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Geometrical product specifications (GPS) — Surface texture: Areal —

Part 607:
Nominal characteristics of non-contact (confocal microscopy) instruments

Spécification géométrique des produits (GPS) — État de surface: Surfacique —

Partie 607: Caractéristiques nominales des instruments sans contact (microscopie confocale)

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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 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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This document was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

A list of all parts in the ISO 25178 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

This document is a geometrical product specification (GPS) standard and is to be regarded as a general GPS standard (see ISO 14638). It influences the chain link F of the chains of standards on areal surface texture and profile surface texture.

The ISO/GPS matrix model given in ISO 14638 gives an overview of the ISO/GPS system of which this document is a part. The fundamental rules of ISO/GPS given in ISO 8015 apply to this document and the default decision rules given in ISO 14253-1 apply to the specifications made in accordance with this document, unless otherwise indicated.

For more detailed information of the relation of this document to other standards and the GPS matrix model, see Annex D.

This document describes the metrological characteristics of confocal microscopes designed for the measurement of surface topography maps.

For detailed information on the confocal microscopy technique, see Annex A and Annex B.

NOTE Portions of this document, particularly the informative sections, describe patented systems and methods. This information is provided only to assist users in understanding the operating principles of confocal microscopy. This document is not intended to establish priority for any intellectual property, nor does it imply a license to proprietary technologies described herein.

Geometrical product specifications (GPS) — Surface texture: Areal —

Part 607:
Nominal characteristics of non-contact (confocal microscopy) instruments

1 Scope

This document describes the influence quantities and instrument characteristics of confocal microscopy systems for areal measurement of surface topography. Because surface profiles can be extracted from surface topography images, the methods described in this document can be applied to profiling measurements as well.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 25178-600 and the following 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
confocal microscopy
measurement method wherein the localization of optically sectioned images during an axial scan through the focus of a microscope's objective provides a means to determine an areal surface topography image

Note 1 to entry: See also ISO 25178-6:2010, 3.3.6.

Note 2 to entry: Confocal microscopes produce optically sectioned images by restricting the illumination onto the sample and through the detection system by means of a pattern, scanning this pattern in-plane to fill the image (see also Figure B.1).

Note 3 to entry: Illumination and detection patterns could be one or several points, slits or any order of structures, that effectively reduce the illuminated area of the surface. The geometry of these patterns influences the evaluation of the sectioned images and has direct influence on the metrological characteristics of the instrument.

Note 4 to entry: The difference between a confocal point sensor and a confocal microscope is defined by the in-plane scanning scheme. In the confocal microscope one or multiple parallel working light paths scan the surface. This is realized with various optical elements. In contrast, the single point confocal probe scans only one point on the sample at a time by moving either the sample or the probe. A single point confocal chromatic probe arrangement is described in ISO 25178-602:2010, Annex B.

Note 5 to entry: Table 1 compiles alternative terms that conform at least in part to the above definition.

Table 1 — Examples of alternative terms sometimes used for confocal microscope

Acronym	Term
ICM	imaging confocal microscope
LSCM	laser-scanning[a] confocal microscope (see also A.2)
CLSM	confocal laser-scanning[a] microscope (same method as LSCM)
CSLM	confocal-scanning laser microscope (same method as LSCM)
LSM	laser-scanning[a] microscope (same method as LSCM)
DSCM	disc-scanning confocal microscope (see also A.3)
PACM or PAM	programmable array confocal microscope or programmable array microscope (see also A.4)
MSCM	microdisplay scanning confocal microscope (same method as PACM)
RSOM	real-time scanning optical microscope
CSOM	confocal-scanning optical microscope

[a] The term 'laser-scanning microscope' has also been used to refer to laser-based scanning probes with height sensors, such as triangulation or dynamic focus, which are different from the confocal methods described here.

3.2
illumination pattern
arrangement of single or repetitive structures placed on a conjugate image position of the microscope's objective (typically the field diaphragm position), restricting the illuminated parts on the sample

Note 1 to entry: The illumination pattern can be a single pinhole, equally spaced pinholes on a grid, slits, parallel slits or any other pattern that effectively reduces the amount of illuminated area.

3.3
detection pattern
arrangement of single or repetitive structures placed on a conjugate image position of the microscope's objective, blocking the out-of-focus light reflected from the surface and from previously illuminated parts

Note 1 to entry: The illumination and detection patterns need not have the same geometry.

