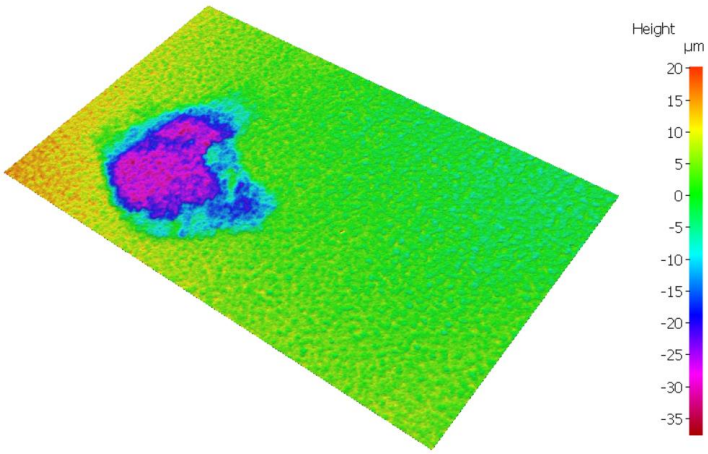
Optical Metrology Application Note: Measurement of Corrosion



Bruker alicona

Bruker Alicona is a leading global supplier of optical metrology solutions based on the principle of Focus Variation.

Focus Variation works on the basis of moving a focal plane over a surface and collecting robust 3D data which can then be used to measure geometric form and surface finish from a single optical sensor.

Measurement processes can be fully automated and provide GD&T measurement capabilities across all industrial & medical sectors.

The systems are in use in Industry, Industrial Research, Universities and production facilities globally.

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Micro Corrosion Pits Measurement

Measuring the rate of corrosion that occurs in pipes and tanks used in the oil industry is important to avoid in service failures leading to leaks. Tanks and pipes are made with a large proportion of sacrificial material to allow for the effects of corrosion but understanding the rate of corrosion allows for a pre-emptive replacement program.

Traditional methods, using weight loss analysis, allow assessment to be made of loss of material caused by corrosion, this is effective where these defects are visually very apparent, and the weight loss is considered significant.

However smaller defects maybe visible but the weight loss is not high, but they may start to form corroded pin holes which can lead to failure in tanks and pipes. A surface with many small defects over time is as dangerous as a surface displaying large defects.

Optical 3D surface metrology provides a solution for this question.

Measurement task and process

The system used for this application is the Bruker Alicona InfiniteFocusSL system as illustrated below.

In use the standard flat coupon sample, as shown in Figure 1, is placed directly on the XY stage of the InfiniteFocusSL system, the stage on this system is able to move 50 x 50mm allowing large areas to be measured

Figure 1

3D data sets are then obtained providing a visual 3D image of the surface with the defects clearly displayed.

This allows the user to examine the surfaces. The definition of large and small pits can easily be seen in the data sets shown below in Figure 2. The left-hand image showing large corrosion pits and the right one displaying small corrosion pits. This is more graphically displayed when the data is displayed in pseudo color related to height in figure 3.

