Designation: F 1048 – 87 (Reapproved 1999)

Standard Test Method for Measuring the Effective Surface Roughness of Optical Components by Total Integrated Scattering[1]

This standard is issued under the fixed designation F 1048; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the measurement of the effective surface roughness of an opaque reflecting surface as determined by the total integrated light scattering (TIS).

1.2 *Applications*:

1.2.1 This test method is particularly applicable to metal mirrors or smooth dielectrics covered with an opaque reflecting surface.

1.2.2 This test method is applicable to specimens ranging in size from 5 mm in diameter to as large as the supporting components will accommodate. The sampling area is approximately 1 mm in diameter.

1.3 *Limitations*—This test method is limited to specimens with optical surfaces that are flat or that are spherical with a radius of curvature greater than 10 m.

1.4 This test method determines the integrated scattering from an angle approximately 2.5° from the surface normal to an angle approximately 70° from the surface normal.

1.5 The test method is performed with a helium-neon laser operating at the wavelength 632.8 nm.

1.6 Repeated use of this test method on different areas of the specimen permits mapping of the surface TIS.

1.7 This test method is nondestructive.

1.8 The maintenance of a control chart to monitor the stability of the measurement process is discussed in Annex A1.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements see Section 8.

2. Referenced Documents

2.1 *ASTM Standards:*

E 691 Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods[2]

2.2 *ANSI Standard:*

Z136.1 Safe Use of Lasers[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *microroughness*, h_{rms}—the root mean square of the short-range deviations of a surface above and below its mean position.

3.1.2 *surface flaws*—defects such as scratches or pits which are not typical of the surface finish.

3.1.3 *total integrated scatter,* TIS—for the purposes of this test method, the radiation scattered by an opaque reflecting surface into a 2π solid angle.

4. Summary of Test Method

4.1 A beam of radiation from a helium-neon laser is made to impinge on the surface of the specimen. First, the specular reflectance is measured. Next, the power of the radiation scattered by the specimen is measured by focussing the scattered radiation onto a Si photovoltaic detector by means of a hemispherical mirror. The specimen is then replaced by a diffuse reflectance standard and the measurement of the scattered power is repeated. The effective surface roughness is computed from the two scattered radiation measurements, the specular reflectance of the specimen, and the total reflectance of the standard. A control chart is established and maintained to monitor the stability of the measurement process over an extended period of time.

5. Significance and Use

5.1 The performance of optical components is affected by the degree to which these components scatter optical radiation.

5.2 The effective microroughness, h_{rms}, may be computed from the TIS.

5.3 This test method may be used in manufacture, quality control, and research.

6. Interferences

6.1 Variations in detector response as a function of the angle

[1] This test method is under the jurisdiction of ASTM Committee F01 on Electronics, and is the direct responsibility of Subcommittee F01.06 on Silicon Materials and Process Control.

Current edition approved May 29, 1987. Published August 1987.

[2] *Annual Book of ASTM Standards,* Vol 14.02.

[3] Available from the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

of incidence can affect the precision of the measurement.

6.2 Flaws or contaminants on the surface can produce scattering which is not characteristic of the microroughness of the surface.

6.3 Stray background radiation will affect the precision of measurement.

6.4 Detector offset voltages will affect the precision of measurement.

6.5 Degradation of the diffuse reflectance standard will degrade the precision of measurement.

6.6 Degradation of the specular reflectance standard can cause the control chart to indicate lack of experimental control.

7. Apparatus

7.1 *Laser*—He-Ne type, operating in the TEM_{00} mode at wavelength 632.8 nm, having a beam diameter of 1 mm or less, a beam divergence of 5 mr or less and an output power of approximately 2 m W.

7.2 *Detector*—Silicon photovoltaic type having a dynamic range of 10^5, with a sensitive area of 2 mm^2 or greater, and in a housing less than 10 mm in diameter. The detector shall be equipped with a diffuser or other means to minimize variation of signal with the position of the image on the detector, with angle of incidence, and with polarization of the radiation.

7.3 *Filters*—Attenuation type to prevent detector saturation.

