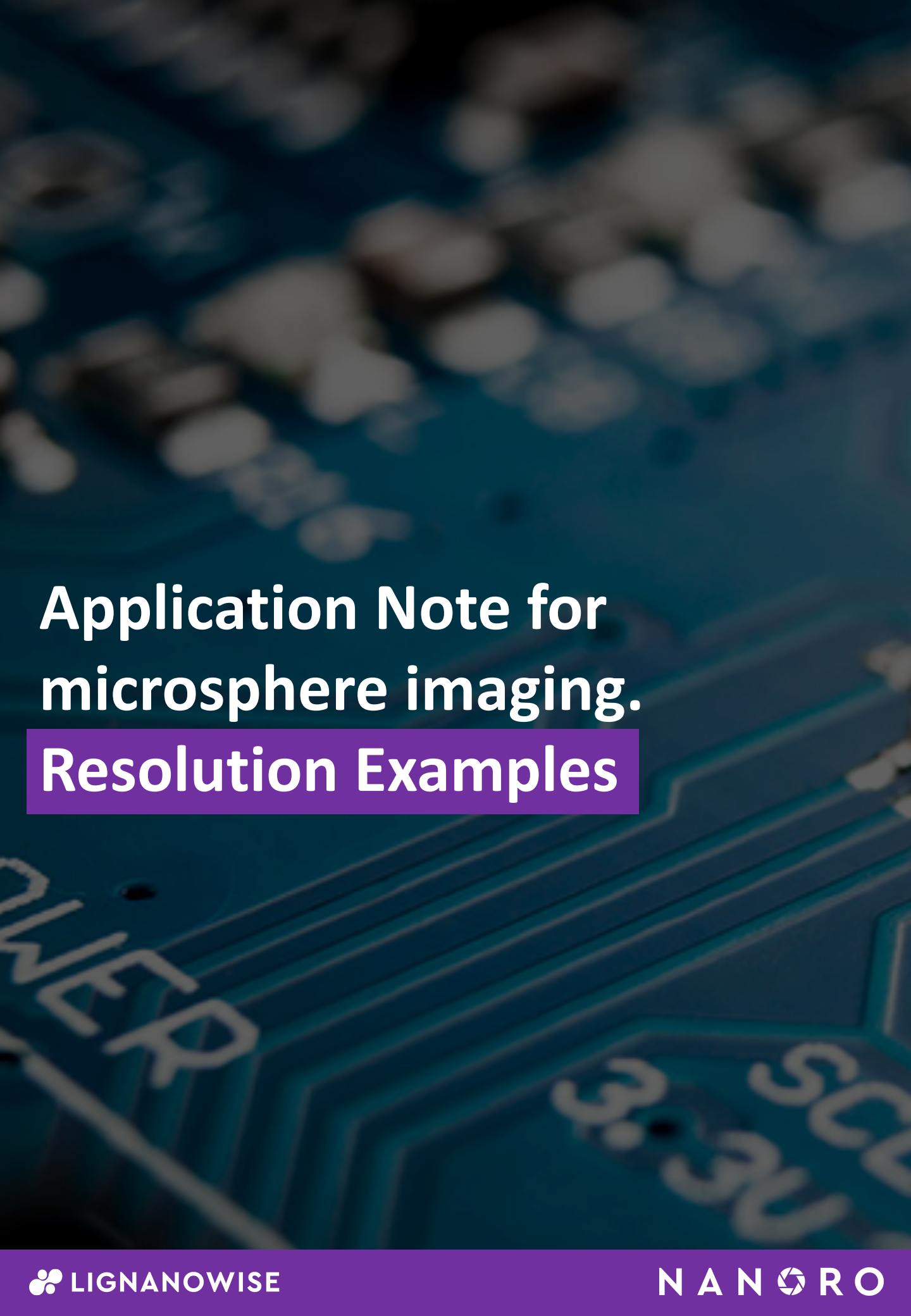

Application Note for microsphere imaging.