Figure 2 *Data Sets Displayed in True Colour*

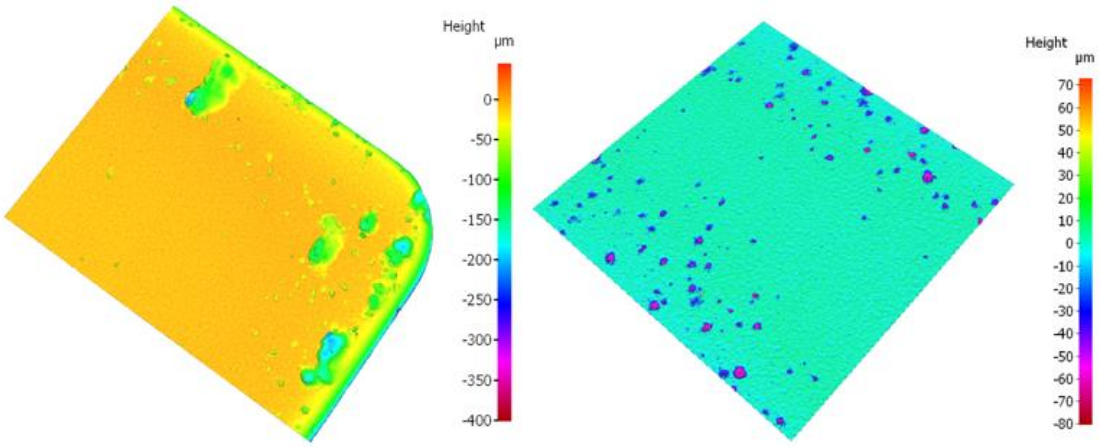
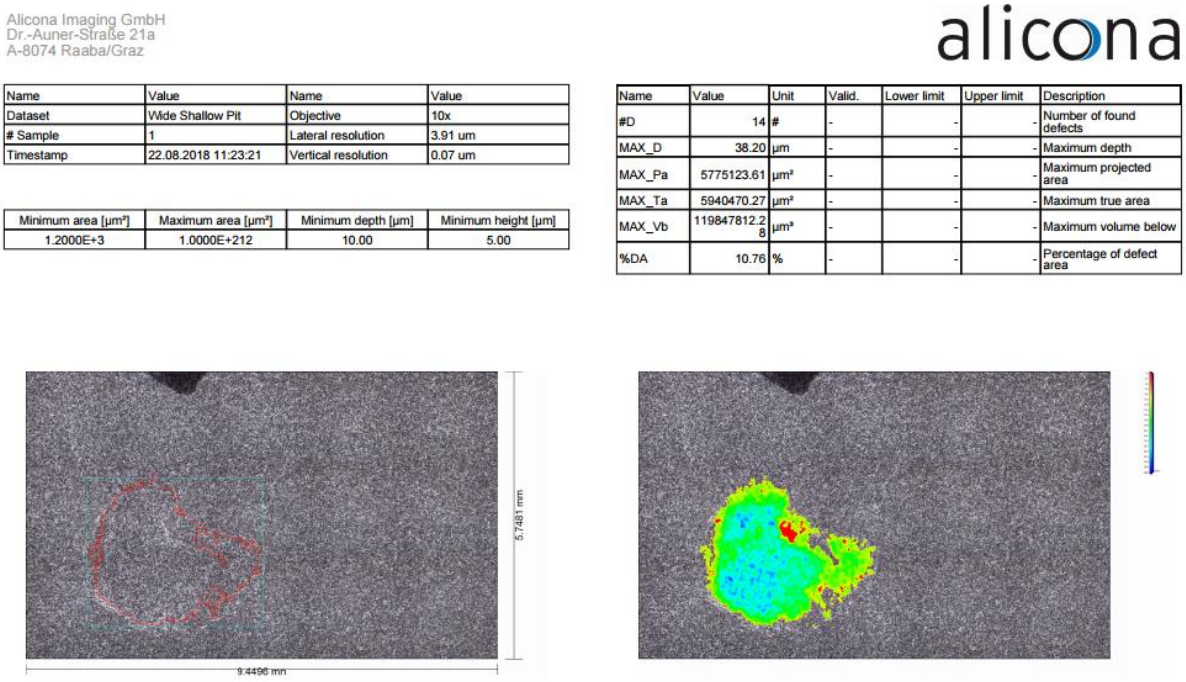


Figure 3 Data Sets Displayed in Pseudo Color related to height

From this data it can be clearly seen that analysis of the larger pits is relatively simple and that weight loss could be used for this over an area. However, using the Bruker Alicona system with the built-in analysis it is possible to provide full surface data. This displays number of defects, maximum depth, maximum projected area, maximum true area, maximum volume, percentage of defect area, shown in figure 4.



