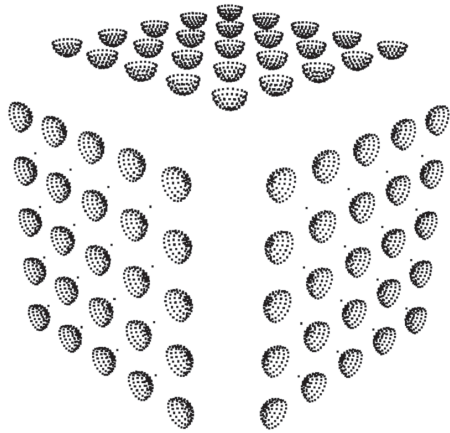
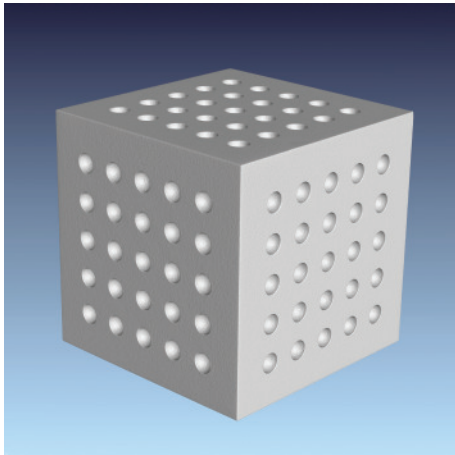


## Tactile calibration



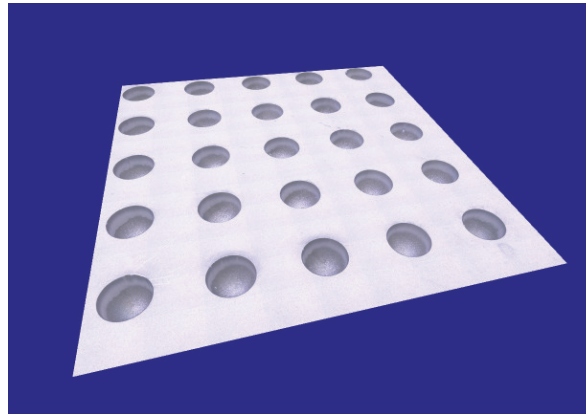
Tactile calibration by DKD laboratory DKD-K-25901 ([www.feinmess.com](http://www.feinmess.com)). 25 000 probing points, extended measurement uncertainty ( $k = 2$ ) for 3D lengths max.  $1 \mu\text{m}$  and  $0.8 \mu\text{m}$  for radii.

## $\mu\text{CT}$ measurement



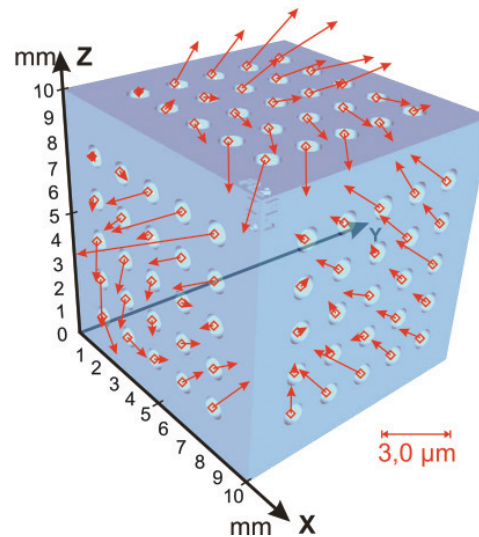
3D- $\mu\text{CT}$  measurement of the Federal Institute for Materials Research and Testing BAM ([www.bam.de](http://www.bam.de)). Accelerating voltage 200 kV, voxel size  $18 \mu\text{m}$ , 1 000 000 data points

## Optical measurement



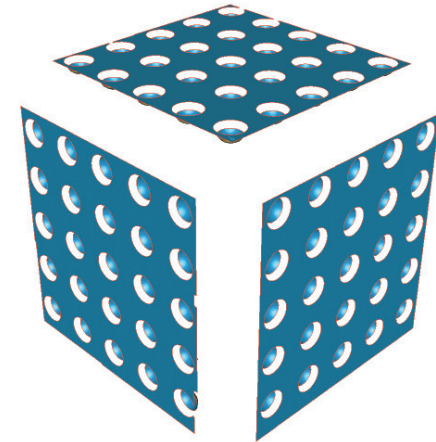
Optical measurement with InfiniteFocus measurement system ([www.alicon.com](http://www.alicon.com)). 10-fold magnification, stitch mode, 1 000 000 data points

