International Standard

ISO 14880-4

Optics and photonics — Microlens arrays —

Part 4: Test methods for geometrical properties

Optique et photonique — Réseaux de microlentilles —

Partie 4: Méthodes d'essai pour les propriétés géométriques

Second edition
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Foreword

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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 document 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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This document was prepared by Technical Committee ISO/TC 172, *Optics and Photonics*, Subcommittee SC 9, *Laser and electro-optical systems*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 123, *Lasers and photonics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 14880-4:2006), which has been technically revised.

The main changes are as follows:

— Introduction revised;

— Updated the references to terms defined in 14880-1;

— Figure 8 replaced;

— References updated.

A list of all parts in the ISO 14880 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Examples of applications for microlens arrays include three-dimensional displays, coupling optics associated with arrayed light sources and photo-detectors, enhanced optics for liquid crystal displays, and optical parallel processor elements.

The market in microlens arrays has generated a need for agreement on basic terminology and test methods. Standard terminology and clear definitions are needed not only to promote applications but also to encourage scientists and engineers to exchange ideas and new concepts based on common understanding.

This document contributes to the purpose of the series of ISO 14880 standards, which is to improve the compatibility and interchangeability of lens arrays from different suppliers and to enhance development of the technology using microlens arrays.

Characteristic parameters are defined and examples of applications given in ISO 14880-1. It has been completed by a set of three other International Standards, i.e. ISO 14880-2, ISO 14880-3 and ISO 14880-4.

The measurement of physical characteristics of pitch and surface modulation depth can be made using a stylus instrument and non-contact optical probe system. Physical thickness can be measured with a micrometer. The measurement processes are described in the body of this document.

Optics and photonics — Microlens arrays —

Part 4:
Test methods for geometrical properties

1 Scope

This document specifies methods for testing geometrical properties of microlenses in microlens arrays. It is applicable to microlens arrays with very small lenses formed on one or more surfaces of a common substrate and to graded-index microlenses.

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 14880-1, *Optics and photonics — Microlens arrays — Part 1: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14880-1 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

NOTE 1 The symbols adopted for this document are chosen for clarity in this application to microlens arrays but some may not be those commonly used for surface texture measurement.

NOTE 2 The parameters P_x, P_y and h are used in this document to describe geometrical parameters encountered in the measurement of surface texture. P_x, P_y are spacing parameters and are defined as the average value of the length of the mean line section containing a profile peak and adjacent valley. An amplitude parameter, h, is defined as the average difference between peak of the lens profile and the rim. Figure 1 illustrates the geometrical properties of microlens arrays which are to be measured.

3.1
pitch
P_x, P_y
distance between the centres of adjacent lenses which may vary across the array and will vary with direction

Note 1 to entry: See Figure 1.

Note 2 to entry: The pitch is expressed in millimetres.

[SOURCE: ISO 14880-1:2019, 3.4.1.5]

Note 3 to entry: For a stylus instrument this will generally equate to the mean width of the profile elements, Rsm, calculated from the roughness profile (see ISO 21920-2:2021, 3.1.14.3).

3.2
surface modulation depth
h
peak-to-valley variation of the surface height

Note 1 to entry: See Figure 1.

Note 2 to entry: For a purely refractive microlens, this will be the same as the lens sag.

Note 3 to entry: The surface modulation depth is expressed in millimetres.

[SOURCE: ISO 14880-1:2019, 3.4.1.8]

Note 4 to entry: For stylus instruments this will generally equate to *Rz* (see ISO 21920-2:2021, 3.1.14.3).

3.3
physical thickness
T_c
maximum local thickness of the array

Note 1 to entry: See Figure 1.

Note 2 to entry: The physical thickness is expressed in millimetres.

[SOURCE: ISO 14880-1:2019, 3.4.1.9]

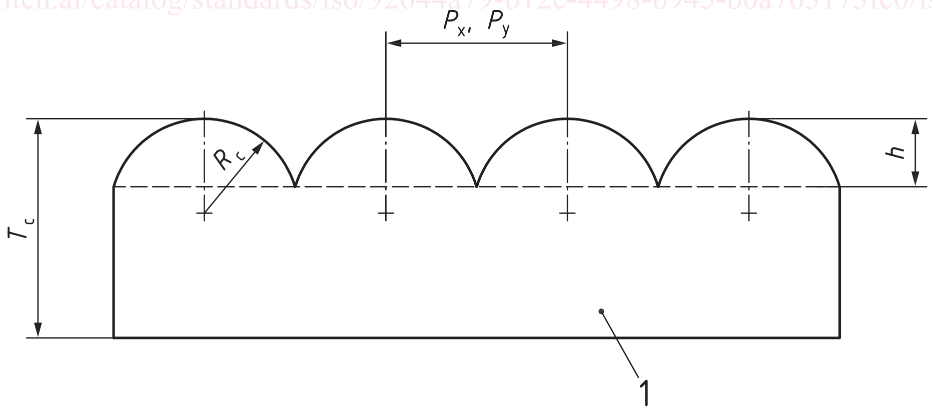
3.4
radius of curvature
R_c
distance from the vertex of the microlens to the centre of curvature of the lens surface

Note 1 to entry: See Figure 1.

Note 2 to entry: The radius of curvature is expressed in millimetres.

[SOURCE: ISO 14880-1:2019, 3.3.3]

Note 3 to entry: For rotationally invariant microlenses or cylindrical microlenses.



