Analyzing Large Surfaces using AFM Stitching

Abstract

This application note describes the automated stitching feature of the Nanosurf Nanite AFM scripting interface in combination with the Nanosurf Report Expert analysis software. AFM measurements on an LCD panel are used as an example to demonstrate how stitching can thus be used to easily and efficiently generate high-resolution topography maps of large surface areas.

Introduction

High resolution imaging techniques like AFM are often limited in their maximum scan range. When both the high lateral resolution of an AFM and a large scan range are required, image stitching could be a solution. Image stitching is commonly used when creating a single panoramic scene from multiple pictures. In a more advanced implementation, this technique can also be used to combine multiple AFM measurements to a single large image. Thus, AFM imaging of large surface areas, e.g. 1 mm × 1 mm or 100 µm × 1 cm in size, can easily be achieved.

The Nanosurf Nanite AFM system is able to measure and stitch the required images fully automatically. The user only has to specify the single AFM image size and the size of the area to be measured. The AFM then takes care of the rest. After measurement, the images are loaded into the Nanosurf Report Expert post-processing software, and are stitched together to a single image. This image still contains all metrological data and can therefore be analyzed like any other AFM image with all available analysis functions, including height and distance measurements, roughness calculation, grain and particle analysis, cross section analysis, and of course 3D visualization.

Imaging of an LCD panel "pixel"

Modern flat screens manufacturing techniques (plasma, TFT-LCD, OLED) are based on multi-layer processes that produce small and complex 3D surface structures. Conventional optical microscopy generally falls short when it comes to verifying the integrity and quality of such surface structures in three dimensions. This is particularly true for failure analysis in the sub-micrometer regime. AFM, on the other hand, is the ideal solution to measure 3D contour data with sub-micrometer precision. With the stitching technique, this can now even be accomplished on large surface areas, such as LCD panels.

Figure 1 shows an optical microscope image of an LCD panel at 120-fold magnification. One pixel of the panel corresponds to the section enclosed in the

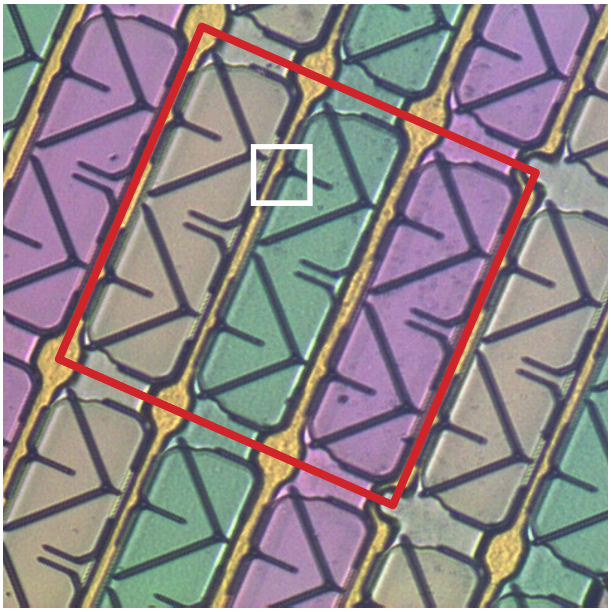


Figure 1: Optical microscopy image of an LCD panel. The image (660 µm × 660 µm; shown here at 120-fold magnification) was recorded using a Nanosurf easyScope. A single LCD "pixel" is enclosed in the large red box. The smaller white box corresponds to the area that can be typically covered by the scan range of an AFM. The result of such a scan is shown in Figure 2.

red box. This area, measuring 407 µm × 407 µm, is much larger than the area that can normally be measured with an AFM, which would correspond to the smaller white box in Figure 1. Figure 2 shows an actual AFM measurement in the area of the white box. The advantages of AFM over optical microscopy — the much higher resolution that is obtained, and the availability of 3D data — become clearly apparent.

