National Institute of Standards & Technology

Certificate

Standard Reference Material® 2553

Optical Fiber Coating Diameter (n = 1.504)

Serial Number:

This Standard Reference Material (SRM) is intended primarily for use in calibrating instruments which measure the diameter of coated optical fibers. Each SRM 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. The index of refraction of the glass rod, 1.504, was chosen to match that of certain fiber coatings. Two other indexes are available: 1.515 (SRM 2554) and 1.535 (SRM 2555).

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 Index of Refraction, n = 1.504 ± 0.0015

Certified Average Diameter (certified region) =

Certified Diameter (certified region) at 0° =

45° =

90° =

135° =

Expiration of Certification: The certification of this SRM is valid indefinitely within the measurement uncertainties specified, provided that the SRM is used in accordance with the instructions given in this certificate. However, the certification will be nullified if the SRM is damaged or modified. The SRM will wear quickly if used with contact-type instrumentation. If wear is suspected, the SRM may be verified by contacting the Calibration Program by telephone at (301) 975-2002 or by fax at (301) 869-3548.

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.

The 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 Precision Engineering Division and M. Young of the NIST Optoelectronics Division. A. Thénot of the NIST Optoelectronics Division assisted with index of refraction measurments.

The support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the Standard Reference Materials Program by R.J. Gettings.

Gordon W. Day, Chief
Optoelectronics Division

Gaithersburg, MD 20899
Certificate Issue Date: 23 February 1999

Thomas E. Gills, Chief
Standard Reference Materials Program

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

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.

Determination of Rod Diameter: The diameter of each SRM 2553 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.

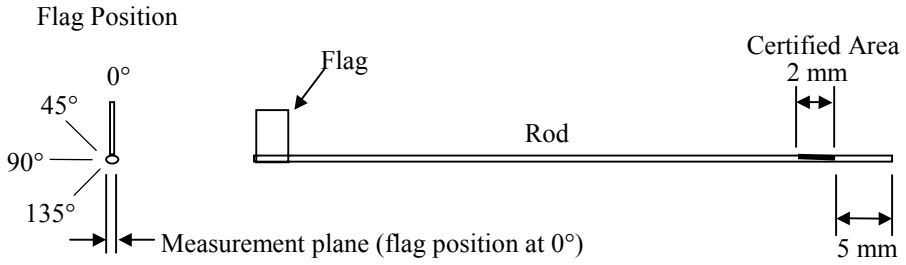

Figure 1. Measurement Positions and Orientation

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.

Instructions for 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.

Cautions to User: Routine cleaning of the rod is not recommended. However, if the rod becomes contaminated, dip the rod into clean, reagent grade isopropyl alcohol or acetone. 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 and Handling: 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.

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	0.115
Rod Geometry: Roundness (full circumference)	Rectangular distribution of data	0.577
Rod Geometry: Roundness (± 2 degrees at each angular position)	Rectangular distribution of data	0.095
Rod Geometry: Roundness (± 1 degree at each angular position)	Rectangular distribution of data	0.057
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 ″	<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)	0.589
Combined uncertainty	u_c (± 2° at each angular position)	0.150
Combined uncertainty	u_c (± 1° at each angular position)	0.129
Expanded uncertainty	$k = 2$ (arbitrary angular position)	1.177
Expanded uncertainty	$k = 2$ (± 2° at each angular position)	0.300
Expanded uncertainty	$k = 2$ (± 1° at each angular position)	0.258

*L = diameter of glass rod SRM.

REFERENCES

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

[2] *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st Ed., ISO, Geneva, Switzerland, (1993): see also Taylor, B.N. and 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).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: Telephone (301) 975-6776 (select "Certificates"), Fax (301) 926-4751, e-mail srminfo@nist.gov, or via the Internet http://ts.nist.gov/srm.