Specification of Universal Calibration Artefact

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 from the current draft of ISO 25178-600. As shown in Fig. 1, six different geometries are required to determine these metrological characteristics. To enable varying microscope magnifications between 5× and 100×, those material measures are measured with area 100 µm x 100 µm, 200 µm x 200 µm, 400 µm × 400 µm and 800 µm × 800 µm, leading to a total number of 24 potential measured areas on the sample (Fig. 1 (b)).

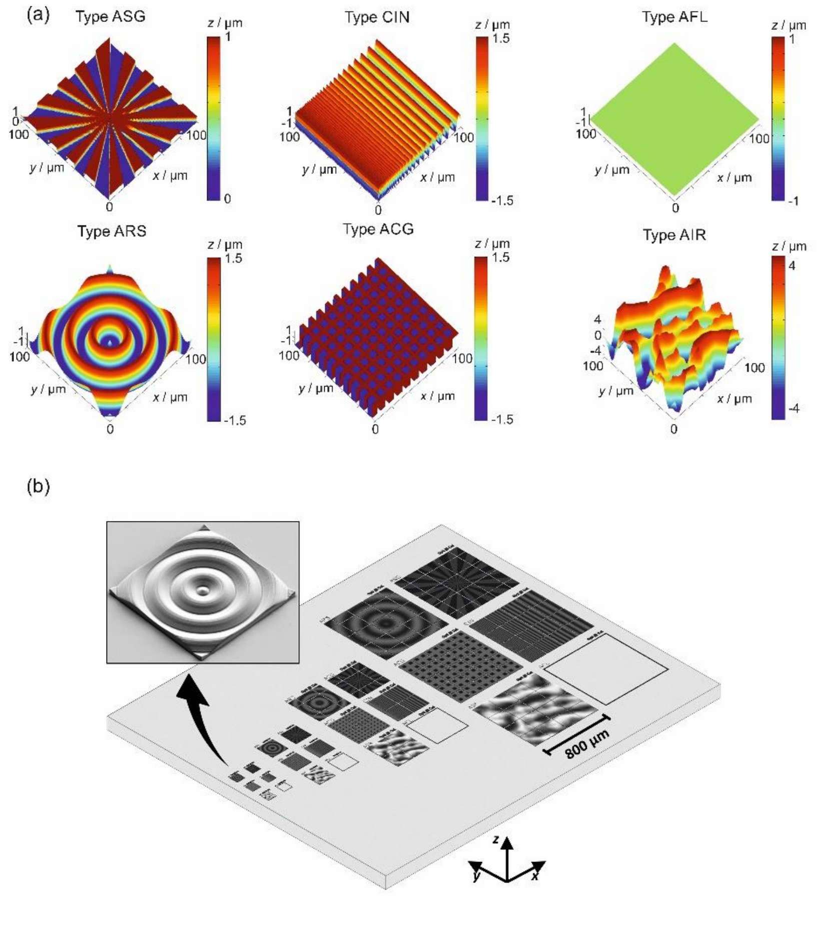

Fig. 1. (a) Target geometries of the six material measures with the size of 100 µm × 100 µm. (b) Overview of all material measures of the universal calibration artefact with different sizes. Excerpt: SEM image of the material measure ARS [1].

The following material measures are included:

1) **Star sample (Type ASG from ISO 25178-70)**
   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].

2) **Chirped material measure (Type CIN, not in current ISO drafts)**
   With the chirp material measure, some aspects of the topographic fidelity can be determined, which will also be related to the topographic resolution in the ISO 25178-600 [3]. The sample with a size of 100 µm × 100 µm exhibits 20 different wavelengths between 9.46 µm and 0.47 µm.

3) **Flatness material measure (Type AFL from ISO 25178-70)**
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.

4) **Radial sine wave (Type ARS from ISO 25178-70)**
With this material measure, a general calibration of all three axes of the measuring instrument is possible. Thus, the measurands S_a and S_a can be determined as stated in ISO 25178-70.

5) **Cross-grating (Type ACG from ISO 25178-70)**
The cross-grating material measure is applied for the calibration of the lateral axes. 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 Δ_{PERxy} of the lateral axes can also be determined.

6) **Irregular rough surface (Type AIR of ISO 25178-70)**
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 in ISO 25178-60x series, however, not a limited number of specific values is used for calibration but the surface features a linear Abbott-curve which can be used to determine the response curve when the measured height values are compared against the target height values with 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.

The artefact enables calibration at different microscope 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.

Table 1. Measurands of the material measures [1].

Type	**Parameter**	**100 µm × 100 µm**	**200 µm × 200 µm**	**400 µm × 400 µm**	**800 µm × 800 µm**
ASG	*spatial period limit of the instrument*				
CIN	*topography fidelity limit (see ISO 25178-700)*				
AFL	S_a / µm	0.000	0.000	0.000	0.000
	S_q / µm	0.000	0.000	0.000	0.000
	S_z / µm	0.000	0.000	0.000	0.000
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

Literature

[1] Eifler, M.; Hering, J.; von Freymann G.; Seewig, J.: A calibration sample for arbitrary metrological characteristics of optical topography measuring instruments. Optics Express26 (13), 16609-16623 (2018).

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