INTERNATIONAL STANDARD

ISO 14880-4

First edition
2006-06-01

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

Reference number
ISO 14880-4:2006(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14880-4 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

ISO 14880 consists of the following parts, under the general title *Optics and photonics — Microlens arrays*:

- *Part 1: Vocabulary*
- *Part 2: Test methods for wavefront aberrations*
- *Part 3: Test methods for optical properties other than wavefront aberrations*
- *Part 4: Test methods for geometrical properties*

Introduction

This part of ISO 14880 specifies methods for testing geometrical properties of microlens arrays. 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 part of ISO 14880 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.

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 part of ISO 14880.

Optics and photonics — Microlens arrays —

Part 4:
Test methods for geometrical properties

1 Scope

This part of ISO 14880 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 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 14880-1, *Optics and photonics — Microlens arrays — Part 1. Vocabulary*

3 Terms, definitions and symbols

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

NOTE 1 The symbols adopted for this part of ISO 14880 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 part of ISO 14880 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 and will vary with direction

See Figure 1.

NOTE 1 The pitch is expressed in millimetres.

[ISO 14880-1:2001, term 6.2.1.5]

NOTE 2 For a stylus instrument this will generally equate to the mean width of the profile elements calculated from the roughness profile, RS_m (see 3.2.2 and 4.3.1 in ISO 4287:1997).

3.2
surface modulation depth

h

peak-to-valley variation of the surface height

See Figure 1.

NOTE 1 For a purely refractive microlens, this will be the same as the lens sag.

NOTE 2 The surface modulation depth is expressed in millimetres.

[ISO 14880-1:2001, term 6.2.1.8]

NOTE 3 For stylus instruments this will generally equate to Rz (see 4.1.3 in ISO 4287:1997).

3.3
physical thickness

T_c

maximum local thickness of the array

See Figure 1.

NOTE The physical thickness is expressed in millimetres.

[ISO 14880-1:2001; term 6.2.1.9]

3.4
radius of curvature

R_c

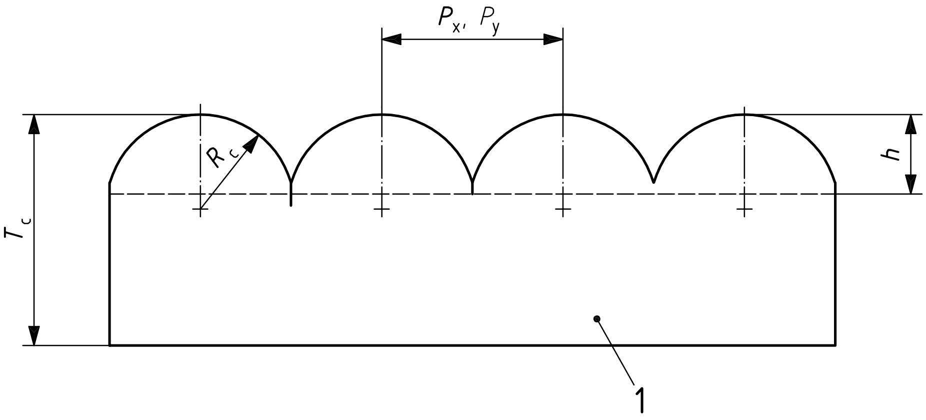
distance from the vertex of the microlens to the centre of curvature of the lens surface

See Figure 1.

NOTE 1 The radius of curvature is expressed in millimetres.

[ISO 14880-1:2001; term 6.1.4]

NOTE 2 For rotationally invariant microlenses or cylindrical microlenses.



