10/2National Institute of Standards & Technology

Certificate

Standard Reference Material® 2554

Optical Fiber Coating Diameter

(Nominal Refractive Index 1.515)

Serial Number: SAMPLE

This Standard Reference Material (SRM) is intended primarily for use in calibrating instruments which measure the diameter of coated optical fibers. The index of refraction of the glass rod, 1.515, was chosen to match that of certain fiber coatings. A unit is individually certified for index of refraction and diameter [1] and consists of an uncoated glass rod approximately 100 mm long and 250 μm in diameter.

Description of SRM: The SRM is a glass rod that has been specially selected to minimize fluctuations of diameter, taper, and roundness over its certified region. Each rod has been measured at various positions along and around the certified region, and the average diameter is reported from these measurements. In addition, the average diameter at specific angular positions along the certified region of the rod is also reported. The rod is marked with a flag to assist in proper orientation during measurement (see Figure 1). The flag also serves as the orientation reference for additional certified measurements at the angular positions indicated below. The average diameter of the rod has been measured and certified inside a zone located 5.0 mm to 7.0 mm from the end opposite the flag. In addition, the diameter at specific 45° increments is also reported.

Certified Values: Certified values for the average diameter and diameter at certified regions for the specified Index of Refraction are listed below. NIST-certified value is a value for which NIST has the highest confidence in its accuracy, in that all known or suspected sources of bias have been investigated or taken into account [2]. A certified value is the present best estimate of the true value based on the results of analyses performed at NIST. The measurand is the diameter of a glass rod of the specified index of refraction, at the oriented measurement positions listed below. The certified diameter values are metrologically traceable to the defined SI units of length, expressed in millimeters.

Index of Refraction n	=	1.515 ± 0.0015	
Certified Average Diameter (certified region)	=	SAMPLE mm	± 0.000 53 mm
Certified Diameter (certified region) at 0°	=	SAMPLE mm	± 0.000 15 mm
45°	=	SAMPLE mm	± 0.000 15 mm
90°	=	SAMPLE mm	± 0.000 15 mm
135°	=	SAMPLE mm	± 0.000 15 mm

Expiration of Certification: The certification of **SRM 2554** is valid indefinitely within the measurement uncertainties specified, provided that the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Handling, Storage, and Use"). Accordingly, periodic recalibration or recertification of this SRM is not required. The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Overall technical direction, measurement process development and analysis, and physical measurements leading to certification were provided by J.R. Stoup and T.D. Doiron of the NIST Semiconductor & Dimensional Metrology Division and M. Young of the NIST Optoelectronics Division.

David G. Seiler, Chief
Semiconductor & Dimensional Metrology Division

Gaithersburg, MD 20899
Certificate Issue Date: 27 October 2014
Certificate Revision History on Last Page

Robert L Watters, Jr., Director
Office of Reference Materials

Maintenance of SRM Certification: NIST will monitor this material over the period of its certification. If substantive technical changes occur that affect the certification, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification. If wear is suspected, the SRM may be verified by contacting the technical division personnel at (301) 975-3471 or by fax at (301) 975-5360.

A. Thénot of the NIST Optoelectronics Division assisted with the index of refraction measurements.

The glass rods were supplied by J. O'Connell, L. Moore, and D. Williams of Corning, Inc., Corning, NY[(1)].

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

INSTRUCTIONS FOR HANDLING, STORAGE AND USE

Handling: Routine cleaning of the rod is not recommended. However, if the rod becomes contaminated, dip the rod into clean, reagent grade isopropyl alcohol. Less than pure solvents will deposit contaminants onto the glass rod surface. Be careful not to bump the rod against the walls of the solvent container as the rod can be easily damaged or broken. Allow the rod to air dry in a clean environment.

Storage: When not in use, the rod should be stored in the plastic vial supplied or some container with equal or better protection. Perform work in a clean environment. Do not handle or expose the rod more than necessary.

Use: The rod can be used anywhere inside of the certified area. If the average diameter value is used, the rod should be measured at random angular positions and rotated to properly sample the angular variations in diameter. If the diameter at a specific angular position is used, the rod should be repositioned longitudinally between measurements to properly sample the variations in diameter (taper). **Extreme** care should be used when manipulating the rod. The rod is brittle and can be very easily damaged or broken, voiding the certification.

Determination of Rod Diameter: The diameter of each SRM 2554 unit has been measured using a contact micrometer combined with a laser displacement interferometer. These measurements were performed at various applied forces to determine the undeformed diameter by projecting the results to a zero applied force condition. Measurements were performed within the zones indicated in Figure 1. For the measurements at specific angular positions, the measurement plane was *perpendicular* to the 0° position of the flag. This axis remained fixed while the rod was rotated to the positions shown in Figure 1.