Resolution Examples

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Introduction

In order to talk meaningfully about resolution it is important to define what resolving means. For more detail on the background to measuring resolution, please refer to technical note TN, "Resolution". This application note shows examples of the application of this knowledge.

LIG developed a software tool that allows a user to define and then extract the light intensity along a line profile. If there is a clear interface along this profile, then the graph will have a clear transition in intensity values. In the following pages, the upper graph will show these intensity values. The lower graph shows the differential of these intensities, effectively removing the offset and helping to clarify where this transition takes place, and also what the spatial size of that transition is.

From the following pages, we see that only the SMAL image has peaks in the differential analysis (pg.4, top & bottom graphs) that relate to the original image. These are indicated as, "P1", "P2" and "P3". Since peaks can be detected, we can conclude that along the line profile (indicated as "Interface 1" and "Interface 2") interfaces between different materials can be detected. Since only SMAL shows this result, we can conclude that separate objects can be detected beyond that of traditional optical microscopy.

The light intensity of the line profiles in images recorded with the other lens (Nikon 100x NA 1.45) doesn't show peaks for these same interfaces. As only one broad object is imaged, the details within can not be resolved.

x100 Imaging of a semiconductor (no detail) NA = 1.45

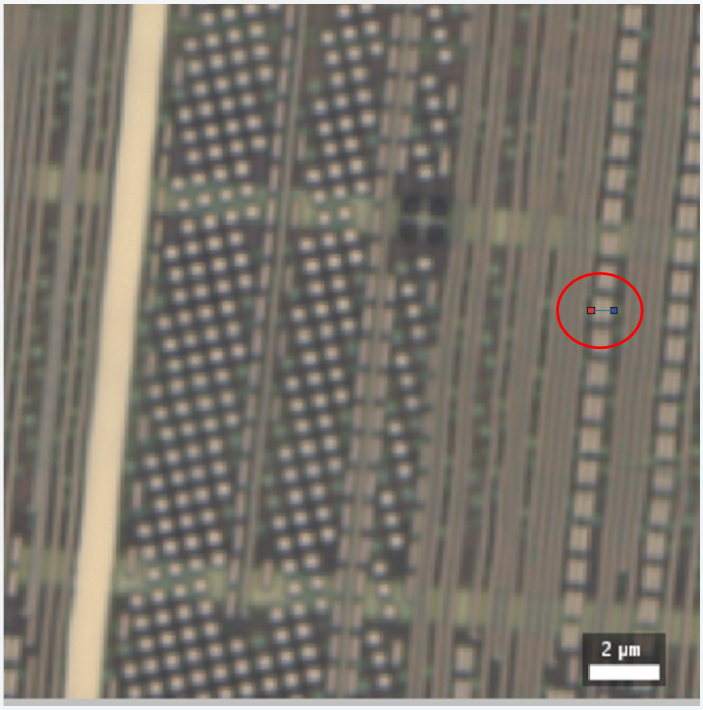
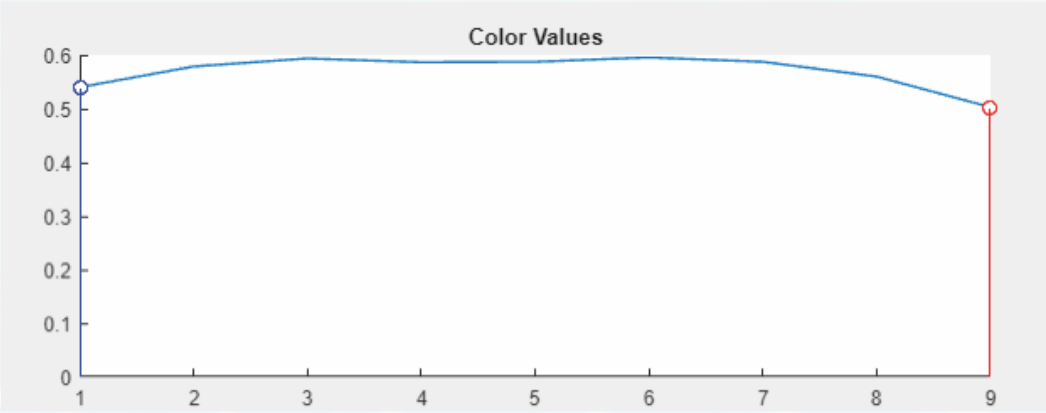
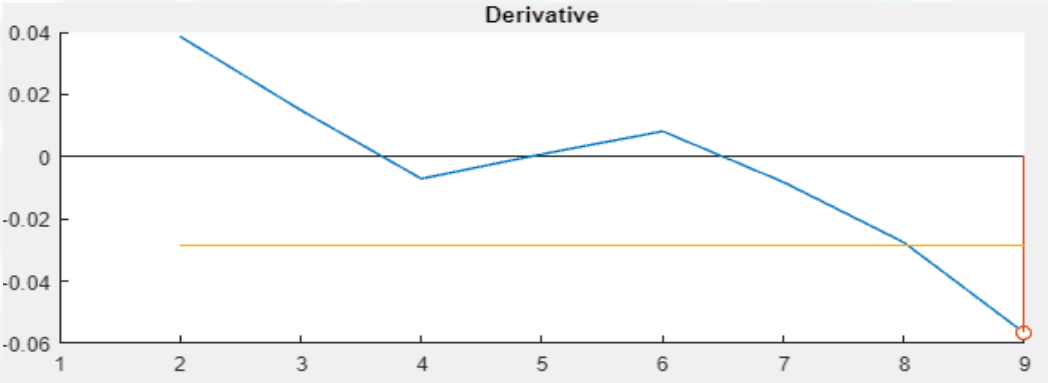


