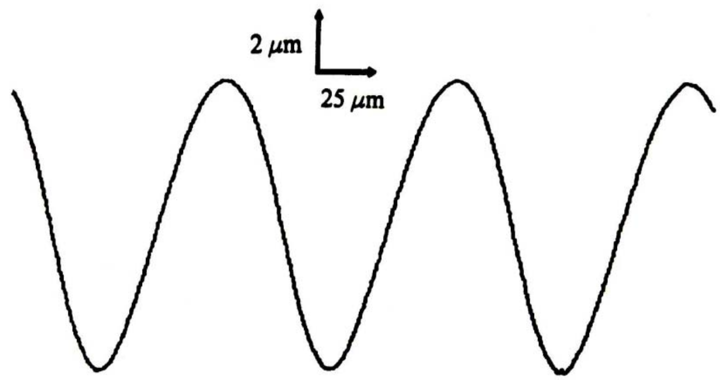

Figure 1 Representative surface profile trace of SRM 2073a. Dimensions are approximate.

NIST Certification Procedure: The roughness average, *Ra,* is the average absolute deviation of the surface peaks and valleys about the mean line, and is defined in the ASME B46.1-2002 standard entitled "Surface Texture" [2]. The surface wavelength, *D,* is the average period of the sinusoidal surface profile. This quantity is also equal to the mean spacing of profile irregularities, *RSm*, as described in ASME B46.1-2002 [2] and ISO 4287:1997(E/F) [3].

The parameters *Ra* and *D* were calculated from roughness profiles of the SRM measured with a stylus instrument using procedures in ASME B46.1 [2]. The stylus instrument was interfaced to a laboratory computer and a HeNe laser interferometer, and its vertical motion was calibrated using an interferometrically measured step. The instrument was operated in the skidless mode with an external reference datum. The sampling rate was 1 point per micrometer over the evaluation length of 4.0 mm. The stylus has a tip radius of 5 µm ± 1 µm as profiled by the razor blade method [4], and calculated in accordance with ASME B46.1 [2].

The SRM was originally certified in October 1995 using a 2RC filter with a 0.76 mm long wavelength cutoff. The 2RC filter was the only standard filter for surface texture metrology at that time.

SRM 2073a was recertified as of February 2009 for use with a Gaussian filter with a 0.8 mm cutoff. The difference in the filter type causes a 0.57 % upward correction in the quoted *Ra* value.

[1] Certain commercial equipment, instruments or materials are 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.

The results for *Ra* and *D* are based on profile traces in pairs at each of nine evenly distributed positions on the specimen surface as shown in Figure 2.

The certification of both parameters is valid for any unflawed positions within the area defined by the extremes of the profile traces shown in Figure 2. Please note that users should measure surface profiles parallel to the long axis of the specimen with evaluation lengths of at least 4 mm for any calibration performed using the SRM specimen. Because of the curvature of the surface markings, the value for *D* outside the limits of the measured area is expected to increase.

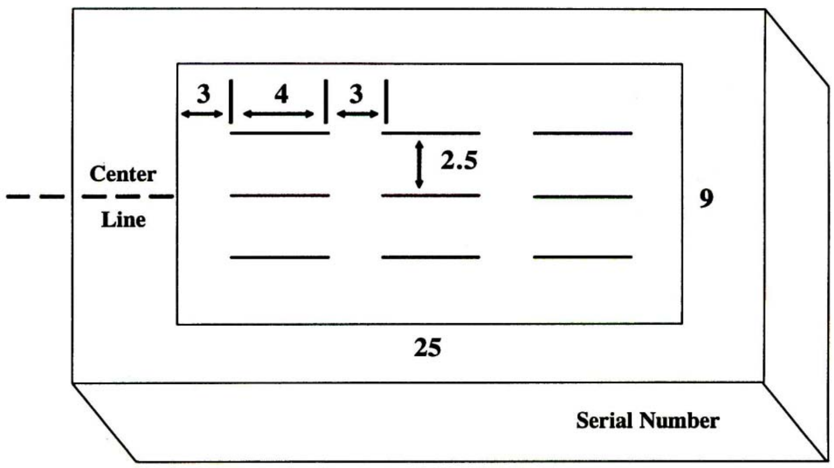

Figure 2 Measurement positions for SRM 2073a. All dimensions are in mm.

