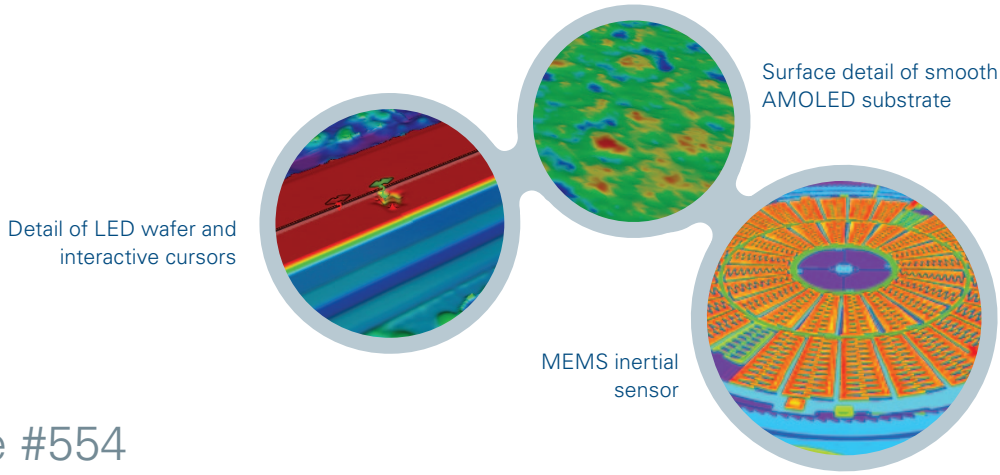

Application Note #554

VXI Universal Surface Measurements for 3D Optical Microscopes

Bruker has recently introduced VXI, a breakthrough measurement mode that enables nearly universal measurement results on widely ranging surfaces. This unique capability is only available on Bruker 3D optical microscopes, and provides fully automated, self-sensing of the surface under test, optimized processing of the complete optical signal, and most accurate computation of surface topography. This application note briefly reviews the VXI technology and imaging and measurement examples from the LED, MEMS, and display industries.

Technology Overview

VXI enables nearly universal surface measurement results. Other competitive "single measurement mode" techniques actually require input and adjustment of several different parameters to achieve optimum results on different surface textures in the same field of view, as well as on surfaces with both low and high reflectivity. VXI is unique in that it can be set to automatically sense the type of surface and provide the most accurate 3D optical metrology representation of the surface available in the market today. VXI provides a single measurement mode that can provide sub-nanometer vertical resolution on almost any surface (transparent or opaque) with vertical range up to 10 millimeters. For example, Figure 1 shows a measurement of a wafer during one of the process steps for LED manufacturing that was created with automatic resolution settings. Both smooth and pitted/rough areas are readily apparent in the data.

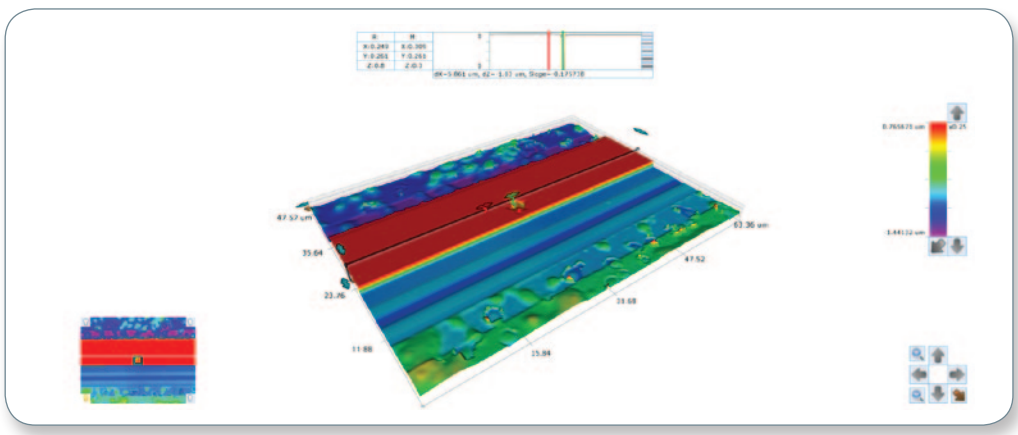

Figure 1. VXI 115X magnification 3D image showing areas of smooth and rough topography on a wafer during fabrication process steps.

