
**Optics and photonics — Optical
materials and components — Test
method for bubbles and inclusions in
infrared optical materials**

*Optique et photonique — Matériaux et composants optiques —
Méthodes d'essai pour déterminer les impuretés des matériaux
optiques infrarouges*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 3, *Optical materials and components*.

Optics and photonics — Optical materials and components — Test method for bubbles and inclusions in infrared optical materials

1 Scope

This document specifies the apparatus, condition, sample, procedure and data processing of measuring bubbles and inclusions in infrared optical materials.

It is applicable to the determination of bubbles and inclusions in infrared optical materials, such as infrared optical glass, infrared crystals and infrared ceramics, which are opaque to visible wavelengths and whose transmission optical spectra are beyond 0,78 μm .

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 10110-8, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 8: Surface texture; roughness and waviness*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

bubble

gaseous voids in the bulk infrared glass and ceramics materials, of generally circular cross section

3.2

inclusion

all localized bulk infrared material defects of generally circular cross section

EXAMPLE Small knots, small stones, sand and crystals.

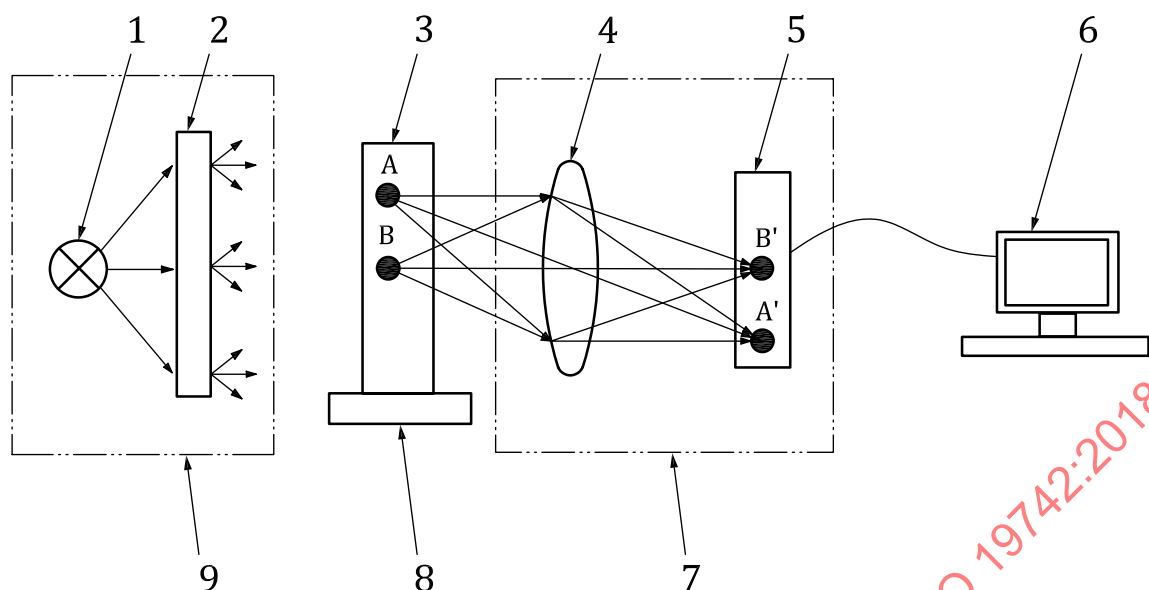
3.3

material imperfection value

total sum of the cross-sectional area of *bubbles* (3.1) and *inclusions* (3.2) per 100 cm^3 of a sample

4 Principle

The principle of this test is to measure bubbles and inclusions by utilizing a diffuse infrared light source to illuminate the test sample, calculate their number and sum up their cross-sectional areas per unit volume. A schematic diagram of the measurement of bubbles and inclusions is shown in [Figure 1](#).



Key

- | | | | |
|---|-----------------------|---|--|
| 1 | infrared light source | 6 | computer data collecting, processing and displaying system |
| 2 | diffuser screen | 7 | infrared imaging system |
| 3 | sample | 8 | sample stage |
| 4 | imaging lens | 9 | diffuse infrared light source system |
| 5 | image sensor | | |

Figure 1 — Schematic diagram of the measurement of bubbles and inclusions

5 Apparatus

5.1 General apparatus arrangement

The apparatus consists of an infrared light source system, a sample stage, an infrared imaging system and a computer data collecting, processing and displaying system.