fig. 1

To the left (fig. 1) is an image taken with a x100 oil immersion microscope with a 1.45 numerical aperture. The features on this sample exhibit a 50 nm gap. The intensity cross-section line (location circled in red) is a smooth profile, as shown in the upper graph below. High resolution detail cannot be seen in either the colour values' cross-section or the differential analysis. Therefore, the interfaces on the semiconductor have not been resolved.





Please refer to Technical Note TN1 on resolution for more details of this analysis.

SMAL Imaging of a semiconductor (detailed)

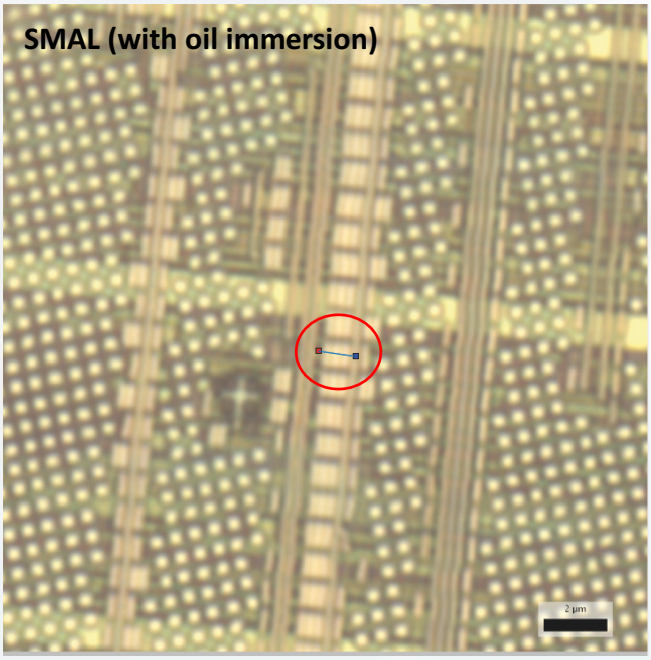