Flexibility for Broad Applications

A key benefit of VXI is the flexibility it affords the user. Based on the surface texture expected, the user can select from four operational resolution modes: *Auto, Standard, High Fidelity*, or *High Speed*. The user selects the processing resolution for different scenarios from a simple pull-down menu (see Figure 2).

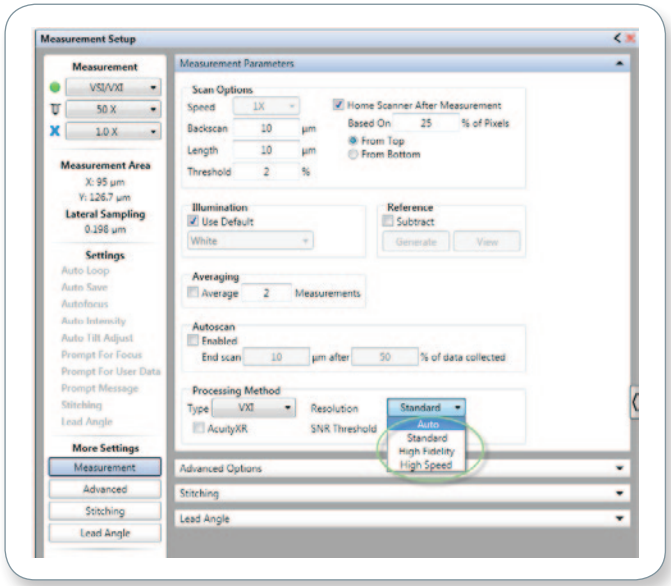

Figure 2. VXI measurement settings dialogue.

The definitions of the four primary resolution settings are:

- *Auto* — Automatic resolution setting for VXI. The 3D microscope system will automatically sense the surface texture properties and adjust the resolution setting accordingly. For relatively smooth surfaces, this setting will default to *High Fidelity*. If the surface is less smooth, *Standard* resolution will be applied to process the surface signal data into a topography map with a balance between resolution and speed.
- *Standard* — This is a phase-based processing of the surface measurement signal with a speed-enhanced algorithm, primarily useful for smooth surfaces.
- *High Fidelity* — This is another phase-based algorithm, useful for when the application requires the absolute best vertical resolution, even on rough or diffuse surfaces.
- *High Speed* — This is a center of mass (COM) enhanced algorithm with improvement in accuracy over previous vertical scanning algorithms. This setting will achieve the fastest VXI measurement results and is primarily useful when surfaces are known to be relatively rough, have long steps to scan for measurement, or where high vertical resolution is less important.

Automatic sensing is recommended for most cases as it balances the optimum quality of the data with speed of acquisition. In cases where the nature of the surface is well known (e.g., in production monitoring applications) then the user is also afforded a set of selection options for processing the data in the most efficient way, including a high-speed option to get data as fast as possible at a slight reduction in vertical resolution.

In addition to the resolution setting dropdown menu, VXI allows for a SNR threshold setting to reject data with low or limited quality, as well as our advanced AcuityXR™ measurement methodology for the absolute highest lateral resolution available for a given magnification and field of view combination. AcuityXR enhances edge detection and improves lateral repeatability 3 to 5 times over conventional microscope imaging for equivalent measurement parameters.