7.4 *Mirror*—Spherical type having a radius of curvature 10 cm or greater and having an aperture at the center that shall subtend an angle of 5° or less at the specimen. The outer diameter of the mirror shall allow for a collecting angle of 70° or greater relative to the specimen normal. The optical quality of the mirror shall be such that the irradiated portion of the specimen is imaged fully within the detector area.

7.5 *Aperture Plate*—Opaque type approximately 10 by 10 cm containing an aperture 3 mm in diameter and a target symbol located 10 mm from the aperture center. See Fig. 1 for schematic of aperture plate.

7.6 *Optical Chopper*, provided with a reference output signal.

7.7 *Amplifier, Lock-In Type*, equipped with a preamplifier with a range of gain settings appropriate for accommodating the range of signals originating from the detector. The amplifier-detector combination shall have a linear response within ±10 % and reproducibility of ±5 % over the required range of measurement.

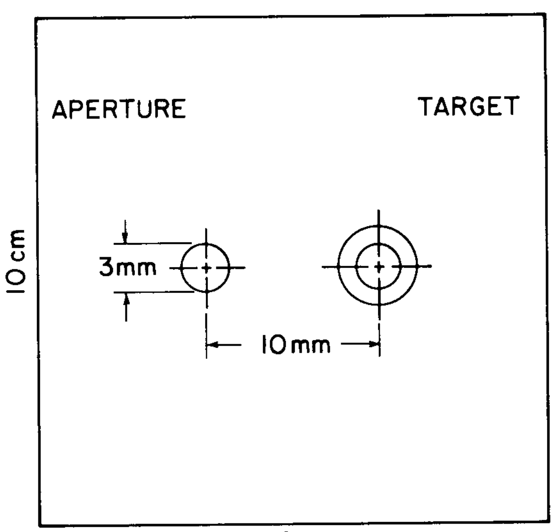

FIG. 1 Schematic Diagram of Aperture Plate

7.8 *Diffuse Reflectance Standard*—A diffuse reflector of known total reflectance, ρ_{RS}.

NOTE 1—Commonly used diffuse reflectance standards are fabri-cated from barium sulfate or polytetrafluoroethylene powders. The total reflectance of reflectors freshly prepared from these materials is typically greater than 0.98; therefore, a reflectance value of 0.98 for such reflectors is adequate for the purposes of this test method.

7.9 *Polished Reflectance Standard*—An optically polished metallic mirror to be maintained in a protected environment to prevent degradation of polish.

NOTE 2—A polished stainless steel mirror preserved in a covered glass petri dish would be adequate for this test method.

8. Hazards

8.1 **Warning:** Lasers with an output power on the order of 1 mW or greater can cause injury to personnel. The provisions of ANSI Z136.1 should be followed.

8.2 **Warning:** Do not let the unexpanded laser beam impinge on the skin. In no case should the laser beam be viewed directly. Avoid looking directly into the beam or into a specularly reflected beam.

9. Sampling

9.1 The location of all measurement positions on the specimen and the number of measurements to be performed at each of these positions shall be agreed to by the parties to the test.

9.2 The number of test specimens and their manner of selection from a given lot shall be agreed to by the parties to the test.

10. Procedure

10.1 Align laser beam, aperture plate, specimen, spherical collection mirror, and detector in accordance with Fig. 2 such that the scattered radiation is sharply imaged on the detector. Adjust the specimen angle such that the specularly reflected beam makes an angle of less than 1.50° with respect to the incident beam and such that it is directed through the center of the entrance aperture in the collection mirror onto the aperture plate.

10.2 Remove the specimen and position the detector at the specimen location.

10.3 Observe the detector reading.

10.3.1 If reading indicates detector saturation, insert attenuation filters into the beam until the reading is within the linear range of the detector and near the upper limit of the linear range.

10.3.2 Record the signal as V_o.

10.4 Remove the detector and reposition the specimen in the beam such that the beam impinges on a specified measurement location on the specimen. Tilt the specimen such that the specularly reflected beam is directed through the center of the entrance aperture of the collection mirror onto the aperture plate, but approximately 10 mm away from the opening in the aperture plate.