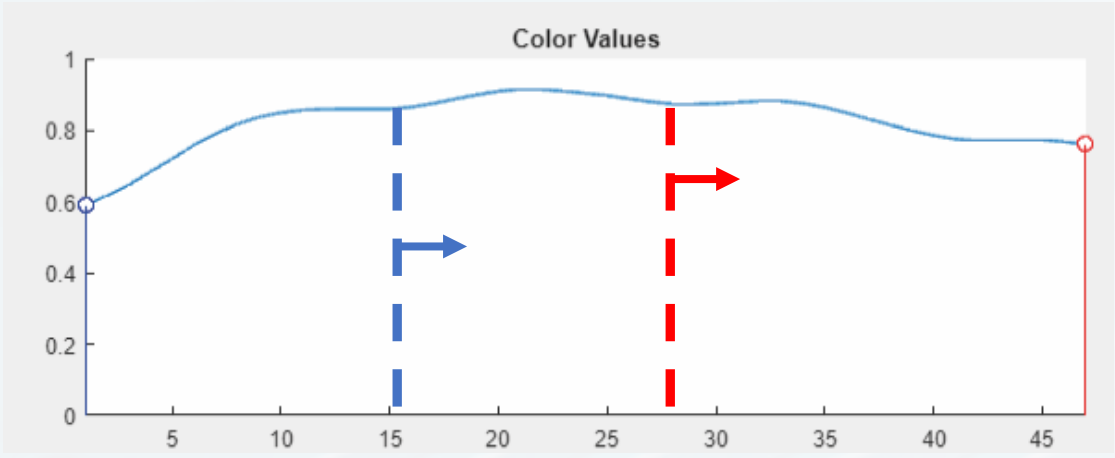
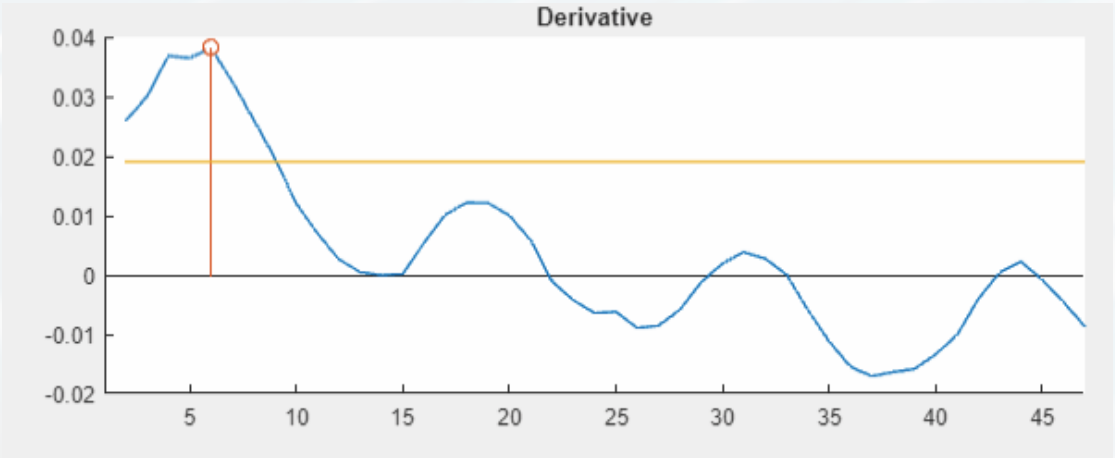


fig. 2

Fig. 2 shows an image taken with a SMAL lens.

In the graphs below, the two interfaces are visible, resulting in the two peaks which correlate with interface 1 and 2 on the sample. The intensity cross-section line (location circled in red) is a not a smooth profile. High resolution detail can be seen in both the colour values cross-section and the differential analysis. Therefore, the interfaces on the semiconductor can be visualised.





Please refer to Technical Note TN1 on resolution for more details of this analysis.

100 nm features using SMAL lens.

