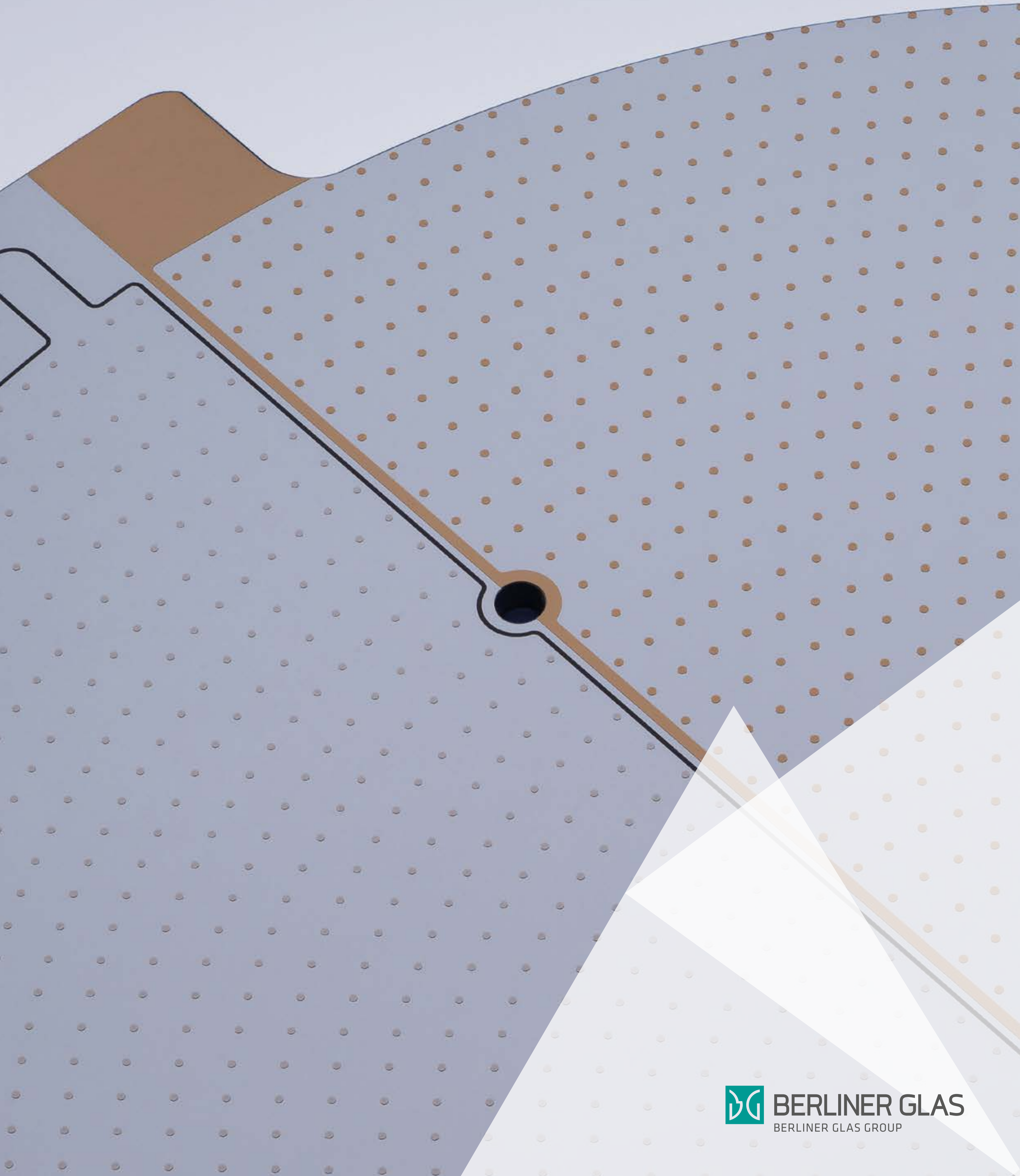
PERFECTING CHUCKS.

CUSTOMIZED PIN PATTERNS FOR SUPER-FLAT VACUUM CHUCKS & ELECTROSTATIC CLAMPS.



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CUSTOMIZED PIN PATTERNS FOR SUPER-FLAT VACUUM CHUCKS & ELECTROSTATIC CLAMPS.

