INTERNATIONAL STANDARD

ISO 13697

First edition
2006-05-15

Optics and photonics — Lasers and laser-related equipment — Test methods for specular reflectance and regular transmittance of optical laser components

Optique et photonique — Lasers et équipements associés aux lasers — Méthodes d'essai du facteur de réflexion spéculaire et du facteur de transmission des composants optiques laser

Reference number
ISO 13697:2006(E)

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Published in Switzerland

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 13697 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

Introduction

Laser-based optical systems require optical components with greatly enhanced reflectance and/or transmission characteristics. It is necessary to be able to measure these characteristics precisely. The measurement procedures in this International Standard have been optimized to allow the measurement of the specular reflectance and transmittance of the optical components to a high degree of accuracy over a wide range of values.

Optics and photonics — Lasers and laser-related equipment — Test methods for specular reflectance and regular transmittance of optical laser components

1 Scope

This International Standard specifies measurement procedures for the precise determination of the specular reflectance and regular transmittance of optical laser components. The accuracy of the described test methods exceeds that of measurement procedures outlined in ISO 15368 by several orders of magnitude.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 31-6, *Quantities and units — Part 6: Light and related electromagnetic radiations*

ISO 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 11145 and ISO 31-6 apply.

4 Symbols used and units of measure

Table 1 — Symbols used and units of measure

Symbol	Unit	Term
ρ_s		specular reflectance of sample
ρ_{ch}, ρ_m		specular reflectance of chopper, specular reflectance of deflecting mirror
τ_s		regular transmittance of sample
λ	m	wavelength
P_{av}	W	average power
β	rad	angle of incidence
d	m	beam diameter on the test sample
f_{ch}	Hz	chopper frequency
f_{am}	Hz	frequency of laser power modulation
P_r	W	power of reference beam
P_p	W	power of probe beam
ΔP	W	power difference between reference beam and probe beam
S_m		signal at frequency of laser power modulation
S_{mo}		signal at frequency of laser power modulation, probe beam blocked
ΔS		signal at frequency, which is the sum or the difference of chopper frequency and power modulation frequency
ΔS_0		signal at frequency, which is the sum or the difference of chopper frequency and power modulation frequency, probe beam blocked
C_1, C_2		arbitrary constants

5 Test and calibration principles

5.1 General

Specular reflectance and regular transmittance are determined optically as the ratio of the regularly reflected or regularly transmitted part of the reflected or transmitted power radiation to the incident power radiation.

The reflectance or the transmittance of the test sample are constant within the temperature fluctuations experienced by the component during the test and are independent of the power density of the impinging radiation.

5.2 Specular reflectance

The reflectance of optical components is determined optically by means of a measuring arrangement as shown in Figures 1 and 2.

An optically flat and highly reflective chopper mirror divides the laser beam into a probe beam and a reference beam. The probe beam is reflected by the chopper mirror and the sample, whereas the reference beam transmits without being affected. Both beams, alternating temporally, impinge upon the same spot on the rear target of the integrating sphere.

Figure 1 shows the measuring arrangement for near-normal incidence, whereas the angular dependence of reflectance can be measured in a measuring arrangement according to Figure 2. Compared with the arrangement in Figure 1, an additional mirror is used to create a double bounce permitting the measurement of the reflectance of the sample at different angles of incidence.

The powers P_p for the probe beam and P_r for the reference beam are related by

$$P_p = \rho_s^2 \rho_{ch} \rho_m P_r \tag{1}$$

where

ρ_m is the specular reflectance of the additional deflecting mirror;

ρ_s^2 is the double bounce on the sample;

ρ_s is the specular reflectance of the sample;

ρ_{ch} is the specular reflectance of the chopper mirror.

The specular reflectance ρ_s of the test sample can be expressed as

$$\rho_s = \sqrt{\frac{1}{\rho_{ch}\rho_m} \times \left(1 - \frac{\Delta P}{P_r}\right)} \tag{2}$$

where $\Delta P = P_r - P_p$

5.3 Transmittance

The transmittance of optical components is determined by means of a measuring arrangement as shown in Figure 3 using an additional mirror with known reflectance ρ_m.