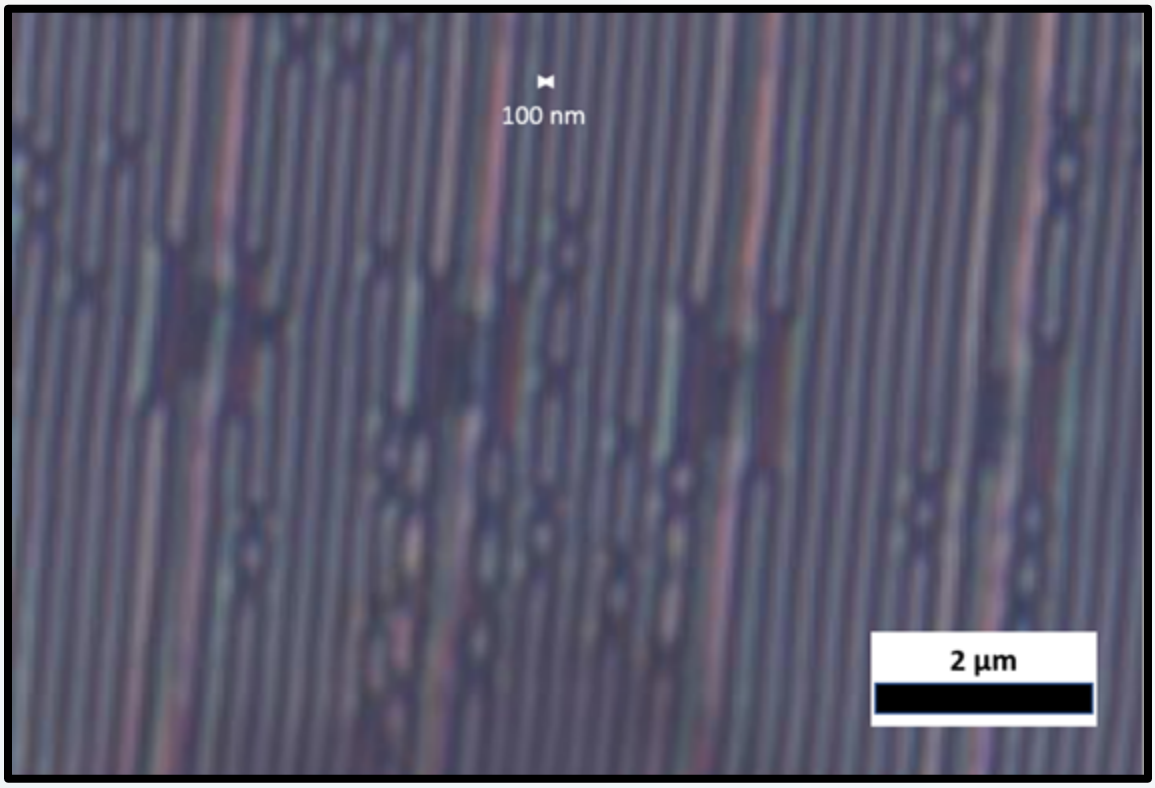


fig. 3

Above you can see a full area scan stitched image (fig.3). The 100 nm features of the processor are clearly visible in colour and are measured using the NANORO software measuring tool (white dimension tool).

Similar results are shown in AN2 on semiconductors using similar high density features on a common high performance microprocessor. The features here demonstrate the imaging capabilities of SMAL lens technology and relate to the fundamental resolution of the instrument. The software measuring tool is used here to imply an imaging feature size although a stricter description on resolution can be found in Technical Note TN1 on resolution.