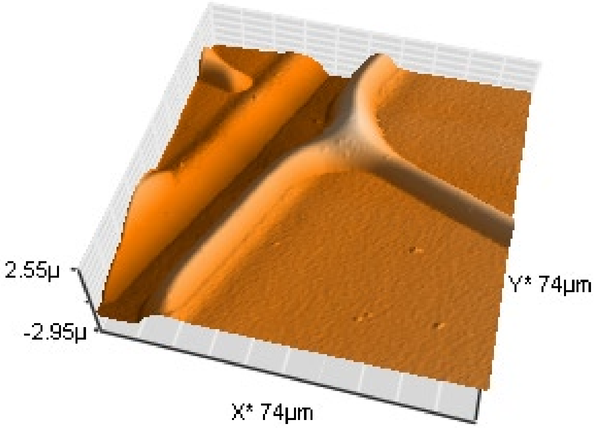
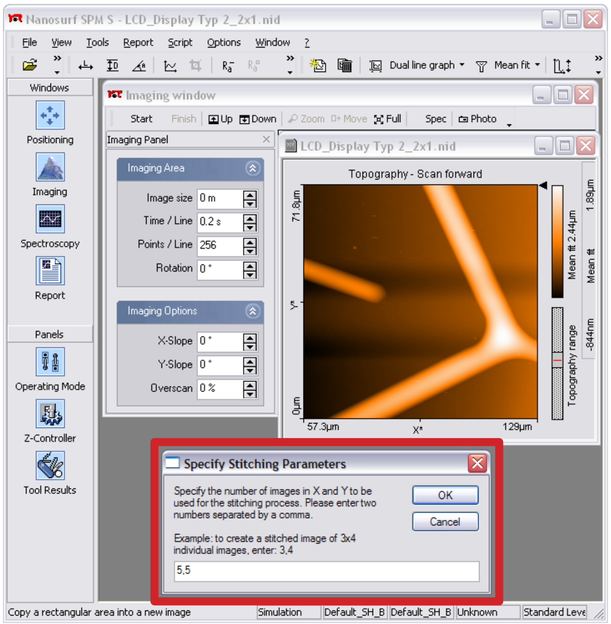


Figure 2: AFM scan of a typical LCD panel area. High-resolution topographic data is available for a limited scan area. The scan here corresponds to 74 µm x 74 µm, and to the white box shown in Figure 1.



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Points / Line 256
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X-Slope 0 °
Y-Slope 0 °
Overscan 0 %

Specify Stitching Parameters

Specify the number of images in X and Y to be used for the stitching process. Please enter two numbers separated by a comma.

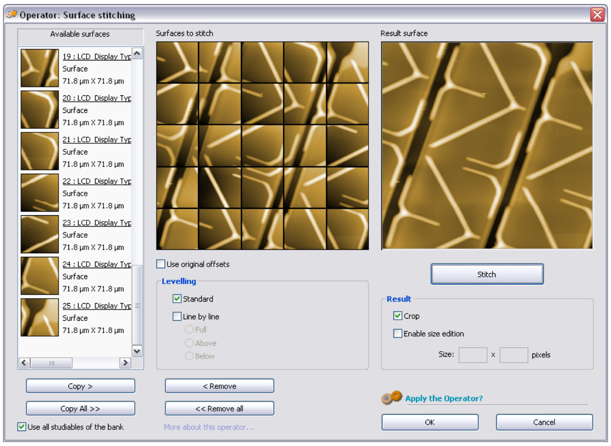
Example: to create a stitched image of 3x4 individual images, enter: 3,4

5,5

Copy a rectangular area into a new image | Simulation | Default_SH_B | Default_SH_B | Unknown | Standard Leve

Figure 3: Stitching script running in the Nanosurf control software. The red box shows the Stitching dialog asking the user to supply basic parameters for the stitching process.

To image an entire LCD pixel would, however, require a scan size that is much larger than those that can be obtained from a single AFM image. A way around this obstacle, is the use of automated measurement of multiple sample areas, followed by stitching of the resulting AFM images. The feasibility of this process is demonstrated in the following example, which illustrates how a matrix of 5×5 AFM images was acquired on an LCD panel and stitched together to a larger image. The instrument used for this process was the Nanosurf Nanite B AFM with an ATS-A100 automated translation stage. After



19 : LCD_Display Typ
Surface
71.8 µm X 71.8 µm

20 : LCD_Display Typ
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24 : LCD_Display Typ
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71.8 µm X 71.8 µm

25 : LCD_Display Typ
Surface
71.8 µm X 71.8 µm

☐ Use original offsets
☑ Standard
☐ Line by line
○ Full
○ Above
○ Below
☑ Crop
☐ Enable size edition
Size: x pixels
☑ Use all studiables of the bank

Figure 4: The Stitching Module interface in the Nanosurf Report Expert software. Simple yet powerful commands allow anyone to perform stitching and to generate professional results.

