NANOVEA®
A Better Measure.

WARPAGE MEASUREMENT OF PCB USING 3D PROFILOMETRY

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INTRO:

In manufacturing and mechanical engineering, flatness is a vital measurement crucial to the quality control of endless applications. Particularly, the manufacturing of precision electronic parts and assemblies are especially vulnerable to warpage and planarity defects. Here, part contact across surface area and part bonding are highly reliant on flatness and must be accurately insured for intended use. It is this very surface measurement that is an ideal match for non-contact profilometry and is a key in such manufacturing processes.

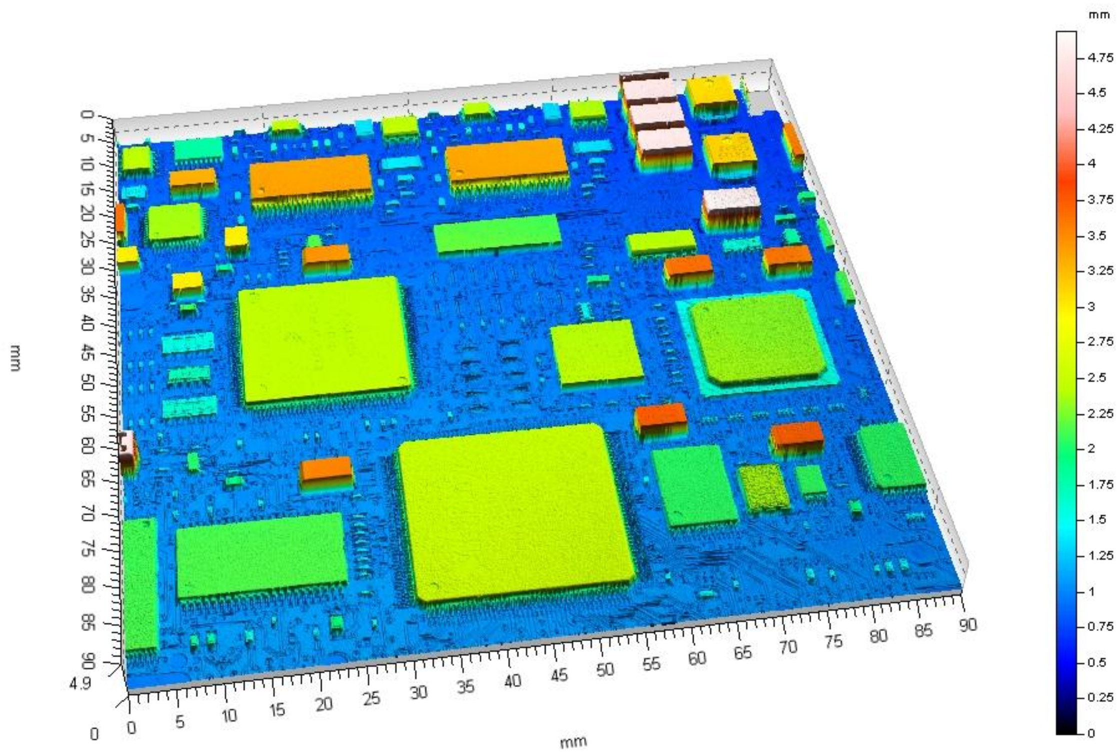
IMPORTANCE OF FLATNESS MEASUREMENT INSPECTION FOR QUALITY CONTROL

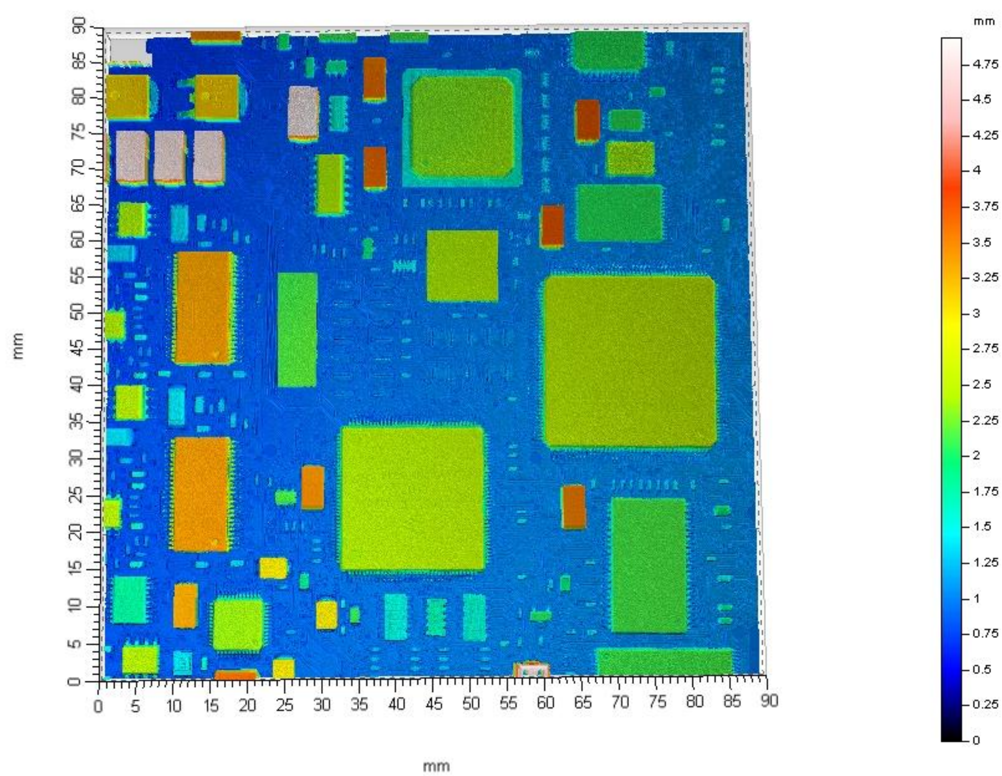