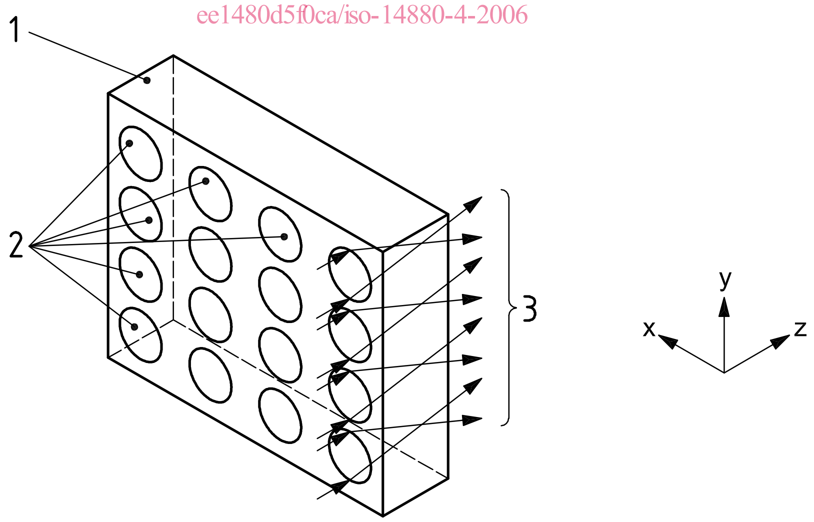
Key

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. 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 pass

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. 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.

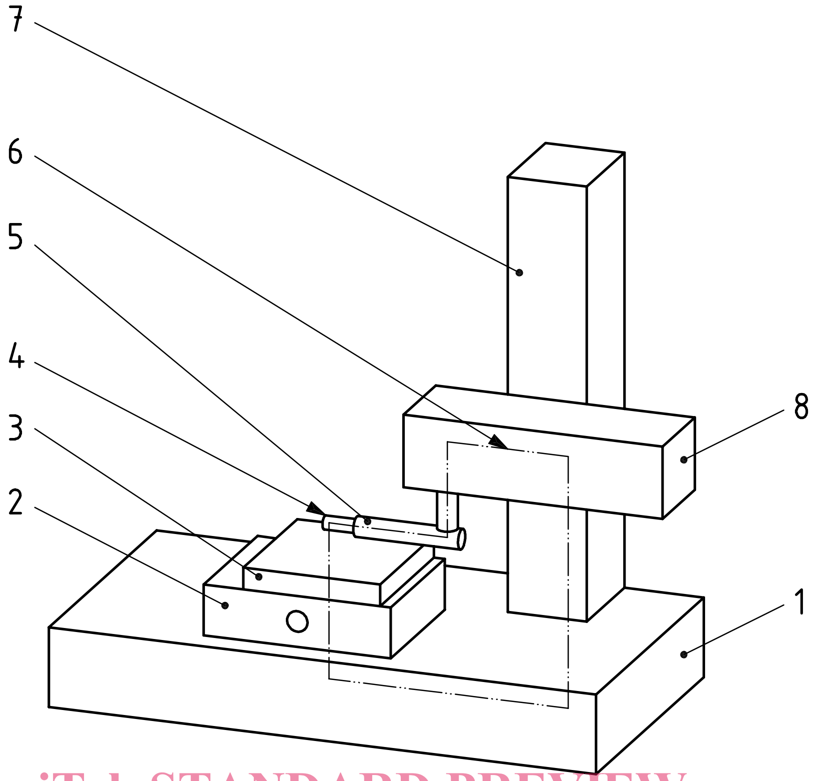
5.1.1.2 Set-up and preparation

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 re-calibration is required.

5.1.1.3 Stylus size and shape

It is important that the dimension and shape of the stylus are chosen appropriately as this can affect the accuracy of the traced profile in a number of ways. On arrays with deep, narrow valleys the stylus may not be able to penetrate fully to the bottom because either the tip radius or the flank angle of the stylus is too large. In such cases, the value of the surface modulation depth will be smaller than the true value. The ideal stylus shape is a cone with a spherical tip. This usually has a cone angle of either 60° or 90° with a typical tip radius of 1 µm, 2 µm, 5 µm or 10 µm.

5.1.2 Use of confocal microscope

5.1.2.1 Principle

The confocal principle can be used for the measurement of surface topography. Depth is discriminated by moving the surface of the object through focus and measuring the reflected intensity using a detector and confocal pinhole. When the object point lies at the focus, the maximum intensity is detected whereas the signal is reduced when the object point is displaced from the focus. The principle has been established in the scanning confocal microscope. By scanning an imaged light spot over the object an area is measured point by point.

5.1.2.2 Set-up and preparation

The principle of the confocal microscope has been developed by generating an array of light spots on the object using a multiple pinhole mask (Nipkow disc) which allows for parallel data acquisition of multiple object points. The Nipkow disc can be replaced by a microlens array in order to improve the light efficiency, as shown in Figure 4.