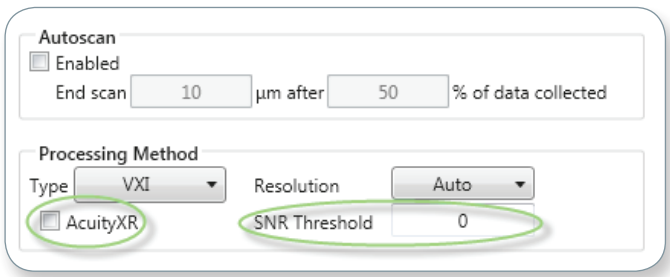

Figure 3. SNR threshold setting showing default setting = 0.

The SNR threshold setting is used to reject data with average modulation less than the set value (the number is specified as a percentage). Any data pixels where the criterion for modulation minimum is not met will be rejected as noise. The default setting of 0 rejects no data and is useful in most cases.

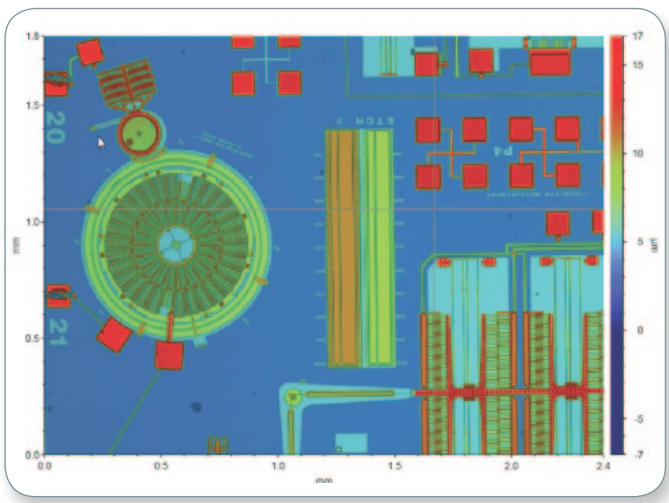

Figure 4. A 2.5X magnification image of MEMS structures (courtesy Sandia National Laboratory).

