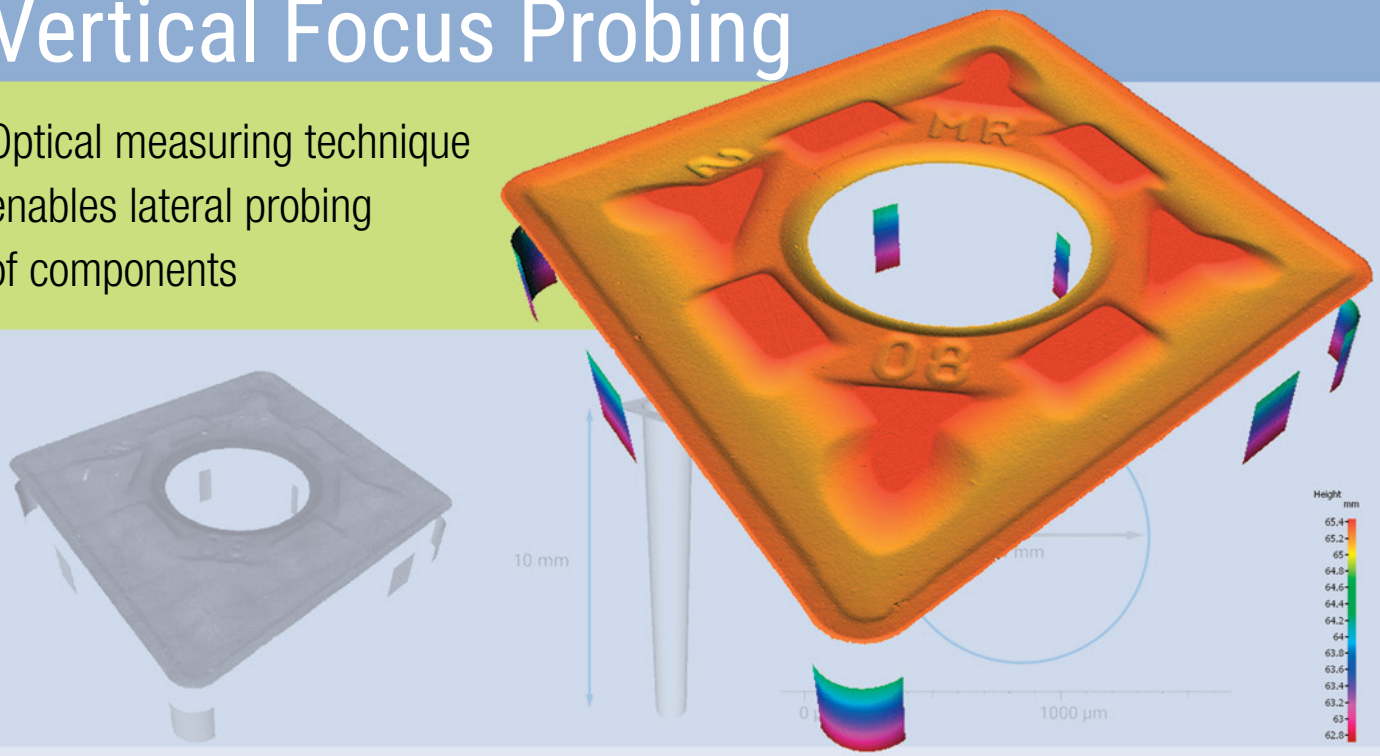
Vertical Focus Probing

Optical measuring technique enables lateral probing of components



Up to now, geometries such as bore holes of injection valves in the automotive industry were difficult to measure optically. The lateral probing of components with vertical surfaces was limited to tactile measuring systems, CT solutions or complex customized solutions. This changes with Vertical Focus Probing, an extension of Focus-Variation technology. Based on areal measurements, the optical probing of components over the entire surface is possible.

Different optical measuring methods allow the measurement of components with different flanks. The spectrum of measurable flanks or slopes has so far covered 0° - 85°, whereby in industrial practice, Focus-Variation has established itself as the most suitable method for steep flanks. However, this technology has also reached its limits for components that show flanks steeper than 85°. Nonetheless, Bruker Alicona has been constantly developing Focus-Variation for 15 years and has complemented their optical measurement principle with a new technique, Vertical Focus Probing. Even surfaces with slopes of more than 90° can now be optically touched and measured in 3D.

