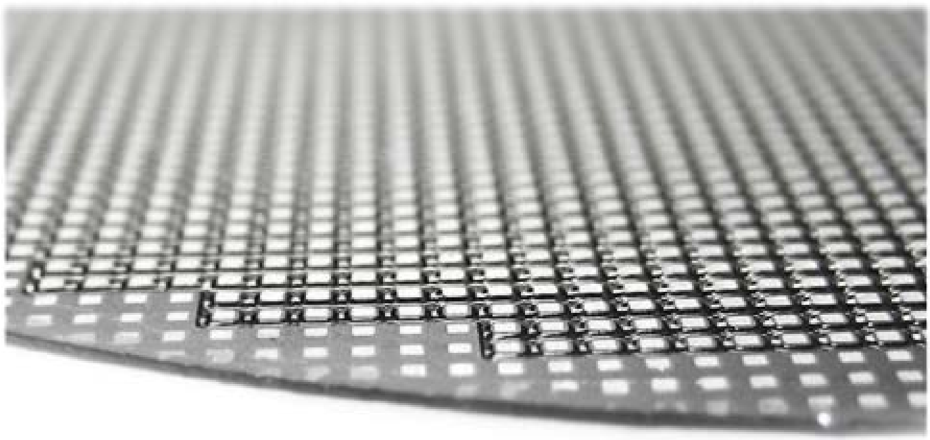
NANOVEA®
A Better Measure.

# WAFER ARRAY FLATNESS MEASUREMENT USING 3D PROFILOMETRY



Prepared by
**Craig Leising**

6 Morgan, Ste156, Irvine CA 92618 · P: 949.461.9292 · F: 949.461.9232 · nanovea.com

## INTRO:

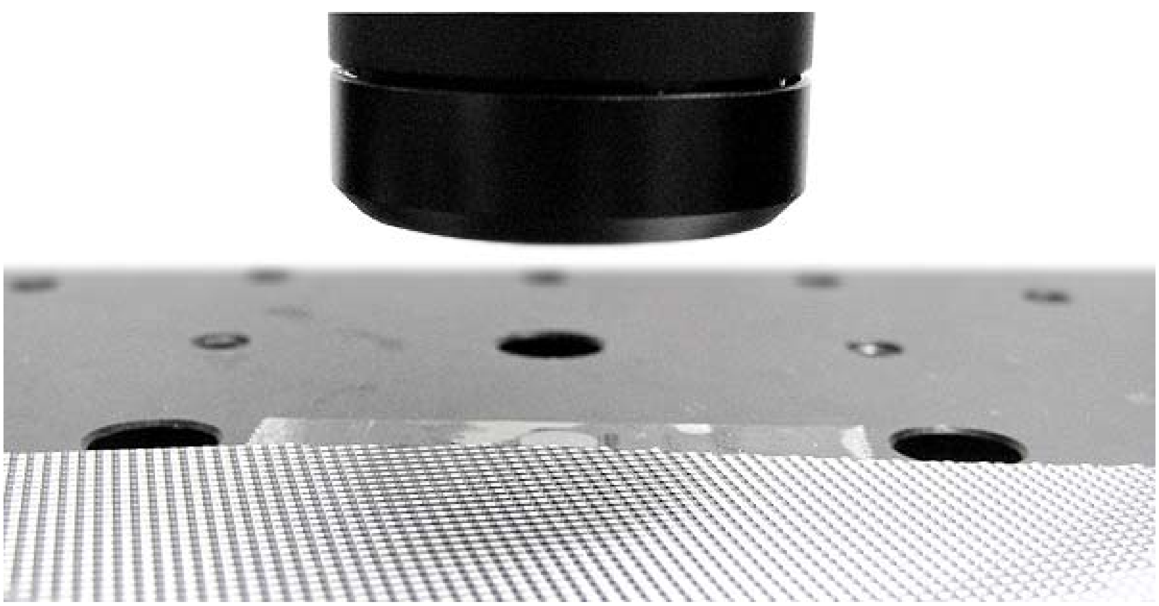
A critical factor which can dramatically affect the quality of wafer arrays is the flatness to adjoining components. The components of the wafer are typically intended to lie in an array pattern. If any component is not flat or planar relative to its neighboring components, it may become overly compressed or stressed, while neighboring components do not make proper contact.

**IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR WAFER ARRAY STUDY**

Unlike other techniques such as stylus or interferometry, the 3D Non Contact Profilometer, using axial chromatism, can measure nearly any surface, sample sizes can vary widely due to open staging and there is no sample preparation needed. Nano through macro range is obtained during surface profile measurement with zero influence from sample reflectivity or absorption, has advanced ability to measure high surface angles and there is no software manipulation of results. Measure any material: transparent, opaque, specular, diffusive, polished, rough etc. The technique of the Non Contact Profilometer provides an ideal, broad and user friendly capability to maximize wafer array measurement; with the benefits of combined 2D & 3D capability.

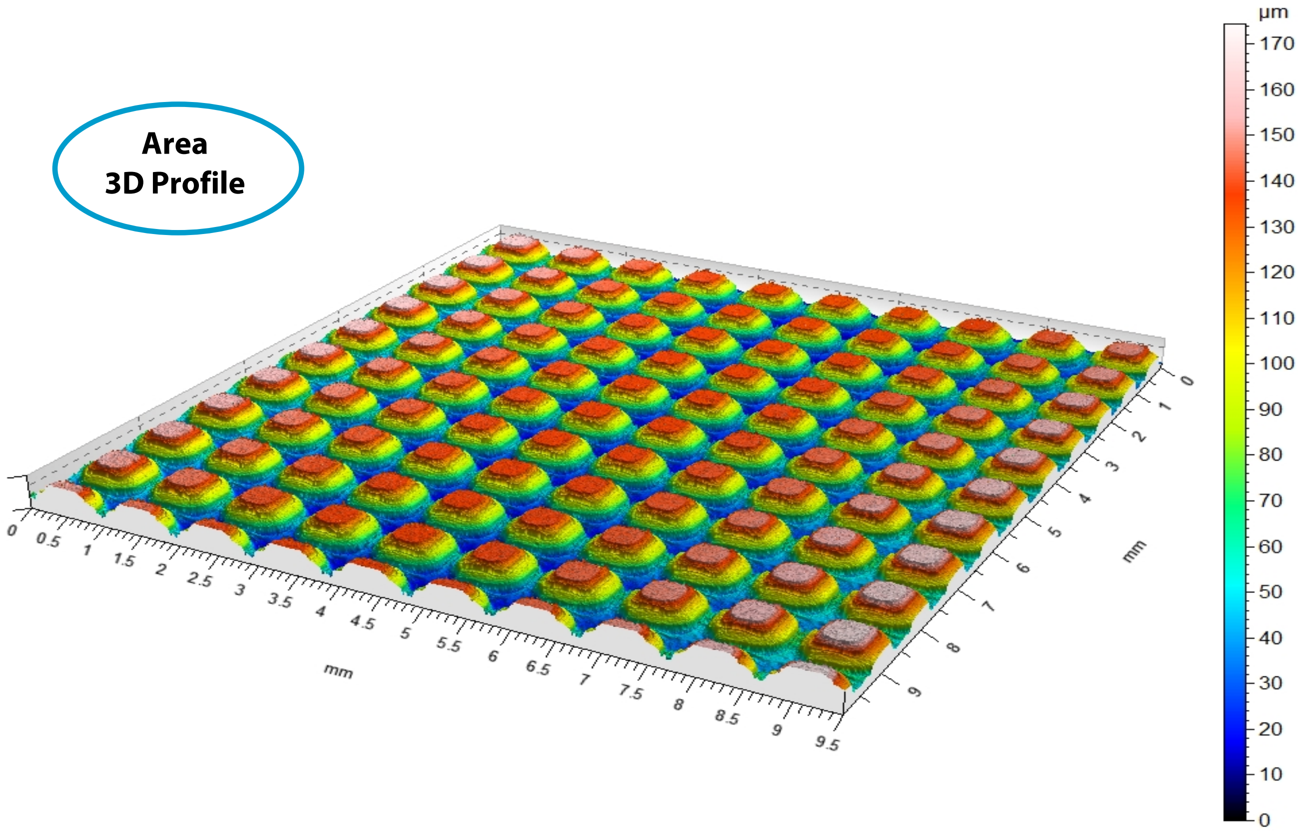
**MEASUREMENT OBJECTIVE**

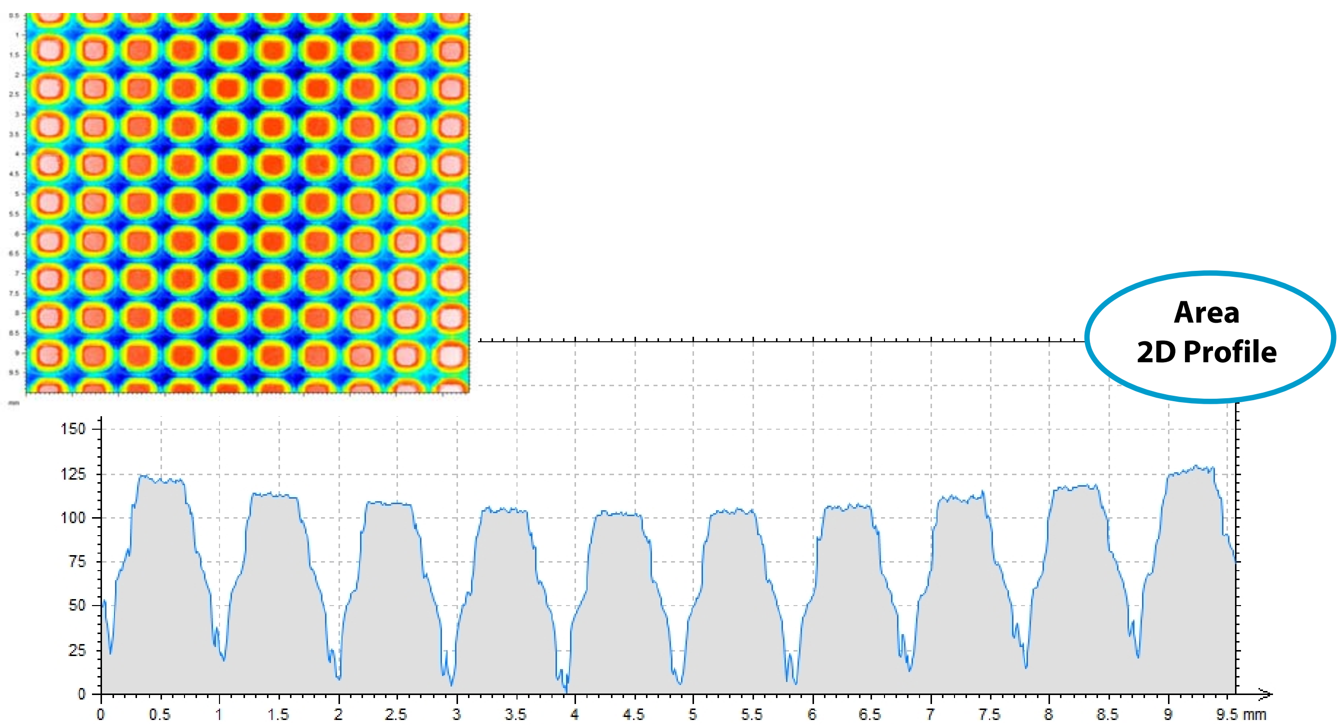
In this application the Nanovea ST400 Profilometer is used to measure the section of a wafer array. The area measured was selected at random, and assumed large enough in that it could be extrapolated to make assumptions about a much larger surface. Surface flatness, planarity & other surface parameters are used to analyze the surface.



## **RESULTS:** 3D & 2D Profile

3D and 2D views of randomly selected area, showing 100 components assembled in an array and a cross-sectional area. Flatness variation can be seen clearly by color and height changes at the top of the devices.

