Tips and settings for measuring features on challenging surfaces, using 4D InSpec

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Measuring Highly Reflective Curved Surfaces with the 4D InSpec

4D InSpec depends on diffuse reflected light to image the surface. In ordinary use, the light source and imaging system are angled to brightly illuminate the surface, producing a strong diffuse reflection, while the specular reflection is directed past the imaging system.

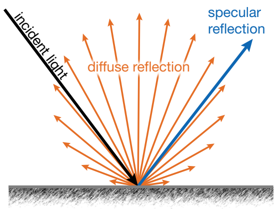

Figure 1: A beam of light's strong specular reflection leaves the surface at an equivalent angle to the beam's angle of incidence from the source. Surface irregularities scatter light from the illuminated area in a diffuse reflection.[1]

However, the specular reflection produces a bright line on a cylinder and a bright spot on a sphere, which can saturate the imaging system in those areas. Too much light, and the area will have no data. In this note we will discuss curved metal surfaces such as a cylinders and spheres, and provide steps you can take to obtain better measurements on them.

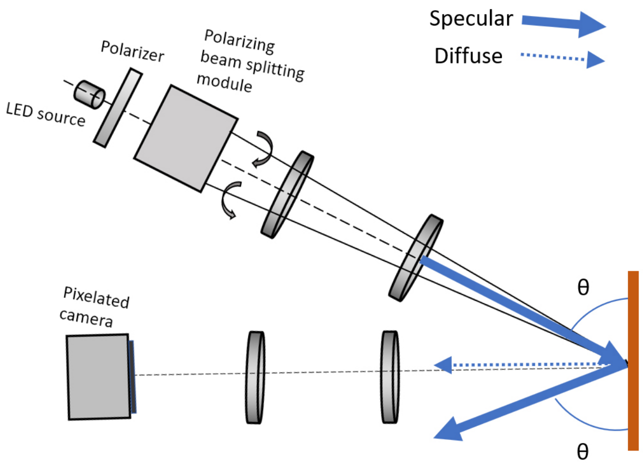

Figure 2. Simplified, default 4D InSpec schematic. Notice that in the default orientation, only diffuse reflection reaches the camera

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This application note is akin to the *"Measuring Flat, Transparent or Shiny Surfaces with the 4D InSpec"* Application Note. In that article, you'll learn how cropping, angling the system, and adjusting the Signal Strength Threshold can improve data quality on flat surfaces that do not have strongly diffuse reflections.

Measuring Cylinders

For cylindrical parts, the measurement angle is key. See Figure 3 for examples. For highly reflective, curved surfaces, the goal is to avoid capturing the specular reflection completely. Good signal strength (green coloring on the live video screen) can be achieved without seeing any of the red pixels. As a reminder, red pixels indicate the camera signal is saturated, and the light is washing out the surface detail.

With the 4D InSpec in the microscope stand and looking straight down, one can translate the cylinder such that the 4D InSpec is looking slightly down the side to avoid the specular reflection. Alternatively, tilting the 4D InSpec can achieve the same effect. If there is enough adjustment available, simply lowering the light level is acceptable as well; the limitation is that some sections of many curved parts reflect too much specular light, even with the system set to its lowest brightness setting.