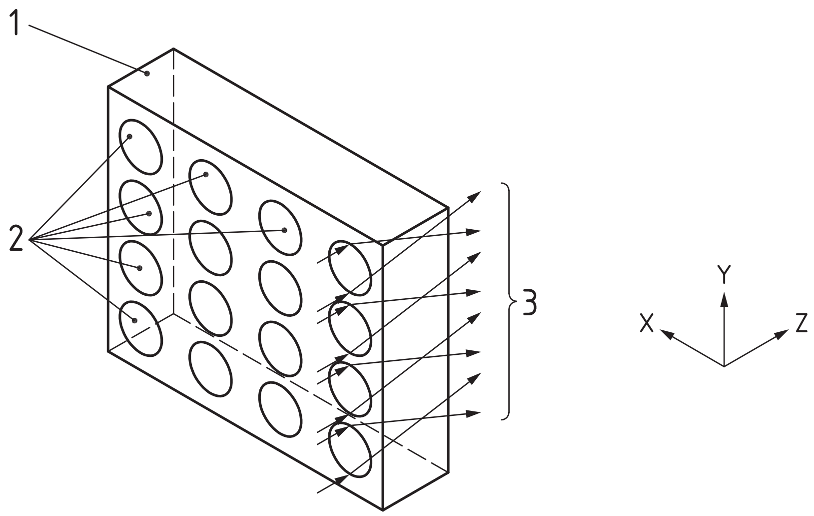
Key

1	substrate
T_c	physical thickness
R_c	radius of curvature
P_x, P_y	pitch
h	surface modulation depth (lens sag)

Figure 1 — Geometrical parameters of microlens arrays

4 Coordinate system

To measure the geometrical properties of a microlens array, a Cartesian coordinate system is used, as shown in Figure 2 (ISO 14880-1:2019, Figure 1). In a right-handed Cartesian set, the X- and Y-axis lie in the substrate plane and the X-axis provides the direction of trace. The Z-axis is the outward direction from the material to the surrounding medium.



Key

1 substrate

2 microlens

3 light paths

Figure 2 — Microlens array with a Cartesian coordinate system

5 Test methods

5.1 Pitch and surface modulation depth measurement

5.1.1 Use of stylus instrument

5.1.1.1 Principle

The basic principle using a stylus instrument is to obtain a profile of the surface of the array[1][2][3][4]. Care shall be taken to ensure that the profile passes through the centre of each lens and that the stylus remains in contact with the surface throughout the measurement process. This enables the pitch and surface modulation depth to be determined.

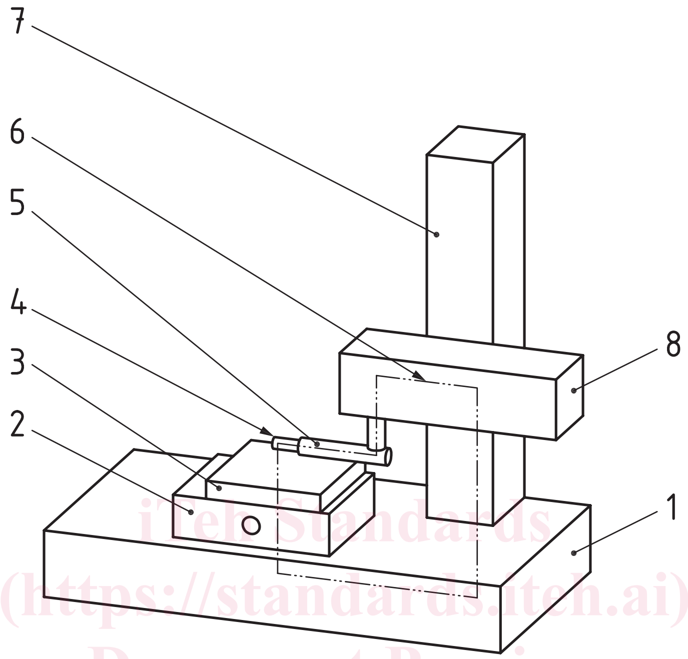
5.1.1.2 Set-up and preparation

The measurement of the geometrical characteristics of a microlens array is similar in principle to the measurement of any surface using a stylus instrument. A typical stylus instrument consists of a stylus that physically contacts the surface and a transducer to convert its vertical movement into an electrical signal. Other components can be seen in Figure 3 and include the following: a pick-up, driven by a motor and gearbox, which draws the stylus over the surface at a constant speed; an electronic amplifier to boost the signal from the stylus transducer to a useful level; a device for recording the amplified signal or a computer that automates the data collection.

The part of the stylus in contact with the surface of the array is usually a diamond tip with a carefully manufactured profile. Owing to their finite shape, some styli on some arrays may not penetrate into valleys and will give a distorted or filtered measurement of the surface. The effect of the stylus forces can have a significant influence on the measurement results. Too high a force can cause damage to the surface of the array. Too low a force and the stylus will not stay reliably in contact with the surface.

The stylus instrument shall be used in an environment that is as free as possible from dust, vibration and direct sunlight in a location where the ambient temperature is maintained in the range 20 °C ± 5 °C (with a condensation-free humidity below 70 % relative humidity). Remove any gross contamination from the surface of the instrument preferably by blowing the surface with filtered air. Any oil or grease may be removed using a suitable solvent.

Due consideration shall be given for testing under more adverse conditions.



Key

1 base

2 fixture

3 microlens under test

4 stylus

5 probe (pick-up)

6 measurement loop

7 column

8 drive unit

Figure 3 — Elements of a typical stylus instrument

The electrical unit on the stylus instrument shall be switched on at least one hour before any measurements take place. This will allow time for the instrument to stabilize (the manufacturer's instructions will normally specify a minimum stabilization time for a given instrument). Calibration of the instrument is essential prior to measurement. Before calibration of the instrument takes place the stylus should be checked for signs of wear or damage. A damaged stylus tip can lead to serious errors.

After measurement of the calibration artefact the indicated value shall be compared with the value attached to the test object. If the measured value differs from the value that is shown on the calibration certificate then recalibration is required.