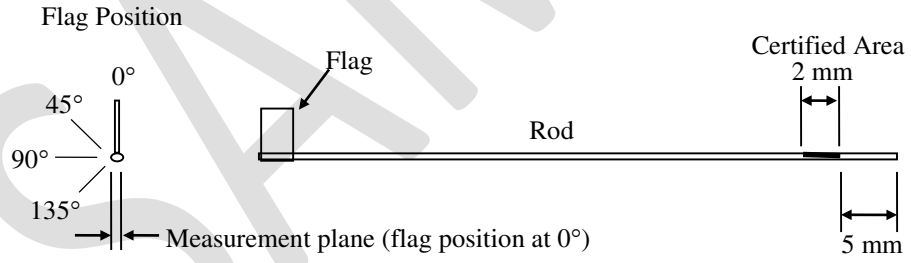

Figure 1. Measurement Positions and Orientation

The absolute diameter measurements were performed with the flag in the 0° position. Between five and eight measurements were made at this position within the 2.0 mm certification zone of the rod. Differential measurements were then performed at 45° intervals around the rod. Eight measurements were made at each angular position reported in this certificate. These differential measurements are related to the absolute measurements through the data collected at the 0° angular position.

The average diameter value is the arithmetic average of all 32 measurements of the rod.

[(1)] Certain commercial instruments, materials, or processes are identified in this report 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 instruments, materials, or processes identified are necessarily the best available for the purpose.

Discussion of Uncertainties: The uncertainty assigned to the diameter values for this SRM unit was calculated according to procedures outlined in reference 2. Measured (Type A) uncertainties were assumed to be normally distributed. Estimated (Type B) uncertainties were assumed to be described by a rectangular probability distribution function. These uncertainties were combined by adding their variances, where the variance of a rectangular distribution is one-third the square of its half-width. Table 1 lists all identifiable sources of uncertainty. The uncertainty values assigned to the rod geometry terms in Table 1 are for a single measurement of the rod.

Table 1. Uncertainty Budget

Source of Uncertainty	Analysis Method	Standard Uncertainty (μm)
Rod Geometry: Taper (within the 2.0 mm certified area)	Rectangular distribution of data	0.043
Rod Geometry: Roundness (full circumference)	Rectangular distribution of data	0.260
Rod Geometry: Roundness (± 2 degrees at each angular position)	Rectangular distribution of data	0.058
Rod Geometry: Roundness (± 1 degree at each angular position)	Rectangular distribution of data	0.043
Elastic deformation correction	Rectangular distribution of 30 nm range	0.009
Laser wavelength	2×10^{-8} m	<0.001
Index of refraction equation	2×10^{-8} m	<0.001
Air temperature measurement	± 0.02 °C	<0.001
Air pressure measurement	± 10 Pa	<0.001
Vapor pressure measurement	± 5 %	<0.001
Instrument cosine error	0.5 ppm × 0.250 mm	<0.001
Abbe offset	0.5 mm × < 0.1 O	<0.001
Micrometer contact geometry	Rectangular dist. of contact form errors	0.012
Rod temperature measurement	α(0.02 °C)L*	<0.001
Thermal expansion (α) uncertainty	[(2.0 ppm)(0.2 °C)L] = 0.4L	<0.001
Thermometer calibration	Rectangular dist. of 0.02 °C range	<0.001
Combined uncertainty	u_c (arbitrary angular position)	0.264
Combined uncertainty	u_c (± 2° at each angular position)	0.074
Combined uncertainty	u_c (± 1° at each angular position)	0.063
Expanded uncertainty	k = 2 (arbitrary angular position)	0.528
Expanded uncertainty	k = 2 (± 2° at each angular position)	0.148
Expanded uncertainty	k = 2 (± 1° at each angular position)	0.126

*L = diameter of glass rod SRM.

REFERENCES

[1] Williams, D.H.; Young, M.; Tietz, L.A.; *Fiber Coating Geometry: Toward a Glass Artifact Standard*; Technical Program, OFMC '95, Third Optical Fiber Measurement Conference, Liege, Belgium, September 25 and 26 (1995).

[1] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (JCGM) (2008); available at http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed Oct 2014); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); available at http://www.nist.gov/pml/pubs/index.cfm (accessed Oct 2014).

Certificate Revision History: 27 October 2014 (Additional units added; editorial changes); 23 February 1999 (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) 948-3730; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.