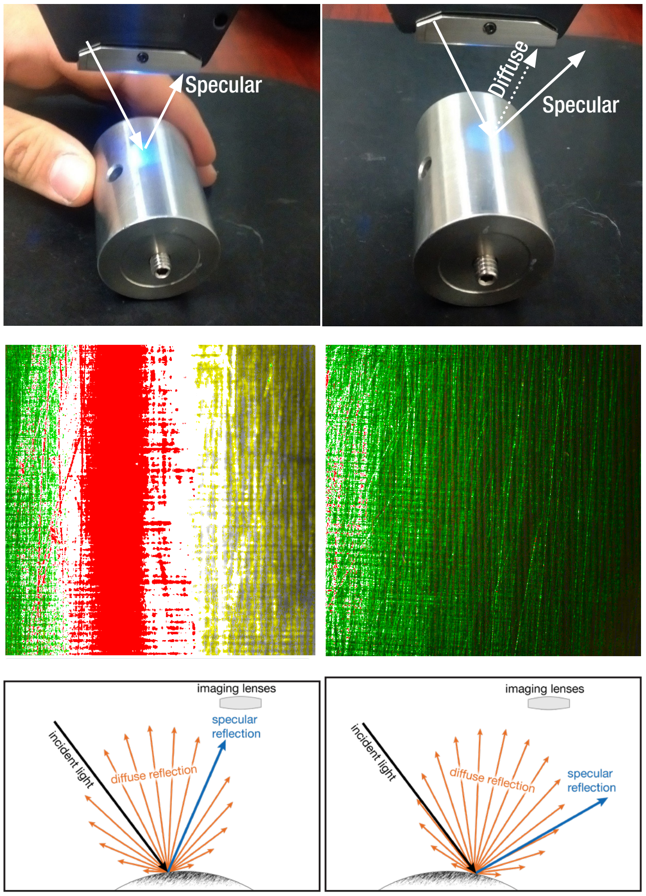

Figure 3. Left – An improper measurement angle results in saturation, shown as red pixels. **Right** – Shifting the cylinder (or angle the 4D InSpec) to illuminate a descending slope results in good data. 1

Using Signal Strength Threshold

The Signal Strength Threshold setting adjusts the minimum pixel value the software uses for unwrapping the data. If the threshold strength is too low, you will get false data (stray reflections), over-saturated, or empty space. If it is too high, you will omit good data from the measurement. Experimenting with various values is not harmful, but we recommend alternating between 5% or 0.5%, depending on your needs, since these will work for the vast majority of surface types. In the example below, both 5% and 0.5% were used with notable differences in the result.

Trying measurements with different Signal Strength Thresholds is a good option for both cylinders and spheres.

Measuring Spheres

Where cylinders create lines of specular reflection that run lengthwise on the cylinder, spheres present specular reflections as bright points of reflection from each light source. An example using a ball bearing:

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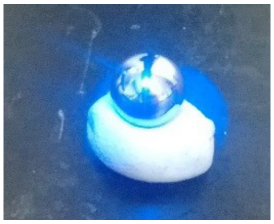

Figure 4: Ball bearing stabilized with clay.

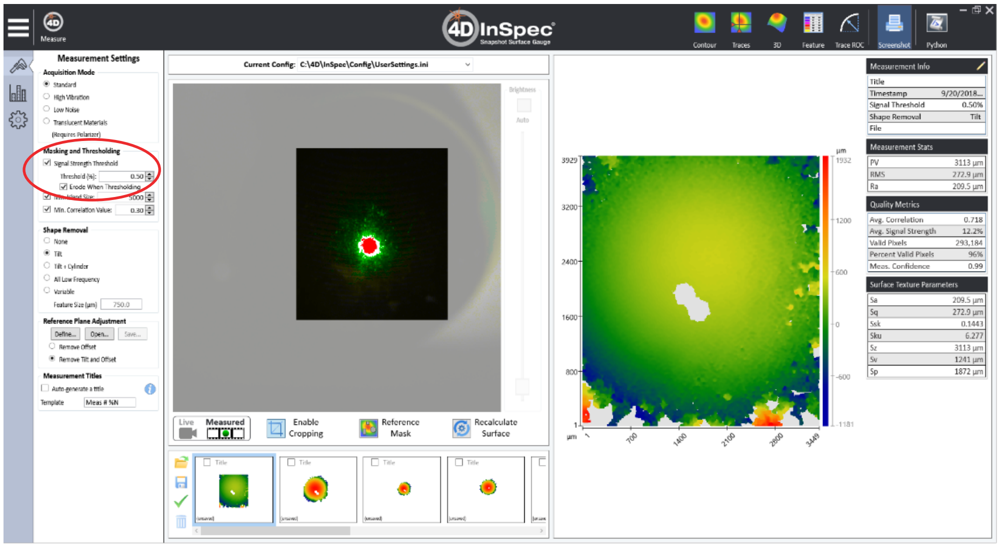

Figure 5: Data set of a ball bearing, using a signal strength threshold of 0.5% with cropping.

In Figure 5, the threshold is set too low. Areas with poor quality signal from the steeper parts of the sphere are analyzed, but do not calculate properly. Low signal strength leads to jumps in the data, seen by red (high) sections of the image next to blue (low) sections.

This is a common effect when measuring empty space with a low signal threshold.