Wafer chucks are versatile tools used in various processes in the semiconductor industry. To reduce effects like wafer sticking or backside contamination of wafers, chucks ordinarily feature pins (also called burls or mesas), which limit the contact area between chuck and wafer. At the same time, chucks face increasing requirements regarding global and local flatness.

Here, the distribution of the pins on the chuck surface plays an important role when it comes to chuck the wafer as flat as possible. The distance between the pins should ideally be the same everywhere within a given chuck area, which is hard to realize with a homogeneous pattern on a surface with features and a non-regular contour. Especially at chuck features like holes and slots a simple, homogeneous pin structure leads to strong local gradients of the wafer.

Berliner Glas has the knowledge to time-effective customize pin patterns on chucks to achieve super-flat chucks with minimized local gradients and wafer sag down to nanometer scale.

Wafer deformation on a chuck with non-optimized pin pattern

Fig.1: Cutout of a vacuum chuck surface, showing pins arranged concentrically around the center of the chuck, a hole with surrounding vacuum seal and a part of the edge vacuum seal.

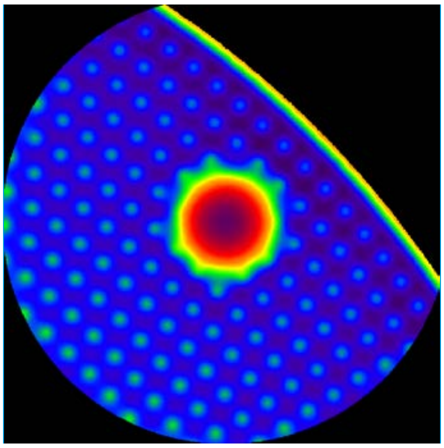

Fig.2: Top view on a wafer clamped onto the cutout from Fig.1. The colours show the sagging and bulging of the wafer.

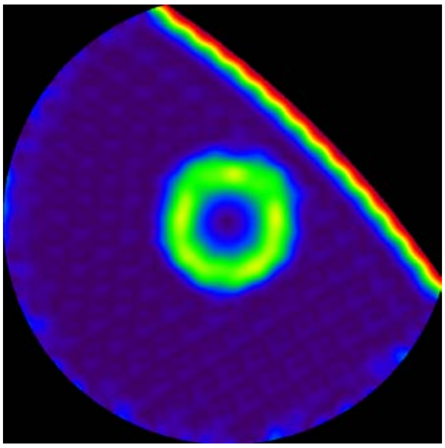

Fig.3: Local gradients of the chucked wafer from Fig.2: Normalized gradient of a plane of 5 x 5 mm^2.

To optimize the local gradients and wafer sag down to nanometer scale, numerous design rules have to be considered while generating a pin pattern:

The ratio of pin pitch and pin height must be chosen carefully, as well as the distance between pins and vacuum seals. The pattern around features like holes must be considered separately to minimize the local gradient, but must then be brought into harmony with the pattern of the surrounding homogeneous area. Moreover, acute angles and narrow areas (e.g. between holes and edges) have to be treated with particular attention.

For this purpose, we have implemented special algorithms in a self-developed software for pattern generation. It allows thousands of pins to be optimally distributed on surfaces with various contours and features in a short time.

With this method, Berliner Glas is able to reduce the wafer sag e.g. over holes below 20 nm and to minimize the corresponding local gradients in the sub-µrad range (depending on the geometry).

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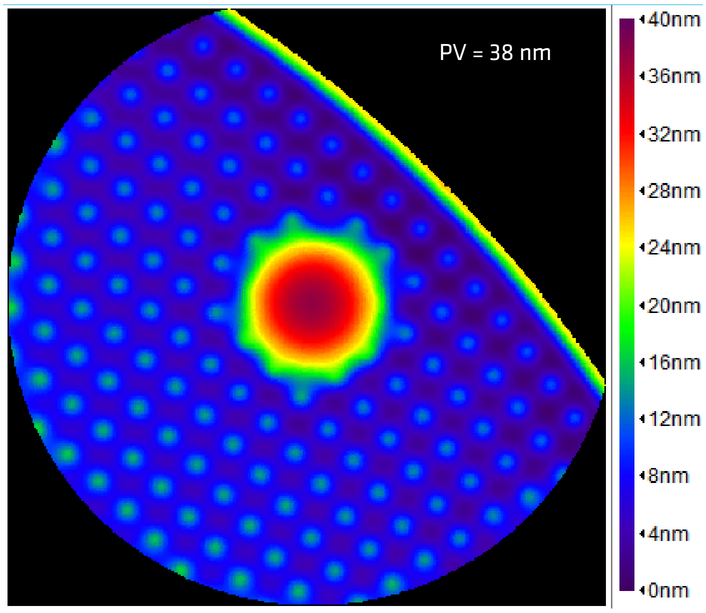
Non-optimized pin pattern