## Assessment of errors of measurement



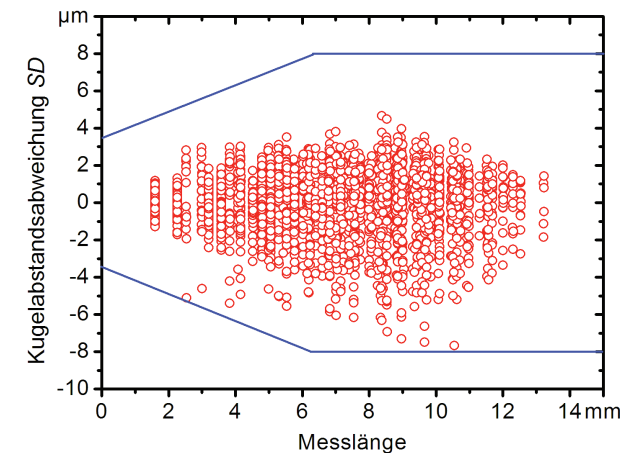
Position errors of CT-measured calotte centres. The errors of measurement are of the order of  $3 \mu\text{m}$ .

## Multi-sensor data fusion

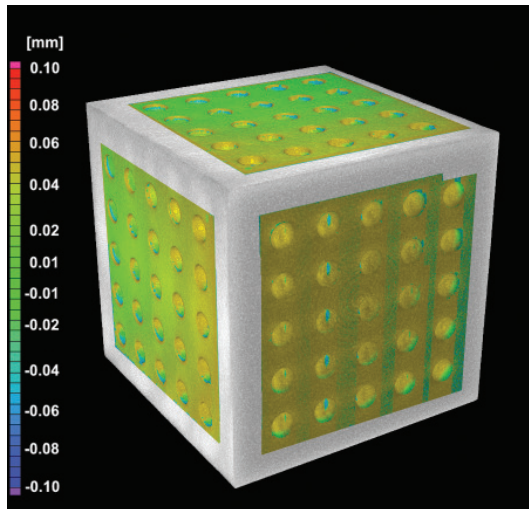


Registration of optical and tactile data. Software: Geomagic Studio ([www.geomagic.com](http://www.geomagic.com))

## Determination of Characteristics



Deviation of the CT-measured calotte distances relative to the calibration value. The calotte cube realizes 2775 lengths in the three planes and in space.



Actual-nominal value comparison of the (optical-tactile) multi-sensor measurement with the CT measurement. Software: Volume Graphics Studio Max 2.0 ([www.volumegraphics.com](http://www.volumegraphics.com))

## Material standard

The material standard is a cube of titanium (Ti-6Al-4V) with 10 mm edge length, which has been manufactured using wire erosion. On three sides, a 5x5 grid of hemispherical calottes (radius 0.4 mm, 1.6 mm spacing) has been introduced using sink erosion. Due to the manufacturing process the surface can be probed optically. The cube was manufactured at the Institut für Mikrotechnik (IMM) Mainz Ltd. ([www.imm-mainz.de](http://www.imm-mainz.de)).

The specimen allows:

1. The determination of errors of measurement and, if necessary, the geometric correction of the CT data using the calotte distance deviations
2. The verification of the surface extraction from the CT voxel data
3. The testing of  $\mu$ CT,  $\mu$ -optical and  $\mu$ -tactile measuring systems by means of characteristics defined in DIN EN ISO 10360 and VDI/VDE 2617 for acceptance, reverification and interim checking.

The standard design of the calotte cube and a modified design for  $\mu$ CT-systems with 90 kV accelerating voltage (for the measurement of plastic parts) are commercially available.

## Information

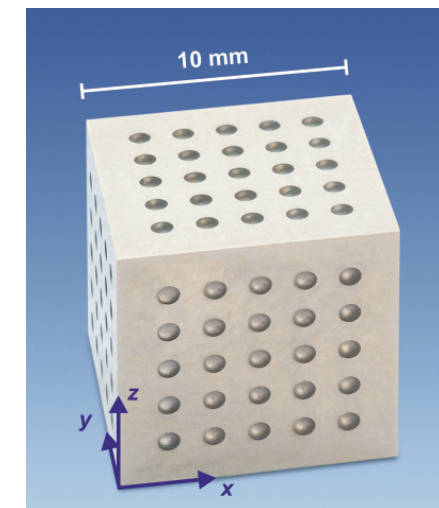
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Material standard for dimensional  
measuring micro-computed-  
tomography( $\mu$ CT) systems

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