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Name	Value	Name	Value
Dataset	Wide Shallow Pit	Objective	10x
# Sample	1	Lateral resolution	3.91 um
Timestamp	22.08.2018 11:23:21	Vertical resolution	0.07 um

Minimum area [µm²]	Maximum area [µm²]	Minimum depth [µm]	Minimum height [µm]
1.2000E+3	1.0000E+212	10.00	5.00

Name	Value	Unit	Valid.	Lower limit	Upper limit	Description
#D	14	#	-	-	-	Number of found defects
MAX_D	38.20	µm	-	-	-	Maximum depth
MAX_Pa	5775123.61	µm²	-	-	-	Maximum projected area
MAX_Ta	5940470.27	µm²	-	-	-	Maximum true area
MAX_Vb	119847812.28	µm³	-	-	-	Maximum volume below
%DA	10.76	%	-	-	-	Percentage of defect area

Figure 4

Specific results from specific areas can also be obtained as shown in figure 5.

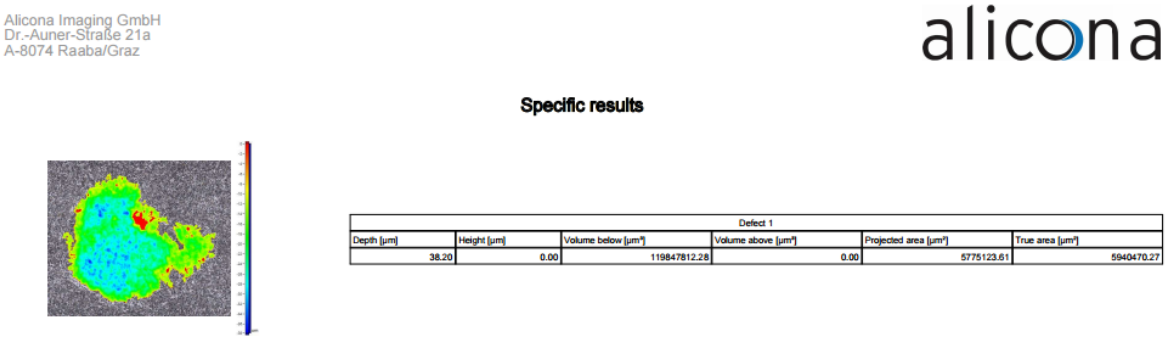


Figure 5

The smaller pits can also be analysed in the same way as shown below in figure 6

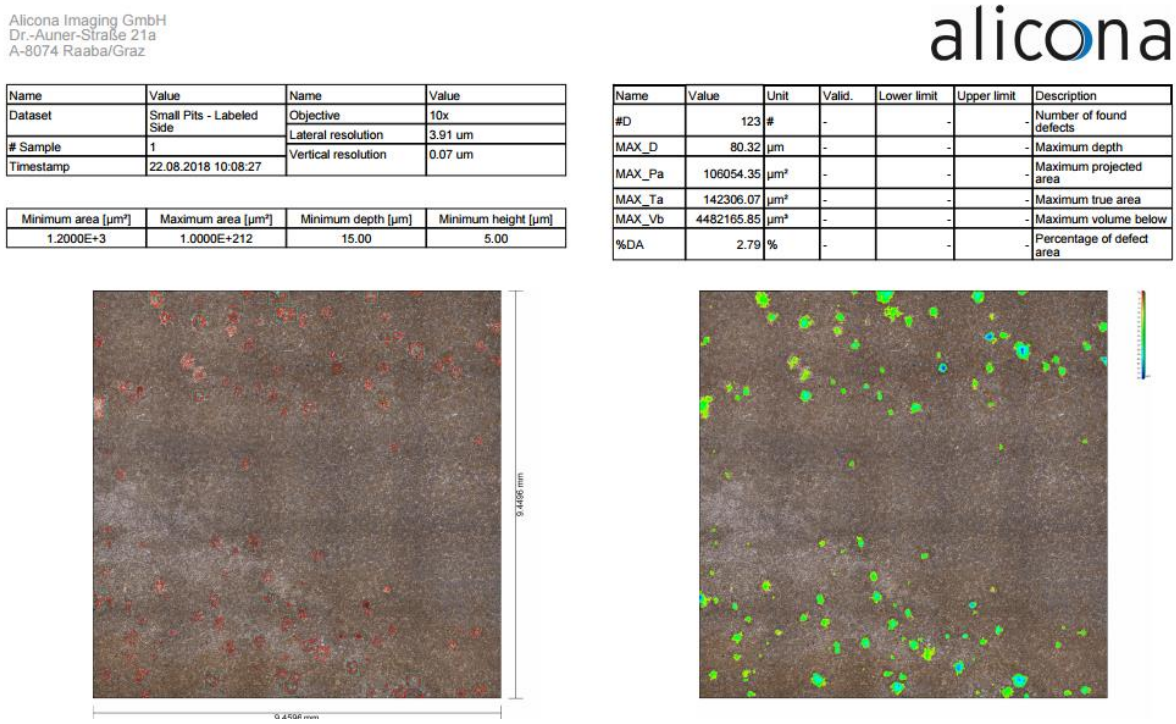
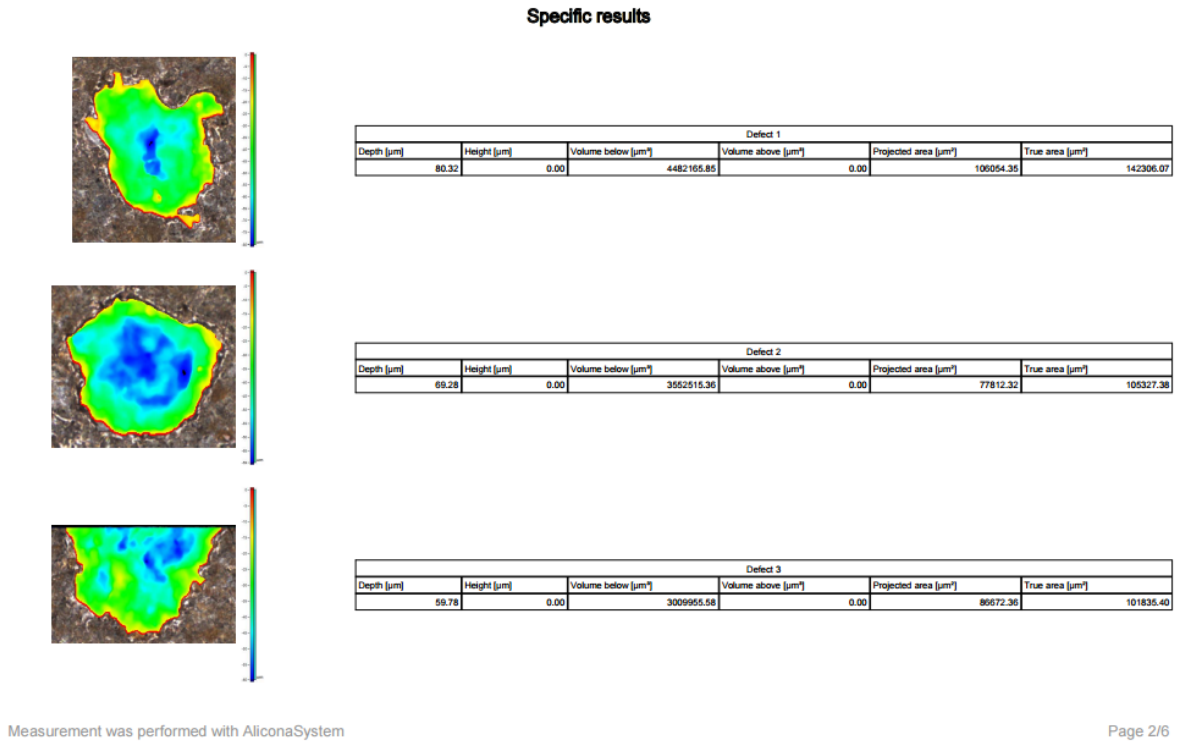


Figure 6

And specific results obtained for each pit individually, a sample of 3 pits is displayed below in figure 7.