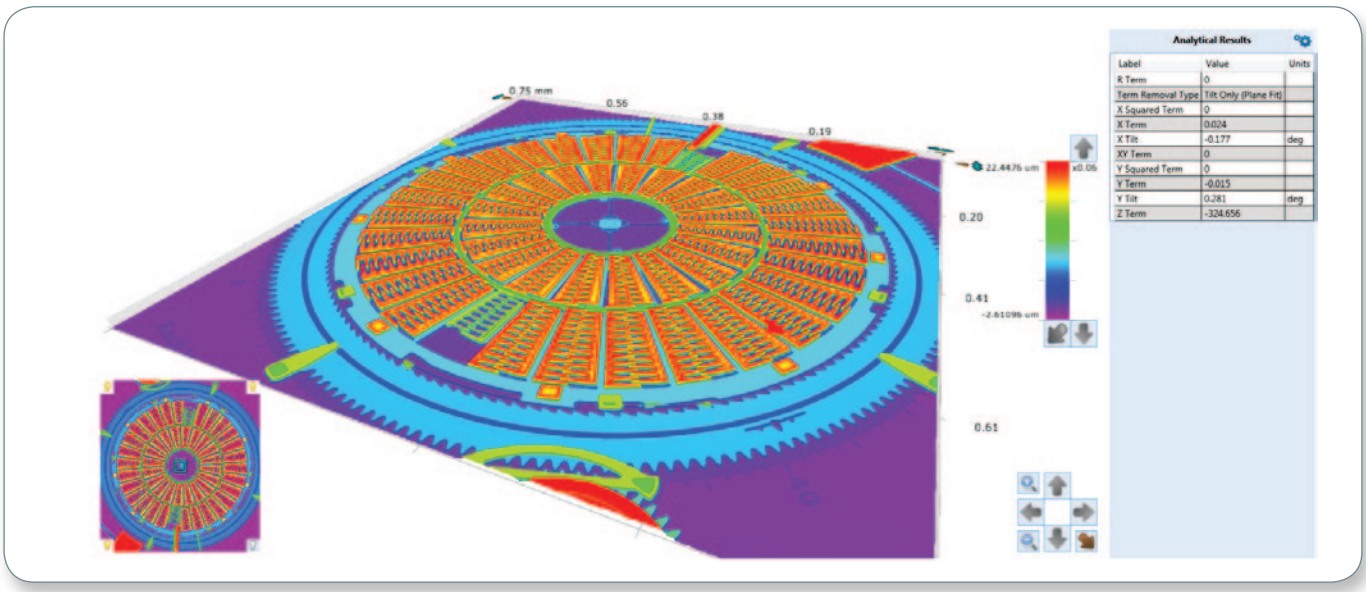

Figure 5. 3D view of 50X image of MEMS structure.

Application Example: MEMS Inertial and Position Sensors

VXI is ideal for measurement of smooth, rough and also stepped surfaces. This versatile power of VXI mode can be seen in the measurement of a MEMS sensor with step heights on the order of 25 microns and large, flat areas also included in the microscope field of view (see Figure 4).

The quality of data obtained with Bruker's VXI technology is readily seen in a closer look at a 3D interactive view of the MEMS structure at 50X objective imaging (see Figure 5).

The surface data produced by VXI are very low noise and accurately represent this relatively large area of interest at 50X magnification with highest fidelity. In a zoomed area of the field of view, cursors show the clean surface data, free of diffraction effects (sometimes called "batwings") that would be visible in other optical measurements of similar stepped structures with smooth surfaces and sharp edges (see Figure 6). VXI easily handles this surface topography and provides accurate, high-quality data of the surface of interest.