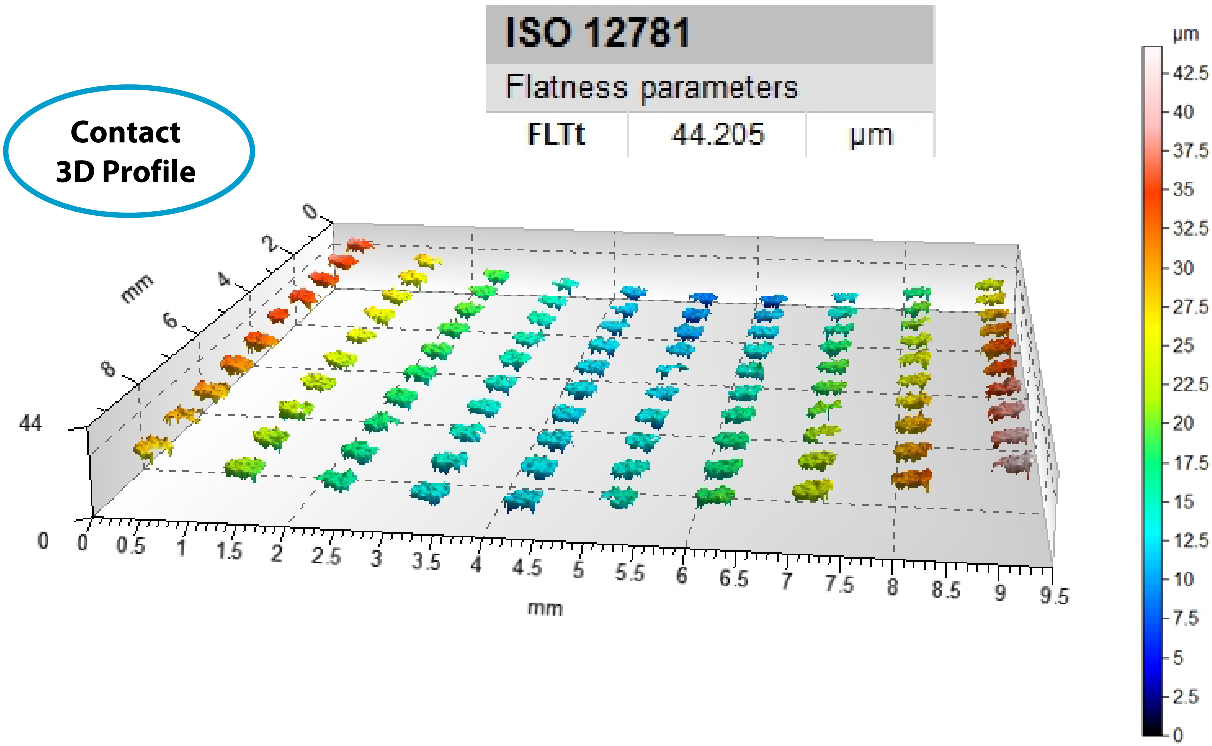


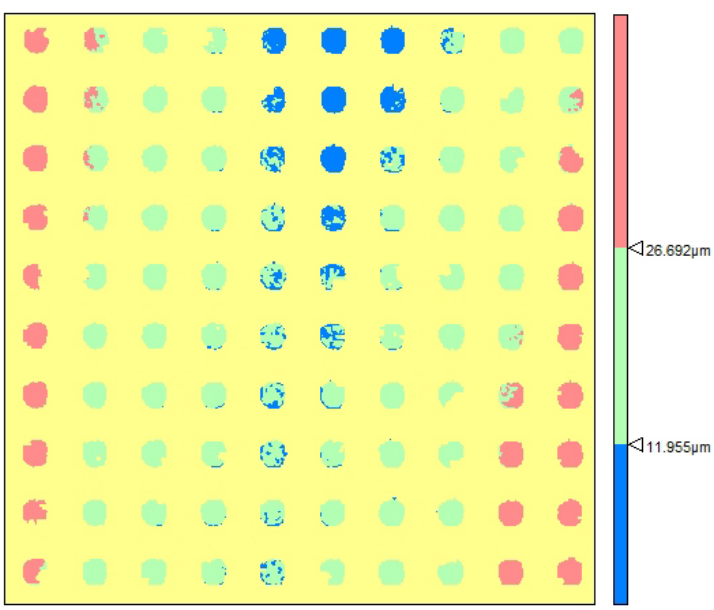
### 3D Profile of Contact Tips

Using data from previous page, top electrical contact pad was isolated to show flatness and planarity. Image below shows contact area at different depths, highlighting the deviation from flat over this small section of the wafer.