Flatness measurement of electronic parts and assemblies, or PCB's, has become increasingly critical as geometries become smaller: finer pitches, smaller solder ball volumes, thinner substrates, etc. Additionally, processing temperatures vary and can play a major role in PCB warpage and or planarity defects. As a result, accurate flatness measurement has become vitally important to warpage characterization and planarity measurement.

MEASUREMENT OBJECTIVE

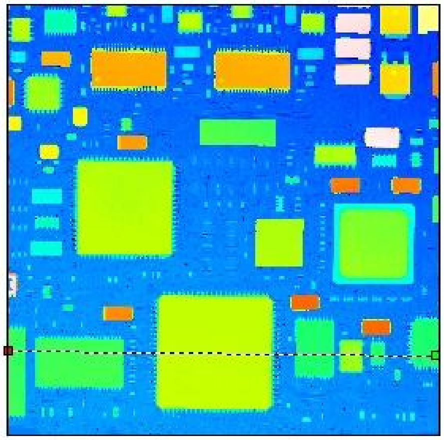
In this application, the Nanovea ST400 is used to measure the surface of a PCB shown below. The Nanovea ST400 provided non-contact measurement with superior accuracies while obtaining flatness, planarity and step-height measurements. Although the ST400 is used here for research and analysis, the Nanovea HS100 could provide high speed automated inspection in quality control environments.

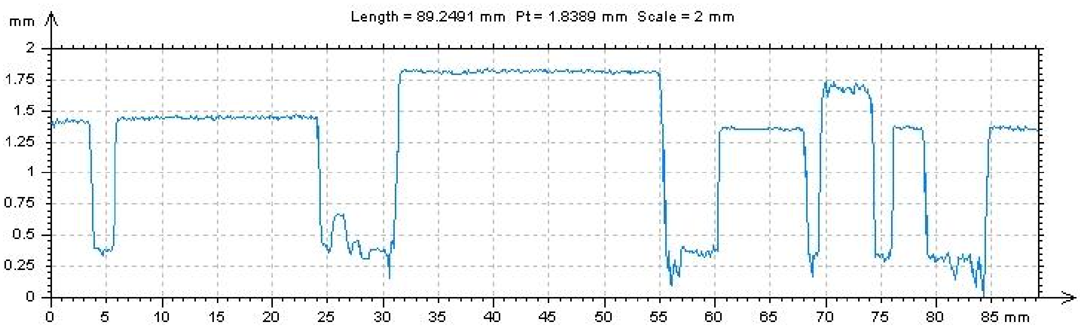
3D Image of PCB

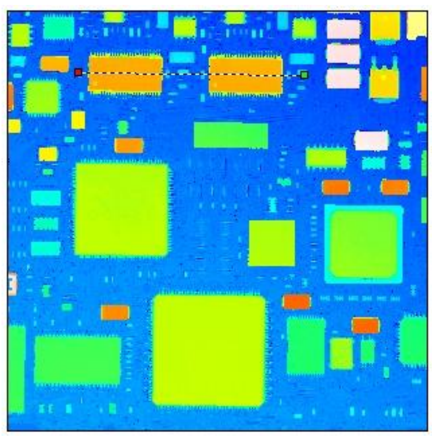


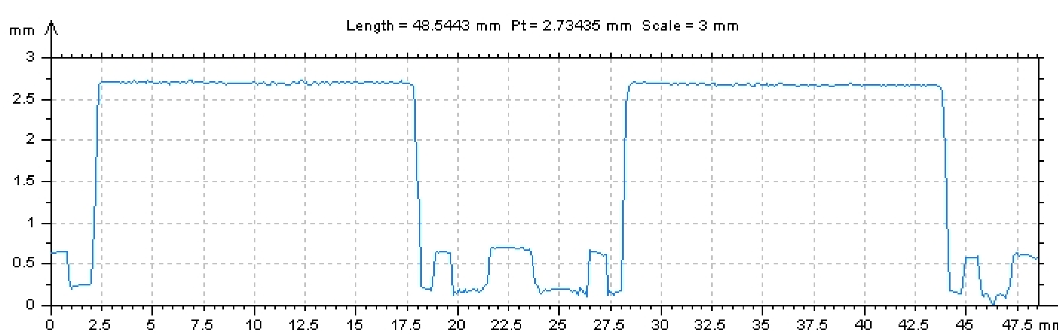


2D Cross Section







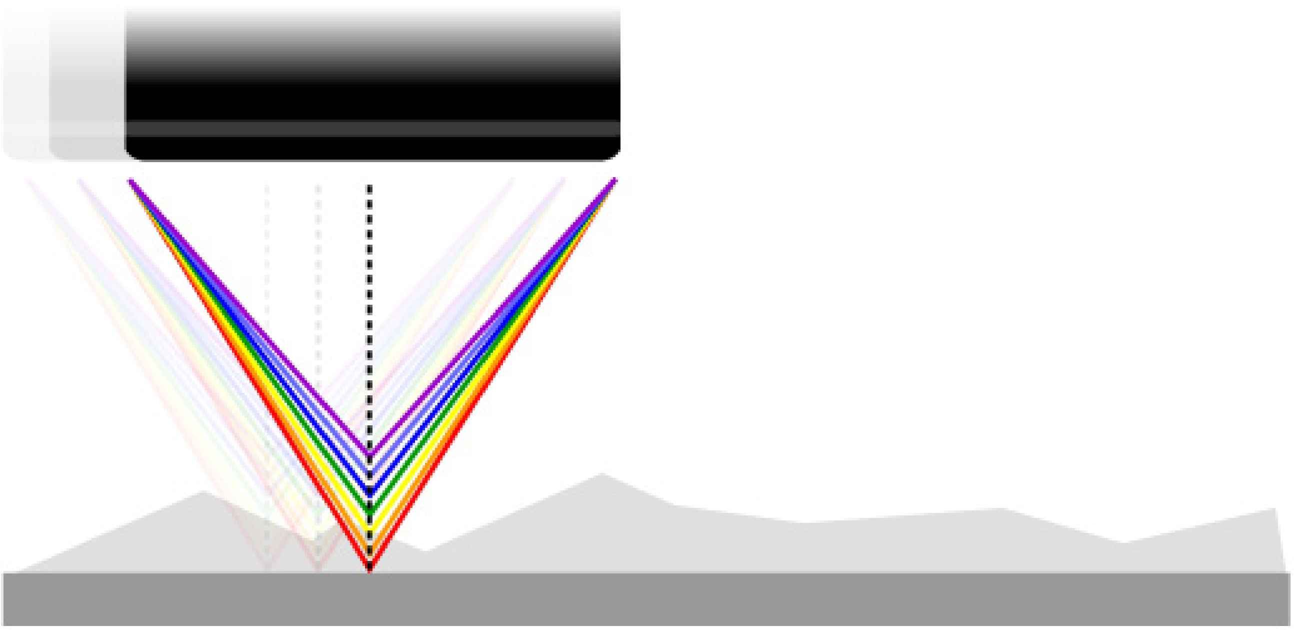


CONCLUSION:

In this application, we have shown how the Nanovea ST400 3D Profilometer with a 12mm and 400 micron optical pen can precisely characterize both the macro surface/shape and the nanometer details of the board. From the 3D image it can be seen that the board is relatively flat, however there is a slight warpage noticeable in the color change from the bottom left to the top right of the 3D images. To further view in detail a 2D cross section can quickly be chosen to analyze, at nanometer range, step height and planarity among others. Nanovea 3D Profilometers speeds range from 20mm/s to 1m/s for laboratory or research to the needs of hi-speed inspection; can be built with custom size, speeds, scanning capabilities, Class 1 Clean Room compliance, with Indexing Conveyor and for Inline or online Integration

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. 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. 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.