Measuring the Features

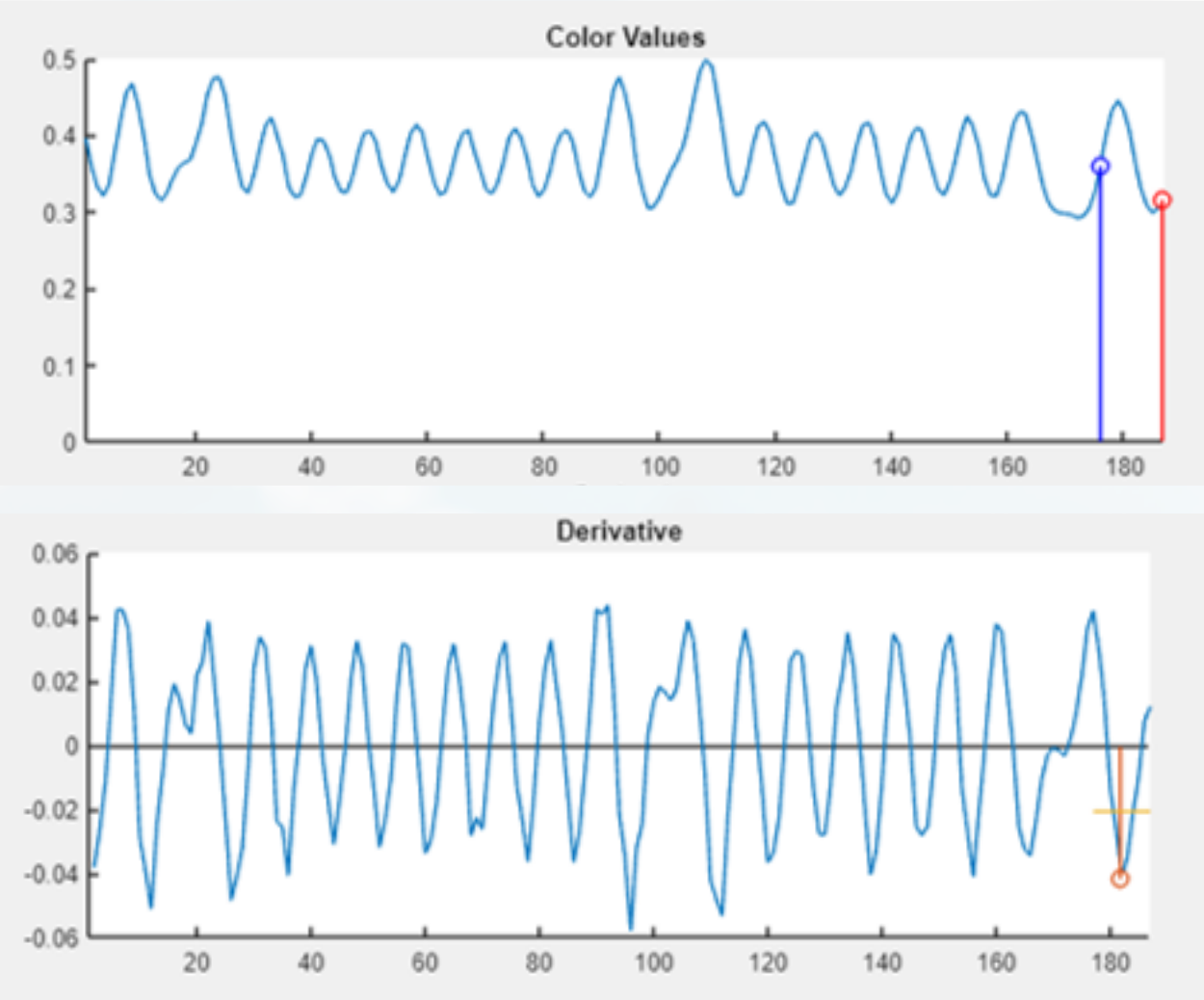


fig. 4

Here, the resolution achieved by the SMAL lens is determined at a transition between silicon and metal substrate by using the image from fig. 3.

The graphs of fig. 4 show the colour values taken at a cross-section of data from fig. 3 (upper chart), the derivative of these colour values (lower chart) and the FWHM (full-width half maximum) point of measurement on the derivative chart (orange cursor). By measuring the colour value changes across intensity or colour transitions we are are able to calculate the resolution from the vertical features from fig. 3 as approximately 80 nm.

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