Calibration Uncertainty: The expanded calibration uncertainty *U,* for both *Ra* and *D* is the combined standard uncertainty u_c multiplied by a coverage factor $k = 2$ [5, 6]. The combined standard uncertainty u_c is the quadratic sum of the statistical variation of the measurements, *s,* and a number of components associated with the measurement system. The statistical variation of the measurements is a Type A uncertainty component [5, 6], which is mainly derived from the geometrical nonuniformity of the specimen under test, but it also includes instrumental random variation during the measurement process. The statistical variation of the measurements, *s,* is calculated as one standard deviation (1σ) of the set of values measured at different positions on the measuring area. The system standard uncertainty for *Ra* arises from seven sources, some of which are described in [7]:

1. Geometrical nonuniformity and surface finish of the step-height used to calibrate the stylus instrument producing small variations in the z-scale calibration constant of the stylus instrument from day to day.
2. Noise in the instrument transducer, the sampling and digitizing processes in the controller, round-off in the software computations, and imperfections in the surface topography of the reference datum of the instrument also producing variations in the z-scale calibration constant from day to day.
3. Variations in the measured *Ra* values due to nonlinearity in the instrument transducer.
4. Uncertainty in the average height of the step-height master as determined from interferometric and other measurements of it.
5. Uncertainty in the horizontal resolution of the instrument due to the finite stylus radius [4, 8] or to the frequency response of the electronics.
6. Potential long-term variation in the surface. The estimate is based on control charts of SRM 2071 - 2075 surfaces maintained over 15 years.
7. Uncertainty in the correction to the *Ra* value arising from the difference in the 2RC and Gaussian filter specifications applied to the nearly sinusoidal surface profile.

Uncertainty components 1, 2, and 6 above are Type A uncertainties, and components 3, 4, 5, and 7 are Type B [5, 6].

The combined standard uncertainty $u_{c\,(Ra)}$ for *Ra* is calculated to be 0.025 µm; the combined expanded uncertainty $U_{(Ra)}$ for *Ra* is calculated to be 0.050 µm ($k = 2$).

The system standard uncertainty for D is the quadratic sum of several uncertainty components:

1. Uncertainty in the vacuum wavelength of the HeNe laser interferometer.
2. Uncertainty in the HeNe wavelength due to the variation in the temperature, pressure, and humidity of the laboratory.
3. Variation in the temperature of the SRM itself leading to dimensional uncertainty.
4. Possible variation in the interferometric path-length due to possible variation in the air temperature and the baseplate temperature during a single measurement cycle.
5. Possible cosine errors in the specimen alignment.
6. Possible errors associated with Abbe offset.
7. Potential long-term variation in the surface.

Component 7 is a Type A uncertainty [5, 6]; components 1 to 6 are Type B uncertainties [5, 6].

The combined standard uncertainty for D is calculated as $u_{c\,(D)} = 0.0203$ µm; the combined expanded uncertainty for D is calculated as $U_{(D)} = 0.0407$ µm, or 0.041 µm ($k = 2$).

Calibration Service: The NIST Precision Engineering Division will verify the calibration of SRM specimens for a fee. To inquire about the service, phone (301) 975-3463.

REFERENCES

[1] Song J.F.; Vorburger T.V.; *Verifying measurement uncertainty using a control chart with dynamic control limits, MEASURE;* Journal of NCSL-International, pp. 76-80, (September 2007).

[2] ASME B46.1-2002, *Surface Texture*, American Society of Mechanical Engineers, New York, (2003).

[3] ISO Standard 4287:1997(E/F), *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters,* ISO, Geneva, (1997).

[4] Vorburger, T.V., Teague E.C., Scire F.E.; Rosberry F.W.; *Measurement of Stylus Radii*, Wear, No. 57, pp. 39 (1979).

[5] Taylor B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297 (National Institute of Standards and Technology, Gaithersburg, MD, 1993), available at http://physics.nist.gov/Pubs/ (accessed Dec 2009).

[6] JCGM 100:2008; *Guide to the Expression of Uncertainty in Measurement;* (ISO GUM 1995 with Minor Corrections), Joint Committee for Guides in Metrology: BIPM, Sevres Cedex, France (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed Jun 2010).

[7] "Appendix A, Measurement Conditions and Sources of Uncertainties for NIST Surface Roughness and Step Height Calibration Reports", January 2008, http://www.nist.gov/mel/ped/smm/upload/nistsurfcalib.pdf (accessed Jun 2010).

[8] Vorburger T.V.; Raja J.; *Surface Finish Metrology Tutorial*; NISTIR 89-4088 (National Institute of Standards and Technology, Gaithersburg, MD, 1990).

Certificate Revision History: 30 June 2010 (Recertified for use with a Gaussian filter with a 0.8 mm cutoff); 24 October 1995 (original certificate date).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.