**Contact 3D Profile**




**Contact Area**



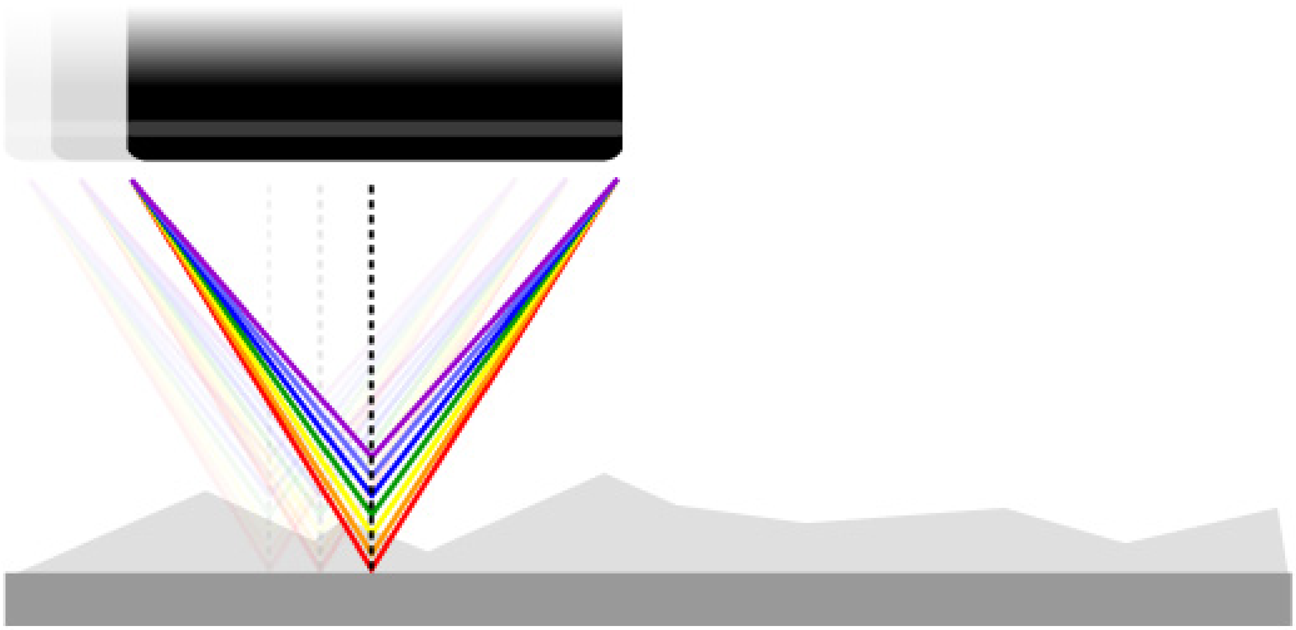

| | (blue) | (green) | (red) |
|---|---|---|---|
| Projected Area (%) | 12.220 | 65.362 | 22.418 |
| Volume of void (%) | 1.4835 | 52.123 | 92.373 |
| Volume of material (%) | 98.517 | 47.877 | 7.6265 |
| Volume of void (µm.mm²/mm²) | 0.17734 | 7.6812 | 16.178 |
| Volume of material (µm.mm²/mm²) | 11.777 | 7.0555 | 1.3357 |
| Mean thickness of void (µm) | 0.17734 | 7.6812 | 16.178 |
| Mean thickness of material (µm) | 11.777 | 7.0555 | 1.3357 |

## CONCLUSION:

In this application we have shown how the Nanovea 3D Non Contact Profilometer can precisely characterize the flatness and planarity of a wafer array. As seen above the results accurately identify the contact area at different relative depths. With this information it is identified that to make complete contact with all 100 devices shown the wafer must compress from the tallest device 44.205µm. The planarity of the devices were also calculated on average to be around 0.61° for neighboring devices and 1.05° at maximum for devices with extreme differences. This planarity calculation will be a result of both the overall flatness and individual device flatness. Learn more about the Nanovea Profilometer or Lab Services

## MEASUREMENT PRINCIPLE:

The Chromatic Confocal technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.

## DEFINITION OF HEIGHT PARAMETERS

| | Height Parameter | Definition |
|---|---|---|
| Sa | Arithmetical Mean Height | Mean surface roughness. $$Sa = \frac{1}{A}\iint_A \lvert z(x,y)\rvert dxdy$$ |
| Sq | Root Mean Square Height | Standard deviation of the height distribution, or RMS surface roughness. $$Sq = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy}$$ Computes the standard deviation for the amplitudes of the surface (RMS). |
| Sp | Maximum Peak Height | Height between the highest peak and the mean plane. |
| Sv | Maximum Pit Height | Depth between the mean plane and the deepest valley. |
| Sz | Maximum Height | Height between the highest peak and the deepest valley. |
| Ssk | Skewness | Skewness of the height distribution. $$Ssk = \frac{1}{Sq^3}\left[\frac{1}{A}\iint_A z^3(x,y)dxdy\right]$$ Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom.<br><br>Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement. |
| Sku | Kurtosis | Kurtosis of the height distribution. $$Sku = \frac{1}{Sq^4}\left[\frac{1}{A}\iint_A z^4(x,y)dxdy\right]$$ Kurtosis qualifies the flatness of the height distribution.<br><br>Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement. |
| Spar | Projected Area | Projected surface area. |
| Sdar | Developed Area | Developed surface area. |