3.4
in-plane scanning
mechanical or optical displacement of the illumination and/or detection patterns to fulfil an optical section image

Note 1 to entry: Annex A describes the principle of in-plane scanning for typical confocal arrangements.

3.5
axial scan
mechanical or optical displacement between the sample under inspection and the imaging optics

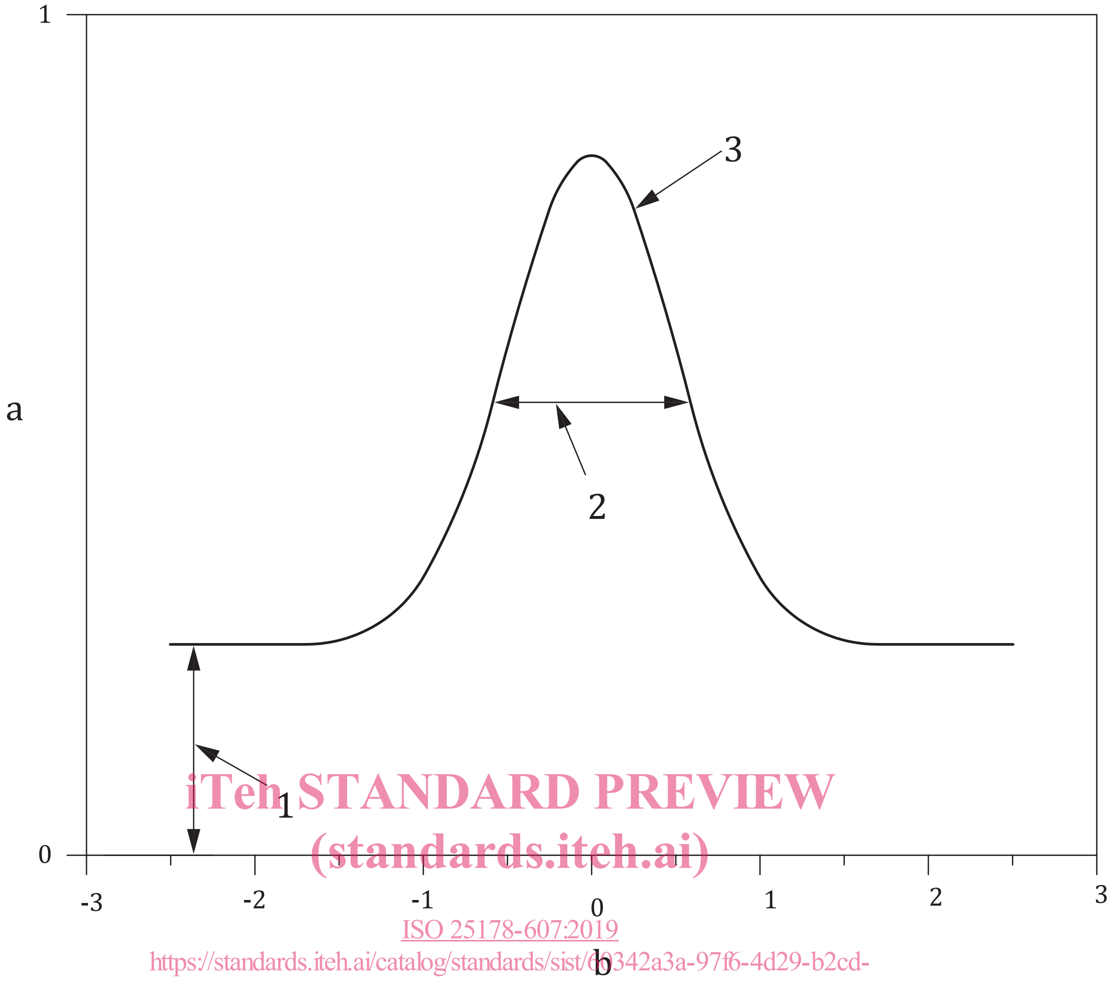
Note 1 to entry: The imaging optics is nominally parallel to the axial scan axis of the microscope.

3.6
axial scan length
total range travelled by the confocal microscope axial scan, usually the total displacement between the sample and the microscope's objective translated along its optical axis during data acquisition

Note 1 to entry: This parameter might be limited by the overall range of the axial scanner, but is generally a parameter chosen by the operator taking account of the height range of the surface topography.

3.7
axial response
signal recorded for an individual image point of the confocal image as a function of the axial scan position

Note 1 to entry: See Figure 1.