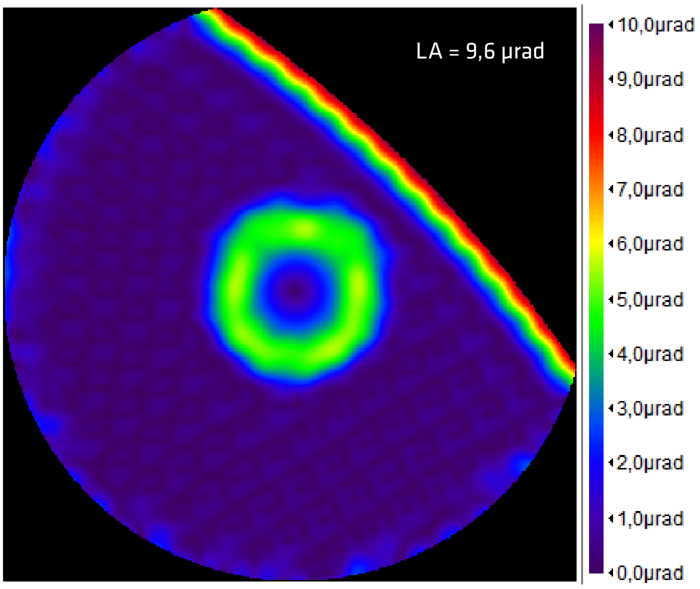
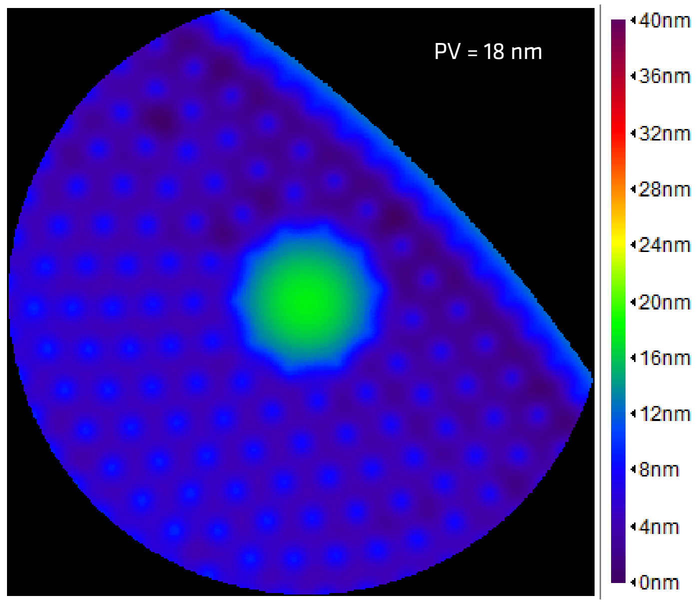


Fig.4 (top), corresponding to Fig.2, shows the flatness of a wafer clamped on a chuck with non-optimized, concentric pin pattern. The peak-to-valley (PV) height difference is 38 nm. Fig.5 (bottom), corresponding to Fig.3, shows the associated local gradients. The maximum gradient is 9.6 µrad.