For the powers P_p and P_r measured with a set-up according to Figure 3, the following relationship exists

$$P_p = \tau_s \rho_{ch} \rho_m P_r \tag{3}$$

where τ_s is the regular transmittance of the sample.

The regular transmittance τ_s of the test sample can be calculated from the following relationship:

$$\tau_s = \frac{1}{\rho_{ch}\rho_m} \times \left(1 - \frac{\Delta P}{P_r}\right) \tag{4}$$

5.4 Calibration

The reflectance of the chopper mirror has to be known for evaluation. Figure 4 shows the measurement set-up used for the calibration procedure. To determine the two unknown specular reflectances ρ_m of the additional mirror and ρ_{ch} of the chopper mirror, two sets of measurements have to be performed. One measurement is done in the set-up of the test procedure described in 8.2, while for the other measurement the integrating sphere and an additional mirror have to be replaced according to Figure 4. The beam transforming optics and the chopper mirror remain unchanged to ensure that the laser hits the chopper under identical conditions. For the set-up according to Figure 4, the following relationship for the powers P_p and P_r exists

$$\frac{P_p}{\rho_m} = \frac{P_r}{\rho_{ch}} \tag{5}$$

This set-up enables the computation of the quotient Q of the specular reflectance of the additional mirror and the chopper mirror.

$$Q = \frac{\rho_m}{\rho_{ch}} \tag{6}$$

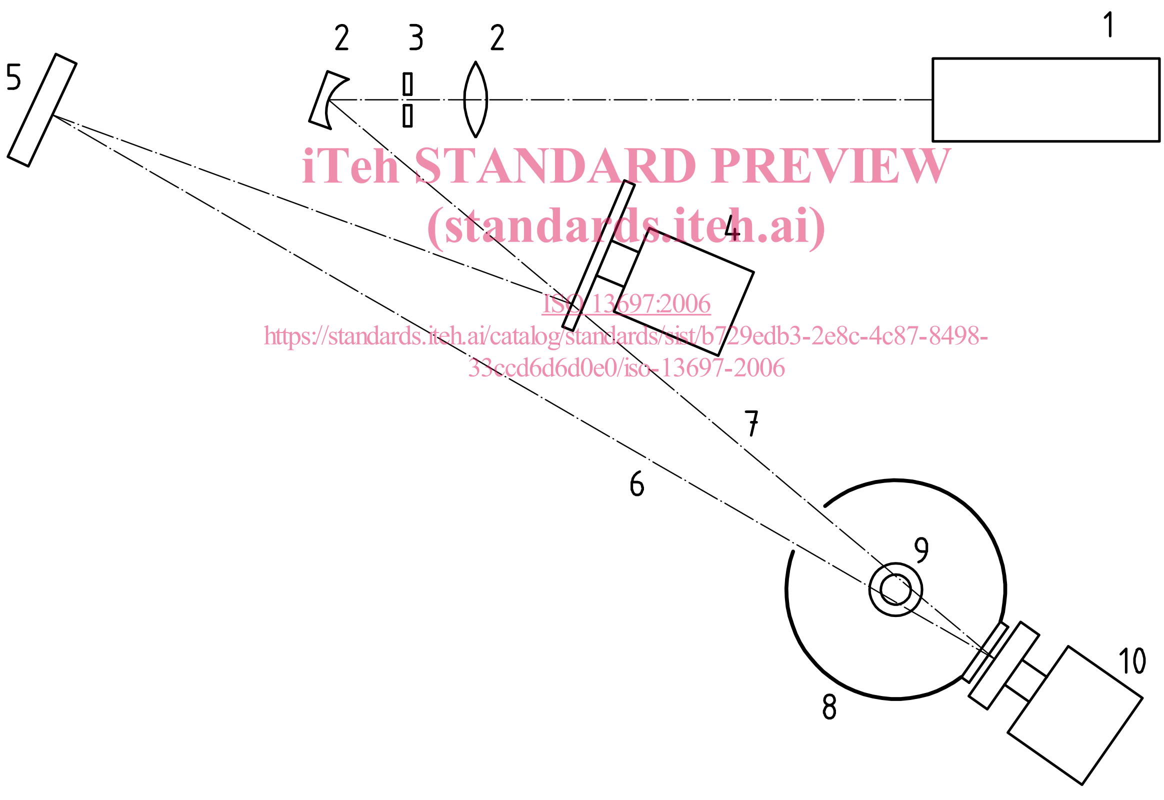
Their product P is determined according to Figure 1, where the sample is replaced by the additional mirror. In this case:

$$P = \rho_m \times \rho_{ch} \tag{7}$$

The specular reflectance of the chopper ρ_{ch} and the additional mirror ρ_m are given by

$$\rho_{ch} = \sqrt{\frac{P}{Q}} \tag{8}$$

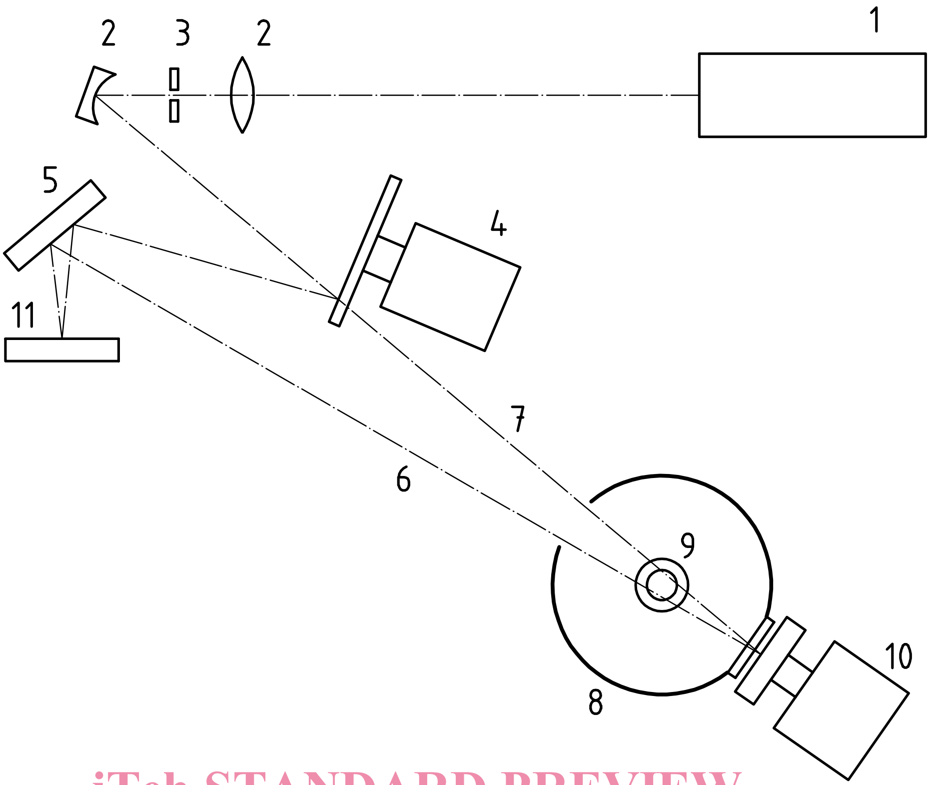
$$\rho_m = \sqrt{P \times Q} \tag{9}$$



Key

1 laser
2 telescope
3 pinhole
4 chopper
5 sample
6 probe beam
7 reference beam
8 integrating sphere
9 detector, mounted on top of the sphere
10 rotating target

Figure 1 — Schematic measuring arrangement for specular reflectance measurement (near-normal incidence angle on sample)



Key

1 laser
2 telescope
3 pinhole
4 chopper
5 sample
6 probe beam
7 reference beam
8 integrating sphere
9 detector mounted on top of the sphere
10 rotating target
11 additional mirror

Figure 2 — Schematic measuring arrangement for specular reflectance measurement (arbitrarily chosen angle of incidence on sample)