5.2 Infrared light source system

The infrared light source system consists of an infrared light source and a diffuser screen. The infrared light source emits light which covers the transmission spectra region of samples. The intensity and uniformity of the infrared light source shall meet the requirements of the response of the image sensor. The diffuser screen shall be uniform and meet the requirements of measurements.

5.3 Infrared imaging system

The infrared imaging system consists of an imaging lens and an image sensor. The depth focus of the imaging lens should cover the thickness of samples. The object spatial resolution of the imaging lens corresponding to the image sensor shall be less than the specified minimum size of bubbles and inclusions in samples. The value of the object spatial resolution is recommended to be not more than 0,1 mm. An array image sensor is generally used. The working wavelength band of an infrared image sensor should be within the transmission spectrum of the sample measurement. When the scanning interfaces between sections can be clearly identified and the images of bubbles and inclusions do not overlap, a scanning image system may be used.

5.4 Computer data collecting, processing and displaying system

The computer data collecting, processing and displaying system consists of a computer, data collecting and processing software and a displaying system. The data collecting and processing software should include an electronic ruler and have the function of calculating the area of bubbles and inclusions and counting their numbers. The contrast of the displaying system should be better than 1 000:1. The resolution of the displaying system shall be greater than that of the image sensor.

6 Test conditions

6.1 Environmental temperature

The environmental temperature shall be steadily kept at any temperature between 15 °C and 35 °C with the temperature tolerance being not more than $\pm 2^\circ\text{C}$.

6.2 Relative air humidity

The relative air humidity should not be more than 80 %.

7 Sample

7.1 Thickness

An appropriate thickness of the sample should be chosen. The maximum thickness of the sample is recommended to be not larger than 12 mm and should normally be 10 mm. When a scanning method is adopted, the thickness of a sample may be larger than 12 mm.

7.2 Polished surfaces

7.2.1 The surface roughness R_q specified in ISO 10110-8 of the sample shall be less than 0,012 μm .

7.2.2 The sizes of scratches and digs on the sample surfaces should not be larger than the specified minimum sizes of the bubbles and inclusions of the sample. If the sizes of the sample surface defects are larger than the specified minimum sizes of the bubbles and inclusions, a portion of the defects shall be subtracted from the result calculated by the computer.

8 Procedure

8.1 Turn on the illumination and measurement equipment and adjust the intensity of the light source so that its irradiation power meets the responding requirements of the image sensor. Allow the illumination and measurement equipment to reach a stable state.

8.2 Clean the surfaces of the sample. Place the sample on the sample stage.

8.3 Align the geometric centre of the sample with the centre of the view field of the imaging system.

8.4 Adjust the infrared imaging system along the axial direction so that the bubbles and inclusions within the thickness of the sample are clearly imaged. If the depth of focus of the imaging lens is unable to cover the thickness of the sample, measurements shall be conducted on separate sections of the sample.

8.5 Collect the images of the bubbles and inclusions with the image sensor. Use the software of the computer data collection, processing, and displaying system to process the image data.

9 Data processing

9.1 For the symmetrically shaped bubbles and inclusions, measure their maximum lengths and then calculate their cross-sectional area S_i . For the asymmetrical ones, measure their maximum lengths and widths and then calculate their cross-sectional area S_i by the product of their lengths and widths.

9.2 Sum up the total cross-sectional area of all the bubbles and inclusions inside the sample according to Formula (1). Bubbles and inclusions with maximum lengths of less than 0,1 mm shall be ignored.

$$S = \sum_{i=1}^n S_i \quad (1)$$

where

S is the total area of the bubbles and inclusions in the sample, in mm²;

n is the number of the bubbles and inclusions;

i is the serial number of a bubble or inclusion;

S_i is the area of a single bubble or inclusion, in mm².

9.3 Calculate the volume of the sample.

9.4 Calculate the material imperfection value of the sample.

10 Test report

The test report shall include at least the following (see [Annex A](#)):

- a) laboratory name and contact information;
- b) test method and instrument;
- c) test wavelength;
- d) client;
- e) sample name and specification (length × width × height);
- f) environmental temperature and humidity;
- g) section number, total volume of the sample, total area of the bubbles and inclusions and the material imperfection value;
- h) tester, reviewer and test date;
- i) remarks.

Annex A

(informative)

Test record of bubbles and inclusions in infrared optical materials

Laboratory name		Contact information	
Test method		Test instrument	
Test wavelength (μm)		Client	
Sample name		Sample specification (length×width×height)	
Environmental temperature		Environmental humidity	
Section number	Total volume of sample	Total area of bubbles and inclusions	Material imperfection value

Remarks:

Tester:

Reviewer:

Date: