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# Recent advances in non-contact metrology, high speed measurement, steep slope measurement and correlation with stylus data

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**ABSTRACT** – High speed, large sample analysis of optics and steep sided rough surfaces are all areas of increasing interest in both research and production environments. New designs of components and materials are finding new applications in the microelectronics, optics and automotive industries and their metrology is becoming increasingly important. The paper will cover details of the challenges the above measurements and also some possible solutions.

## 1. INTRODUCTION

In the last 5 years improvements in hardware and software have expanded the measurement possibilities of non-contact metrology. High speed, large sample scanning, and steep sided rough surfaces are now all possible. Also correlation between traditional 2D stylus techniques and modern 3D interferometry techniques is an important consideration.

LuphoScan enables high speed form measurements of aspheres, spheres, flats and some freeform components. The scanning process is accomplished by means of an MWLI point sensor (MWLI–multi-wavelength interferometer) and four precision stages. The MWLI point sensor continuously measures the distance to the object surface under test. Objects are rotated by means of a 360 degree rotary stage (C), while the position of the sensor is controlled by 2 linear stages (enabling horizontal (R) and vertical (Z) movements) and 1 rotary stage (T). In standard operation mode the sensor is presented normal and equidistant to the surface. It is controlled to follow the profile of an ideal counterpart of the specimen. During a measurement the C stage rotates the object and the other stages move the probe so as to perform a spiral scan over the whole surface. The resultant point cloud reveals shape deviations and defects of the object surface. Key benefits of the systems include fast measurement speeds, high flexibility with regard to uncommon surface shapes (e.g. flat apexes or profiles with points of inflection), and maximum object diameters up to 420 mm. Due to the employed MWLI® sensor technology various different surface types such as transparent materials, metal parts, and ground surfaces can be scanned.

Coherence Correlation Interferometry (CCI) [1] is a scanning coherence interferometry (SCI) technique combining a coherence correlation algorithm with a high-resolution digital camera to generate a three-dimensional representation of a structure. The technique involves scanning in the z direction through the surface and then processing the information to transform the data into a quantitative three-dimensional image. It is capable of 0.01nm vertical resolution and <500 nm lateral resolution where the lateral resolution is determined by the wavelength of light and the NA of the objective lens. The data can then be used to generate a wide variety of accurate quantitative parameters such as step height, form, wear volume, roughness lateral positioning and a variety of other metrology applications. Recently, the technique has been extended to measurements of thin film thickness from semi-transparent thin films [2,3]. The CCI algorithm is capable of measuring a wide of different surface finishes from the very rough to the very smooth giving it an unrivalled capability. This is critical for accurate control of different surface finishes

The advantages of CCI over other metrology techniques are that it is fast, non-contacting, (and hence non-destructive) and it takes its data from a relatively large and hence more representative area.

## 2. RESULTS

### *2.1 Large Optic Non-Contact Measurement*

The LuphoScan system is capable of measuring complex surfaces such as gull wing shapes (Figure 1). The size and shape of the part means that it is almost impossible to measure in a reasonable time using non-contact techniques.

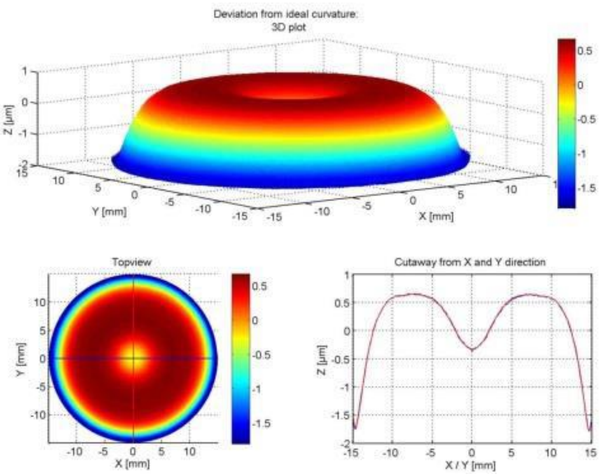


Figure 1 Measurement of a gull wing object.

The speed and accuracy of the system can be demonstrated by looking at the measurement of a 210 mm plane mirror (Figure 2). The peak to valley repeatability is +/-6 nm and the peak to valley reproducibility is =/-10nm. The overall time for measuring the form of the 210 mm diameter mirror is 8 minutes and 9 seconds.

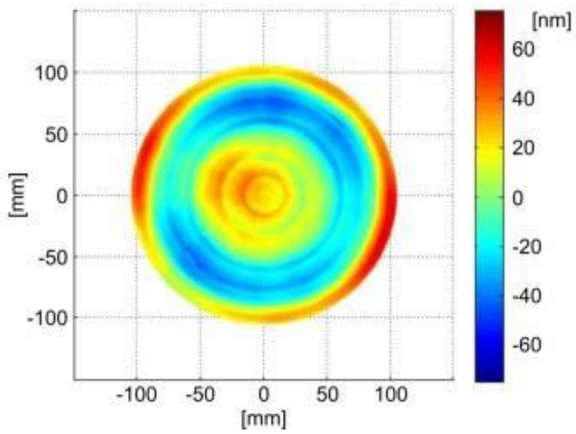


Figure 2 Deviation from flat of a plane mirror.

### 2.2 *Measurement of Steep Slopes Using Traditional Interferometry*

One of the limitations of traditional scanning interferometers such as the CCI has been the maximum angle that can be measured. The maximum angle of a specular surface that can be measured is dependent on a number of factors including numerical aperture of the interferometric lens used. The larger the field of view, the lower its numerical aperture will be and therefore the shallower the angle that can be measured. Where the angle is too steep, light reflected from surfaces is not collected by the optical system, making measurement impossible.

With improvements in instrumentation it has become possible to collect scattered light from rough surfaces so while it is still impossible to measure specular surfaces at steep angles, getting information from rougher surfaces in now possible and indeed recent developments in processing algorithms now enables the measurement of some steep surfaces with almost no data loss. Measuring the form (angle, radius, cone angle etc.) and wear of the rough surfaces is now possible as shown in Figure 3 where both the 2D contact and 3D CCI measurement data (5x lens) are shown.

Table 1 shows the difference in the cone angles between the two measurement techniques.

Table 1 Difference in angle measurement between 2D stylus and 3D CCI measurement.

| Sample | Difference |
|---|---|
| 120 degree internal cone angle | 0.014 degree |
| 90 degree internal cone angle | 0.021 degree |

### 2.3 *Correlation between 2D Stylus and 3D CCI Measurements*

As more and more metrology is carried out using non-contact 3D techniques, the need to be able to compare 2D stylus and 3D data becomes more important. Correlation between the 2 techniques can be demonstrated as long as the correct measurement and analysis parameters are selected.

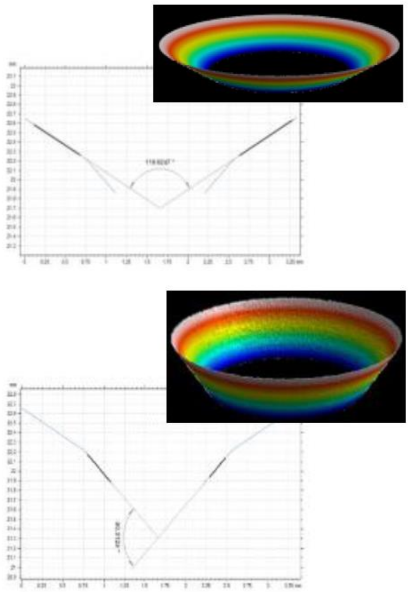

Figure 3 2D and 3D cone analysis.

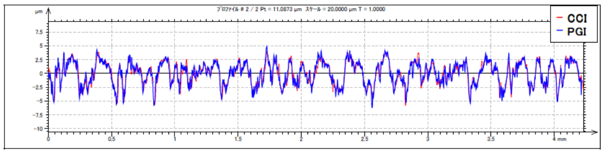


Figure 4 Correlations between contact and non-contact metrology.

## 3. CONCLUSIONS

Modern developments in metrology are expanding the types of sample it is possible to measure. High speed large area and steep slope measurement offer the possibility of improved process control and better understanding of the components. Careful selection of the measurement and analysis parameters can be used to correlate 2D and 3D measurements.

## 4. REFERENCES

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