Key

a normalized detector signal

b *z*-height

1 background offset

2 full width at half maximum

3 axial response

Figure 1 — Schematic axial response signal

3.8
full width at half maximum
FWHM
$\Delta_{\text{z-HM}}$
region of the axial response symmetrical to the maximum peak where the signal falls to one-half of the maximum peak signal

Note 1 to entry: The FWHM is used as a metric (or estimator) of the thickness of the optically sectioned slice.

3.9
maximum signal position
position of the axial scan where the amplitude of the axial response is maximum

3.10
background offset
value of the axial response for axial positions far from the maximum signal position

Note 1 to entry: The background offset might be caused by residual reflected and scattered light within the instrument and from the sample, “cross talking” between pinholes and incomplete sectioning behaviour of the light path.

Note 2 to entry: Methods exist which reduce or make use of background offset effects.

3.11
axial steps
distance between two consecutive confocal images during an axial scan

3.12
confocal imaging rate
number of confocal images per second provided by a confocal microscope without axial scan

3.13
axial scanning rate
number of confocal images per second provided by a confocal microscope during an axial scan, expressed as the number of acquired plane sections per second

Note 1 to entry: The axial scanning rate might be equal to or lower than the confocal imaging rate depending on the scanning hardware used and the processing algorithms.

3.14
flatness calibration surface
reference surface used to measure and adjust for the microscope flatness error

Note 1 to entry: The calibration surface is typically an optically flat single surface mirror (flatness ≤ $\lambda/10$ and roughness average R_a < 0,5 nm).

3.15
confocal peak location algorithm
algorithm used to estimate the maximum signal position of the surface point from the axial response

Note 1 to entry: The maximum signal (confocal peak) position is equated to the axial location of the surface.

Note 2 to entry: The confocal peak is not necessarily represented by the absolute maximum of the axial response; there are multiple algorithms (see Annex B).

3.16
maximum measurable local slope
<confocal microscopy> largest slope that can be measured on an optically smooth surface

Note 1 to entry: See ISO 25178-600:2019, Annex A.

3.17
confocal stack
series of optical sections taken during an axial scan

3.18
confocal topography image
areal topography image derived from a stack of optical sections obtained during an axial scan

Note 1 to entry: Generally, for each pixel of the image the *confocal peak location algorithm* (3.15) is applied to the *confocal stack* (3.17) to calculate the height of the surface.

3.19
confocal intensity image
areal intensity image derived from a stack of optical sections obtained during an axial scan

Note 1 to entry: For each pixel of the image an algorithm is applied that finds the reflected intensity of the surface. The applied algorithm might be different from the algorithm (3.15) to find the height of the surface.

Note 2 to entry: Such a group of images typically shows a depth of field close to the axial scan range.

4 Descriptions of the influence quantities

Influence quantities for confocal microscopy instruments are given in Table 2. The table indicates the metrological characteristics (see ISO 25178-600:2019, Table 1) affected by deviations in the influence quantities.

Table 2 — Influence quantities for confocal microscopy

Component	Element	Influence quantities		Metrological characteristic affected
Light source		λ_0	Measurement optical wavelength (see ISO 25178-600)	α_z
		$B_{\lambda 0}$	Measurement optical bandwidth (ISO 25178-600)	α_z
Microscope imaging system		A_N	Microscope numerical aperture (see ISO 25178-600)	α_x, α_y, α_z, W_R
		M_IMG	Magnification between object sizes on the surface and image sizes on the sensor	α_x, α_y
		Δ_PATH	Optical aberrations – a function describing net deviations in the measured optical path of the system, derived from imperfections in the optics and the topography of the flatness calibration surface	α_z
		Q_OPT	General quality of the optical components used, including aberrations, transmission and alignment errors	α_x, α_y, z_FLT, l_x, l_y, l_z, W_R, Δ_x, Δ_y
		$P_{\mathrm{DIS}xy}$	Lateral distortion of the magnified image on the camera	α_x, α_y, α_z, z_FLT, l_x, l_y, l_z, W_R, Δ_x, Δ_y
		$U_{\mathrm{I}(x,y)}$	Illumination uniformity – distribution of illumination across the field of view of the object (a highly uniform, constant distribution is desired)	α_x, α_y, α_z, z_FLT, l_x, l_y, l_z

[a] These influence quantities arise from the interaction between the instrument and the sample being measured.