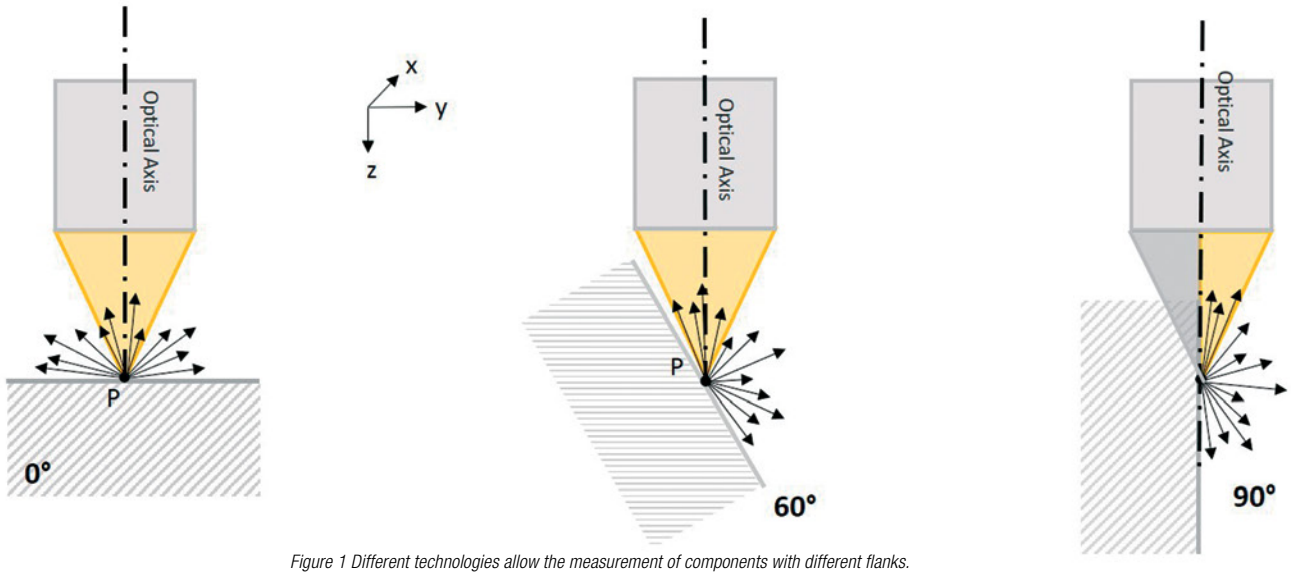


Figure 1 Different technologies allow the measurement of components with different flanks. Here: Surfaces with 0°, 60° and 90°

Vertical Focus Probing is based on the use of partial light. This means that in addition to coaxial light, light from different directions is used. As a result, individual light rays diffusely reflected from vertical surfaces are captured again by the objective, enabling the traceable and repeatable measurement of flanks with more than 90° in a high-resolution.

How high the proportion of reflected light rays is depends on the geometry and the roughness of the surface to be measured as well as on the light source used. The objective also plays a role as depending on its diameter an objective can also capture reflected light from surfaces that show flanks steeper than 90°. This is where the numerical aperture

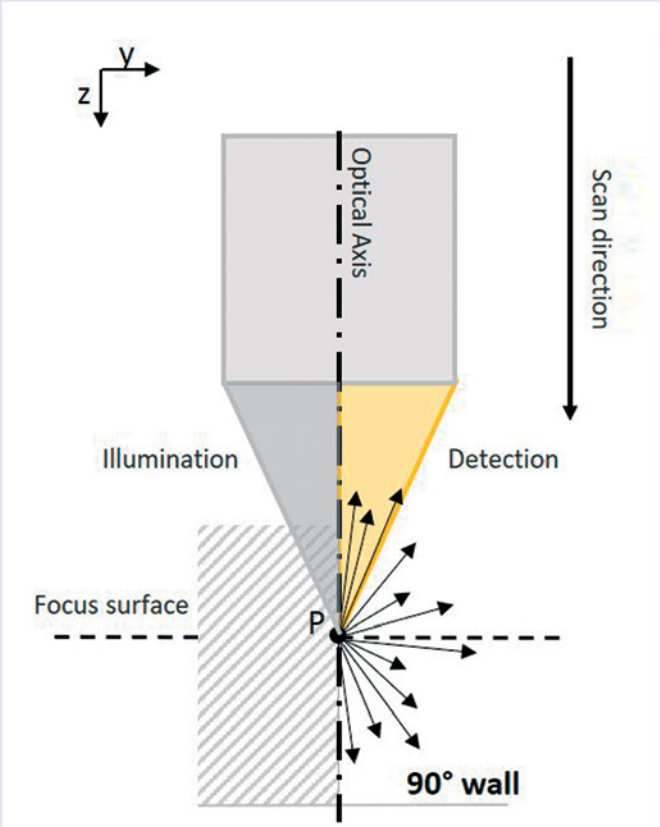


Figure 2 In Vertical Focus Probing, individual reflected light beams are captured again by the objective, making surfaces with more 90° optically measurable

(A_N) comes into play, which is defined by the objective diameter and the working distance. It influences how much the measurable slope of a surface can still exceed the 90° mark.

