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Specification of the Universal Calibration Artefact 2024

The universal calibration artefact enables a comprehensive calibration of areal surface topography measuring instruments. The material measures included on the artefact allow a determination of the metrological characteristics according to ISO 25178-600.

Generally, six different geometries are required to determine these metrological characteristics. To enable the most common microscopic magnifications from 5× to 100×, different material measures featuring an area of 100 µm x 100 µm, 200 µm x 200 µm, 400 µm × 400 µm 800 µm × 800 µm and 1500 µm x 1500 µm are included in the layout, leading to a total number of 17 potential measured areas on the sample.

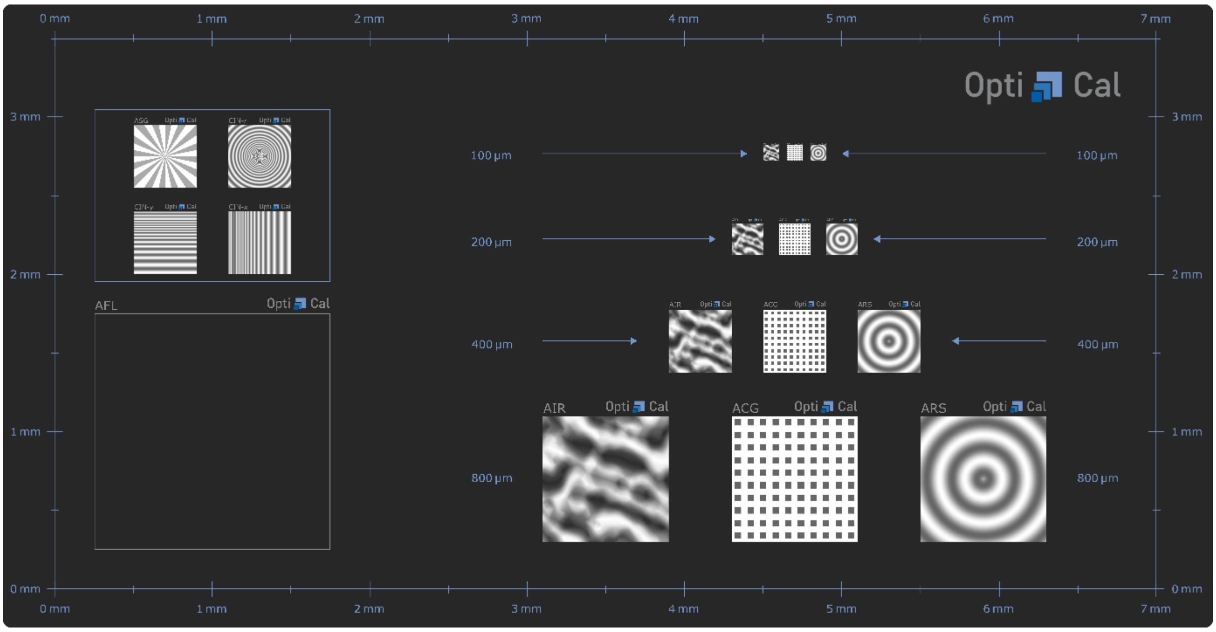

Fig. 1: Universal Calibration Artefact (schematically). Sample layout featuring 17 material measures for all metrological characteristics as defined in ISO 25178-600.

The following material measures are included:

1) **Siemens Star sample (type ASG from ISO 25178-70) featuring an area of 400 µm x 400 µm**
   With this material measure, a measurand can be calculated which corresponds to the topographic resolution of the measuring instrument. In doing so, the spatial frequency, which is transmitted with an amplitude of 50% of the original amplitude, is determined (the spatial period limit) [2].

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2) **Chirped material measures (type CIN, not within current ISO): In x-direction featuring an area of 400 µm x 400 µm and in y-direction featuring an area of 400 µm x 400 µm**
   With the chirped material measures, some aspects of the topographic fidelity can be determined, which are related to the topographic resolution in the ISO 25178-600 [3]. The samples allow an individual evaluation for the x- and y-direction, feature a size of 400 µm × 400 µm exhibit 16 different wavelengths between 0.807 µm and 48.389 µm.