Optimized pin pattern



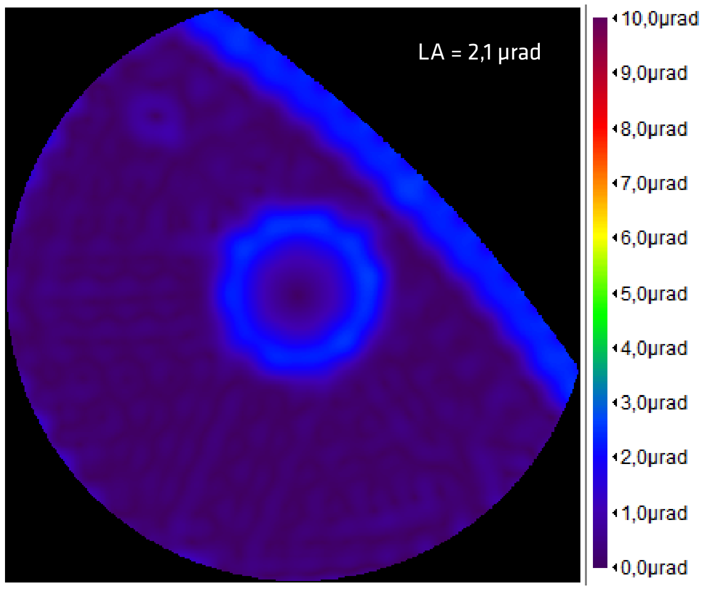


Fig.6 (top) shows the increased flatness of a wafer clamped on a chuck with optimized pin pattern. The pattern around the hole is considered separately but then be brought into harmony with the pattern of the surrounding homogeneous area. The higher stiffness of the seal was also taken into account wherefore the distance of the pins to the seal was modified. The peak-to-valley (PV) height difference is 18 nm.
Fig.7 (bottom) shows the associated local gradients which are significantly below those of the non-optimized pattern. The maximum gradient is 2.1 µrad.

Last but not least the FEM-simulation of the wafer deformation caused by the generated patterns is a challenge since the aspect ratios are extremely large. While the simulated surface often has a diameter of over 300 mm, up to 30,000 pins with a height in the range of only 0.1 mm have to be meshed and simulated.

A conventional FEM-simulation reaches its limits here. Certain assumptions and simplifications must therefore be made, regarding e.g. material behavior, pin model simplification or chucking force (either by vacuum or the electric field over electrodes). The additional use of customized meshing algorithms makes it possible to drastically reduce the time required for simulations. Here, numerous projects show that Berliner Glas has the experience to achieve simulation results that are accurate to within a few nanometers of the later chuck.

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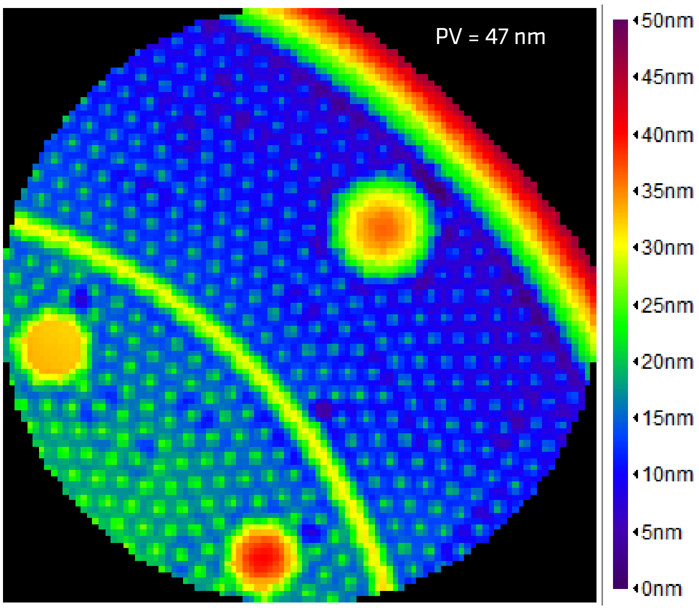
Simulated flatness