The following graphic illustrates the measurement of a surface with a slope of more than 90°. It shows that even with this geometry reflected light is still captured by the objective.

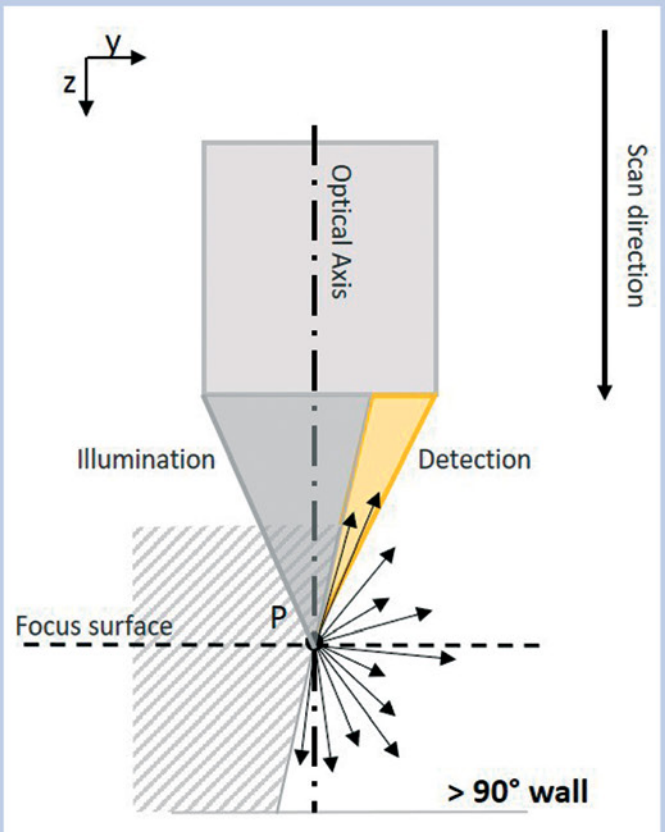


Figure 3 Reflected light can also be detected by the objective when measuring slopes steeper than 90°

$$A_N = \mathrm{n.sin}(\propto)$$

$\propto$ defines the angle between the scanning direction and the maximum light beam that can be captured:

$$\propto = \arctan\left(\frac{objective\ radius}{working\ distance}\right)$$

Difference between Focus-Variation and Vertical Focus Probing

Vertical Focus Probing, like Focus-Variation, is based on the vertical scan of the surface to be measured. The focus information curve is evaluated for each position. The difference to Focus-Variation is that in Vertical Focus Probing not only one, but several Z-values are calculated for each measuring point (XY). These Z-values represent the vertical surface.

Accuracy, benefits and fields of use

Vertical Focus Probing can be used for a wide range of applications in dimensional metrology, respectively in all areas of the manufacturing industry and production. Among others, the tooling industry, precision manufacturing, the automotive industry as well as the aerospace sector benefit from new measurement possibilities whenever it comes to components with vertical surfaces. Features such as holes, bores, reference surfaces, contours, lengths etc. can thus be optically measured with high accuracy, in high resolution and short measuring times.

PMI verifications (Product and Manufacturing Information) including dimensional and position tolerances (GD&T characteristics) are realized by measuring several positions from only one measuring direction, as it is with tactile systems. It is not necessary to un- or reclamp components in order to measure parameters such as diameter, lateral distances etc. Due to the area-based measuring principle and the resulting high measurement point density, a large number of measuring points can be used for the evaluation of e.g. form deviations, which enables the robust measurement of especially small geometries.

Typical applications of Vertical Focus Probing are, as of example, the measurement of micro bore holes such as injection nozzles or cooling holes. The diameter to depth ratio of holes ranges from 1:3 to 1:10, the measurable diameter is 0.1 mm to 2 mm. Users measure parameters such as outer and inner diameter and opening angle.