Specific results

Defect 1					
Depth [µm]	Height [µm]	Volume below [µm³]	Volume above [µm³]	Projected area [µm²]	True area [µm²]
80.32	0.00	4482165.85	0.00	106054.35	142306.07

Defect 2					
Depth [µm]	Height [µm]	Volume below [µm³]	Volume above [µm³]	Projected area [µm²]	True area [µm²]
69.28	0.00	3552515.36	0.00	77812.32	105327.38

Defect 3					
Depth [µm]	Height [µm]	Volume below [µm³]	Volume above [µm³]	Projected area [µm²]	True area [µm²]
59.78	0.00	3009955.58	0.00	86672.36	101835.40

Figure 7

Using this optical method, it is possible to also easily identify shallow pits that may not always be visible to the eye, this is clearly seen in the 2 images displayed below in Figure 8, when pseudo color is applied the defect is clearly visible

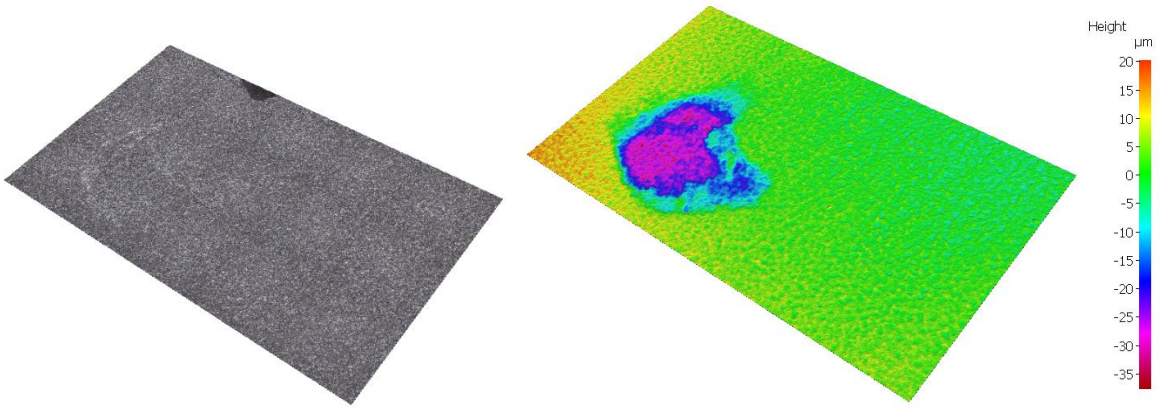


Figure 8

All of these processes are time based, examples would be 30,60,90 days where the requirement is to monitor the increase in damage over those periods.

This is easily achieved using the database function within the Bruker Alicona measurement system where data can be saved and compared against the previous dataset allowing measurement of difference.

Round Coupons:

It is also often a requirement to measure round coupons as illustrated below in Figure 9.

Figure 9

Using the optional real3D rotation system it is possible to carry out full 3D measurement of the length and circumference of the coupon providing the same measurement capabilities as with the flat coupon. The device is shown fitted to the measurement system in Figure 10 below.

Figure 10

Summary:

It can be clearly seen that Optical 3D metrology can offer a solution to the measurement of micro pits caused by corrosion.

In a simple to use package, and not requiring any metrology knowledge to operate users can easily scan a surface and measure pit size and volume and can be used to supplement weight loss methods.

Equipment Available

These measurements can be made using one of the 3 products shown below from Bruker Alicona. The InfiniteFocusSL will measure up to 50 x 50mm, the InfiniteFocusG5 plus will measure up to 200 x 200mm, the PortableRL allows in field measurement, e.g. on pipelines.

InfintiteFocusSl system with 50x50mm XY stage and fitted with rotation device. Info at https://bit.ly/3sZS43H

PortableRL instrument for field use with battery pack. Info at https://bit.ly/2ZnB1OB

InfiniteFocusG5 plus system with 200 x 200mm XY stage and fitted with rotation device. Info at https://bit.ly/2TF9ctH