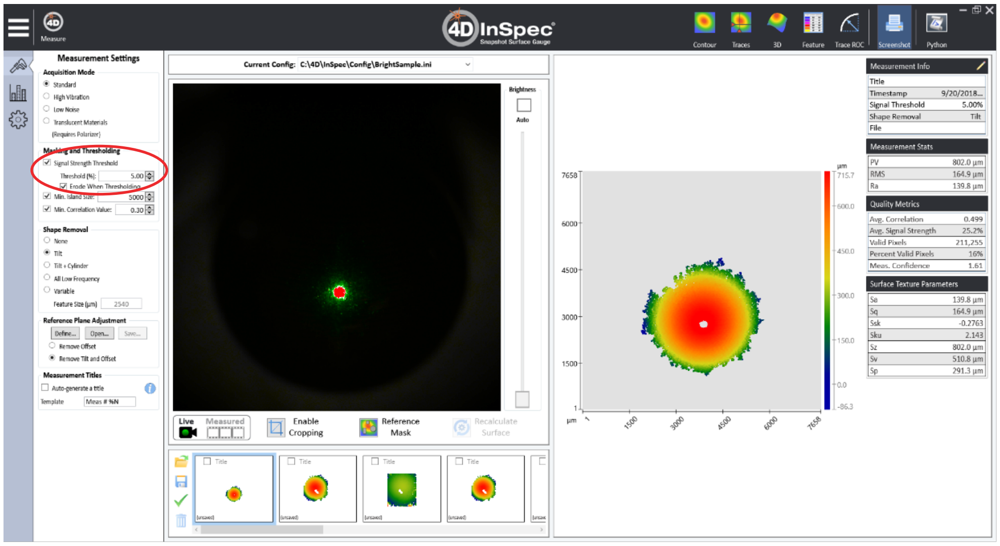

Figure 6: Data set from the same ball bearing as figure 4, but with a higher signal strength threshold of 5%.

In Figure 6, the signal threshold is set to 5.00%. The data on the spherical part smoothly transitions from high at the top to low at the edges, without noisy zones. Cropping was not necessary to achieve high-quality data. The analysis portrays the sample accurately, except for the small saturated point in the middle, which is not analyzed due to its high brightness.

For spherical surfaces, the saturation peak in the middle is often not avoidable the data. The key becomes making sure that the saturation area is small, and there is no defect inside it.

Cropping the data area

Cropping is another way to avoid saturated areas and can be used to narrow your field of view to only the measurable area. This can be used in conjunction with adjusting the Threshold Signal Strength, or separately. For example, if you have a super bright surface next to a really low reflector (the defect area), you may want to crop out the bright area and then use a higher Signal Strength Threshold to capture the necessary data. Figure 5 shows a square mask in the imaging field.

Crop an image area by clicking the icon button under the field of view area, helpfully labeled “Enable Cropping”. Clicking this button sets the cursor to the cropping tool, and you can click and drag in the camera field of view to create a zone of interest. Grayed areas outside the cropped area will be ignored when a measurement is taken.

That bright spot

For spherical surfaces, the saturation peak in the middle is often not avoidable in the data. The key becomes making sure that the saturation area is small, and that no defect you are trying to measure is inside it.

Altering Camera Settings

On the main screen, you are able to adjust the brightness of the image by changing the gain of the camera. Sometimes, even at the lowest brightness setting there is still too much light. When this occurs, one can try loading the ‘BrightSample.ini’ user configuration file, which changes the camera settings even further to allow for lower brightness settings than usual. The configuration file is located in the User Config folder (located C:\4D\InSpec\Config). This setting has a lower exposure time, which can dramatically increase the ability to measure high reflectors. Figure 6 used this lower exposure while Figure 5 did not; note the smaller saturation point in Figure 6 as a result.

Conclusions

Highly-reflective, curved surfaces can be analyzed with the 4D InSpec but sometimes take additional adjustments as compared to measuring mostly flat samples.

These adjustments can include: modifying—separately or in combination—the area of measurement, the angle of measurement, or software settings, to achieve the best results.

Have a Question?
4D Technology’s Applications Engineers are here to help:

Support: info@4dtechnology.com
Phone: 1-800-261-6640

1. Source: en.wikipedia.org/wiki/Diffuse_reflection#/media/File:Lambert2.gif, 2018.11.15

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