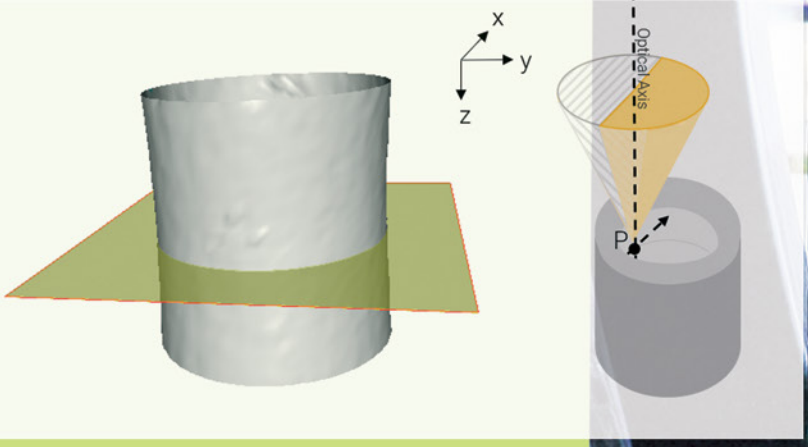
Here, further examples are introduced.

Hole measurement, diameter 0.2 mm
Measurement METAS [1] [mm]
0.20065 ± 0.00013
Measurement Vertical Focus Probing [mm]
0.200568
Deviation [mm]
0.000082

Measurement of a pin, diameter 0,6 mm
Measurement DAkks [2] [mm]
6.00033 ± 0.00050
Measurement Vertical Focus Probing [mm]
6.00092
Deviation [mm]
0.00059

[1]Swiss Federal Institute of Metrology
[2]German Accreditation Body GmbH

Coordinate measuring machines are verified according to ISO 10360. Part of this process is, among other things, the measurement of the bidirectional length measuring error of e.g. ball bars. Typically, tactile methods are very well suited for this purpose, since they can probe the ball laterally. For optical methods this was not possible until now. With Vertical Focus Probing, this is changing: balls can be probed at the equator, which makes it possible to determine the distance.


x
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Optical Axis
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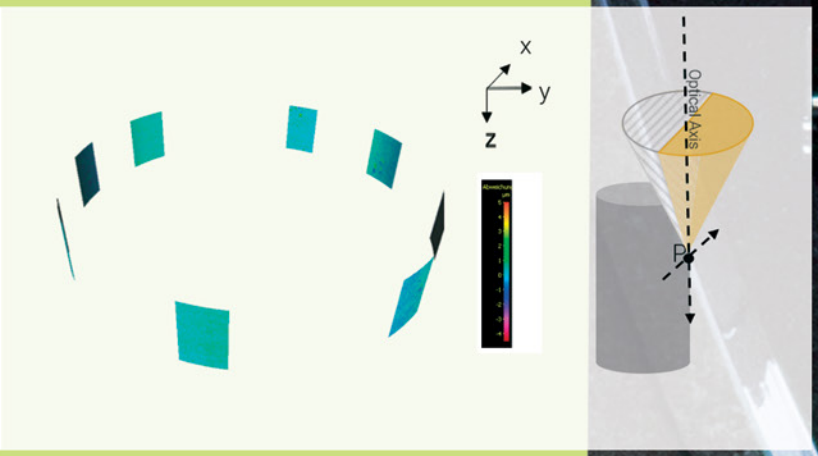
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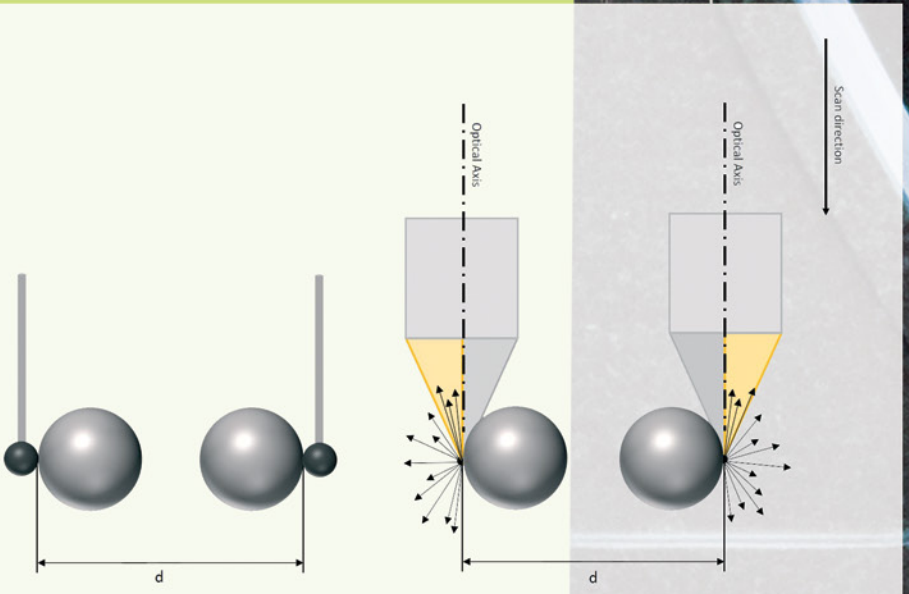
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d
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