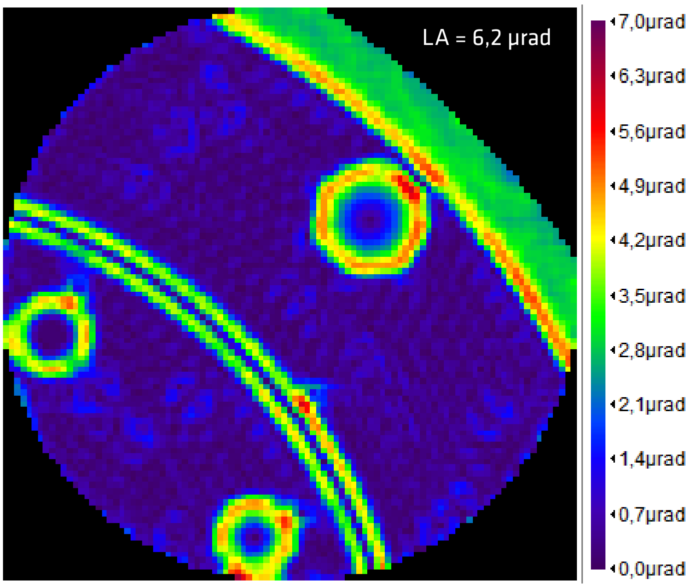
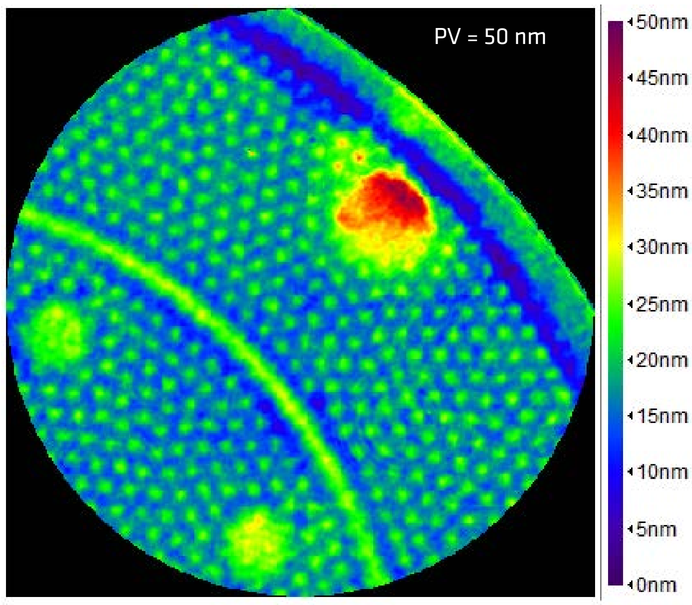


Fig.8 (top): Cutout of the flatness simulation of a vacuum chuck, including 3 holes with surrounding vacuum seals, a part of an inner vacuum seal and a part of the edge vacuum seal. The peak-to-valley (PV) height difference is 47 nm.
Fig.9 (bottom): Local gradients of the chucked wafer from Fig.8: Normalized gradient of a plane of 5 x 5 mm². The maximum gradient is 6.2 µrad.

Measured flatness



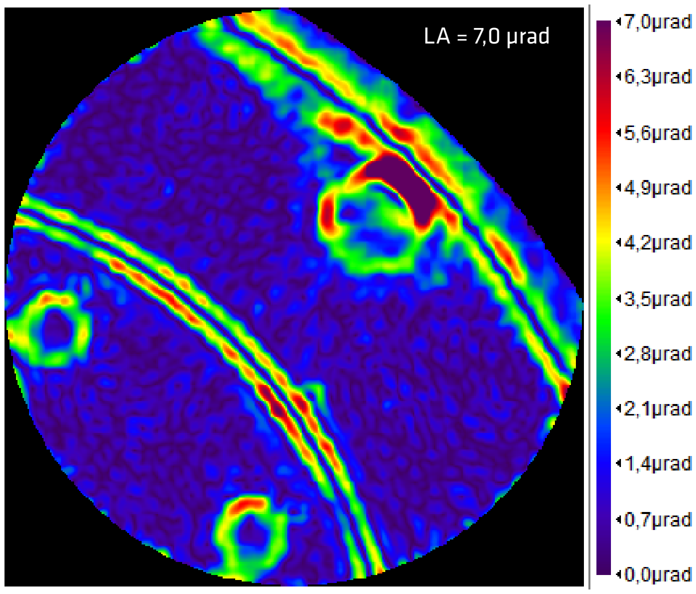


Fig.10 (top): Interferometric measurement of the chuck simulated in Fig.8. The PV height difference is 50 nm, the PV deviation between simulation and measurement is 3 nm for the given area.
Fig.11 (bottom): Local gradients corresponding to Fig.10: Normalized gradient of a plane of 5 x 5 mm². The maximum gradient is 7.0 µrad, the maximum gradient deviation between simulation and measurement is 0.8 µrad for the given area.

We have shown that Berliner Glas is able to use advanced software and simulation methods to time-effective generate customer-specific pin patterns for super-flat chucks and to simulate them realistically.

For customers this means a leading edge flatness design with shorter design phase and lower engineering costs.

This document belongs to a series of documents that Berliner Glas has published under the title “Perfecting Chucks”. Please visit the website for more information: https://www.berlinerglas.com/perfecting-chucks

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