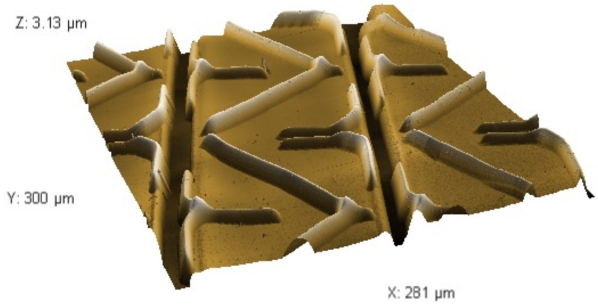

Figure 5: 3D representation of a stitched AFM image. The image (corresponding to the stitching result in Figure 4), shown here at 200-fold magnification, demonstrates how easily high-resolution 3-dimensional data can be acquired using the Nanosurf Nanite B AFM and an automated translation stage. It also demonstrates how seamless the result of the stitching process is.

Mounting the LCD sample on the translation stage, the AFM cantilever tip was positioned over the region of interest, and the stitching script was started (Figure 3). With the desired parameters set, the AFM system autonomously acquired all images, saved all measurements to files, and transferred these to the Nanosurf Report Expert software, where the Stitching Module of this program stitched all files together (see Figure 4). A 3D representation of the result is presented in Figure 5, which shows how seamlessly the individual images are merged into one.

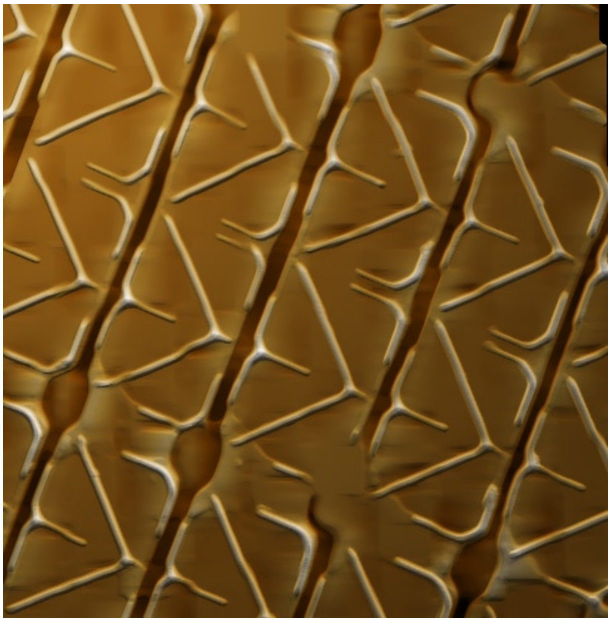

Figure 6: AFM stitching image of an LCD panel. The image (560 µm × 570 µm; shown here at 160-fold magnification) is the result of 10×10 images recorded and stitched using the Nanosurf Nanite B and the stitching features of the Nanosurf Control and Report software. The result is comparable in size to the optical picture shown in Figure 1, but in this case offers much more detail and 3D data.

Using even more individual AFM images (10×10) for the stitching process resulted in a high-resolution topographic map (Figure 6) of an even larger surface area of the LCD panel (560 µm × 570 µm, after cutting off the rough edges), almost similar in size to the optical image shown in Figure 1. More than one complete LCD pixel can clearly be distinguished. The use of such large surface AFM data in quality control of LCD panel production provides detailed information with regard to the individual micro-fabrication process steps, and allows batch-wise approval or rejection of production lots. In addition, the information provided by AFM measurements — in particular AFM measurements spanning large surface areas, as is the case for stitching — can even be used to adjust production parameters for future lots. This make the AFM not only a quality control instrument that provides the highest possible resolution in industrial quality control processes, but also a valuable optimization tool during product development and production. The autonomous operation, the easy handling, and the excellent price/performance ratio of the Nanosurf Nanite make it the ideal tool for small and large industries alike to move their quality control into the 21st century.

Instruments used

All measurements were performed with a Nanosurf Nanite B (110 µm) AFM scan head attached to an ATS-A100 automated translation stage.

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