3) **Circular chirp material measure (type CIN-r, not within current ISO) featuring an area of 400 µm x 400 µm**
   With the circular chirped material measure, different aspects of the topographic fidelity can be determined for different directions, which are related to the topographic resolution in ISO 25178-600 [3]. The samples allows an individual evaluation in different directions, features a size of 400 µm × 400 µm exhibit 15 different wavelengths between 0.807 µm and 36.830 µm.

4) **Flatness material measure (type AFL from ISO 25178-70) featuring an area of 1500 µm x 1500 µm**
   With the flatness material measure, instrument noise and flatness deviation can be determined. This is achieved by measuring the areal surface texture parameters as outlined in ISO 25178-700.

5) **Radial sine wave (type ARS from ISO 25178-70), featuring areas of 100 µm x 100 µm, 200 µm x 200 µm, 400 µm × 400 µm and 800 µm × 800 µm**
   With these material measures, a general calibration of all three axis of the measuring instrument is possible. Thus, the measurands S_a and S_q can be determined as stated in ISO 25178-70.

6) **Cross-grating (type ACG from ISO 25178-70), featuring areas of 100 µm x 100 µm, 200 µm x 200 µm, 400 µm × 400 µm and 800 µm × 800 µm**
   The cross-grating material measures are applied for the calibration of the lateral axis. The metrological characteristic, as defined in ISO 25178-600, is the local *x-y* mapping deviation. The linearity deviations l_x, l_y, amplification coefficients α_x, α_y and the perpendicularity $\Delta_{\mathrm{PER}xy}$ of the lateral axis can also be determined.

7) **Irregular rough surface (type AIR from ISO 25178-70), featuring areas of 100 µm x 100 µm, 200 µm x 200 µm, 400 µm × 400 µm and 800 µm × 800 µm**
   The irregular rough surface is typically applied for the determination of areal amplitude-based surface texture parameters. The surface was determined by a model-based design approach and is based on an actual engineering surface [4]. Further, the functionality is extended by the calibration of the height axis [5]. This calibration of the height axis is possible by calculating the linearity deviation l_z and the amplification coefficient α_z. The parameters are determined as described within the ISO 25178-60x series. However, not a limited number of specific values is used for calibration, but the surface's linear Abbott-curve is used to determine the response curve when the measured height values are compared against the target height values with

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the total number of measured points. Thus, a large number of points is used for the calibration and a highly precise and practical calibration procedure results.

Tab. 1 Measurands: Shown are all metrological parameters of the material measures to be determined [1].

type	size	parameter	
ASG	400 µm x 400 µm	*spatial period limit of the instrument*	
CIN-x, CIN-y, CIN-r	400 µm x 400 µm	*topography fidelity limit (see ISO 25178-700)*	
AFL	1500 µm x 1500 µm	S_a / µm	0.000
		S_q / µm	0.000
		S_z / µm	0.000
		$S_{q,noise}$ / µm	0.000

type	parameter	100 µm × 100 µm	200 µm × 200 µm	400 µm × 400 µm	800 µm × 800 µm
ARS	S_a / µm	0.944	0.944	0.945	0.948
	S_q / µm	1.053	1.053	1.053	1.056
ACG	l_x / µm	10	20	40	80
	l_y / µm	10	20	40	80
	α / °	90	90	90	90
AIR	*linearity deviation* l_z				
	amplification coefficient α_z				
	S_a / µm	2.297	2.297	2.297	2.297
	S_q / µm	2.655	2.655	2.655	2.655

The artefact enables a calibration at different microscopic magnifications without changing the sample. Thus, with only one sample, many other material measures can be substituted which lead to a cost and time-efficient calibration. The metrological characteristics represent the most recent state of the art of the international standardization in the field of areal surface topography measurement. The defined measurands are summarized in Table 1. The nominal values in the table were calculated based on the target geometry for manufacturing.

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