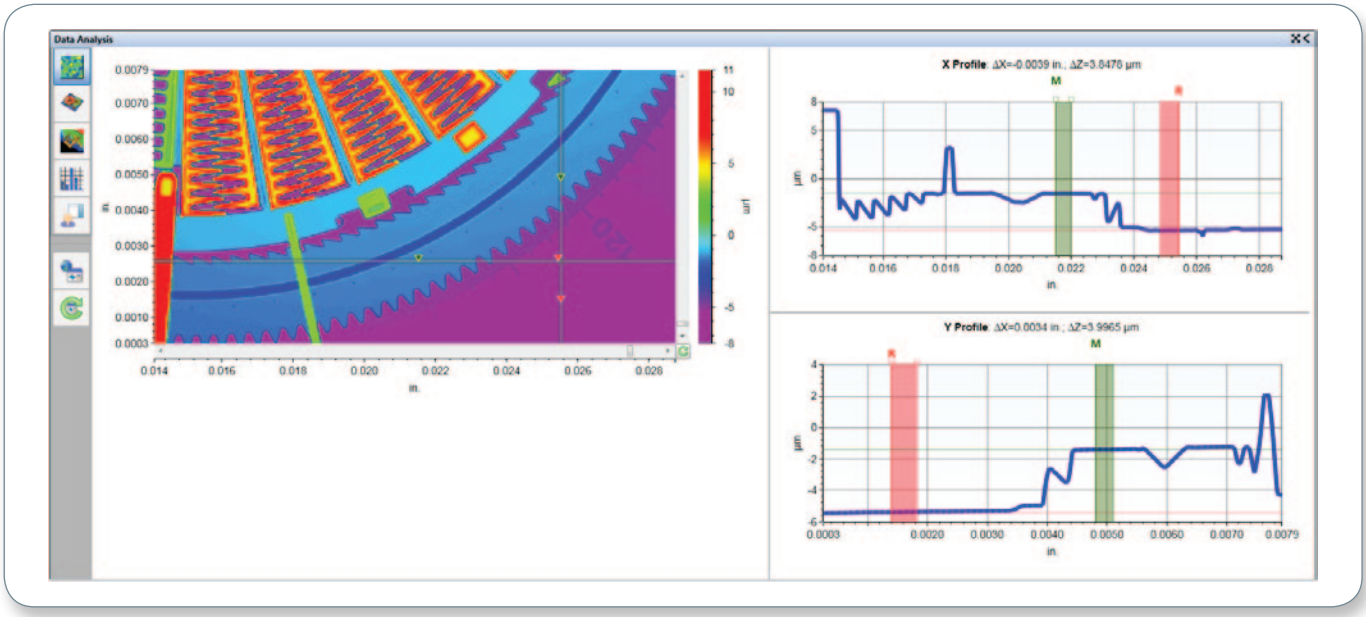

Figure 6. Zoomed area of MEMS structures and cursor analysis showing high-quality height information.

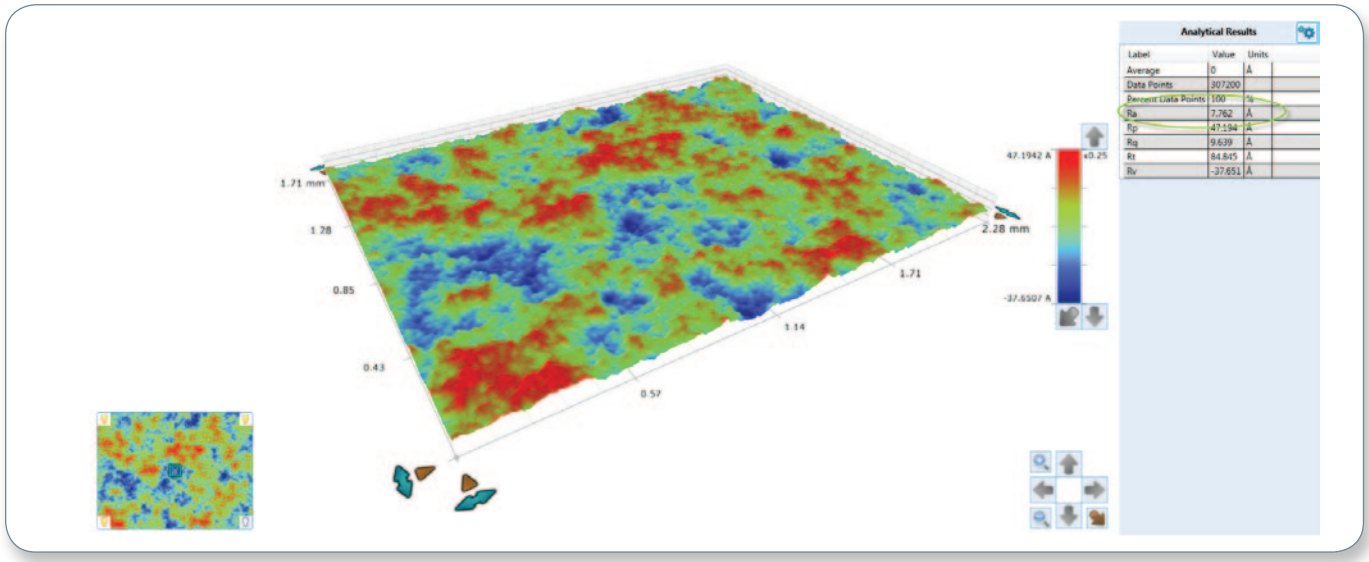

Figure 7. A 2.2mm x 1.7mm area of an AMOLED substrate showing <1nm Ra imaged with VXI.

As a final demonstration of VXI measurement capability, it is interesting to examine more closely a view of a large area measurement on a very smooth surface. We measured a transparent coated glass substrate used in the display industry for creation of Active Matrix OLED (AMOLED) devices. In this case, VXI was used to image both a smooth area free of defects and an area with a small pit defect approximately 100 nanometers deep (see Figure 7). Note that the VXI measurment still shows angstrom-level roughness while at the same time being capable of handling the pit deviation from the ideal surface (see Figure 8).

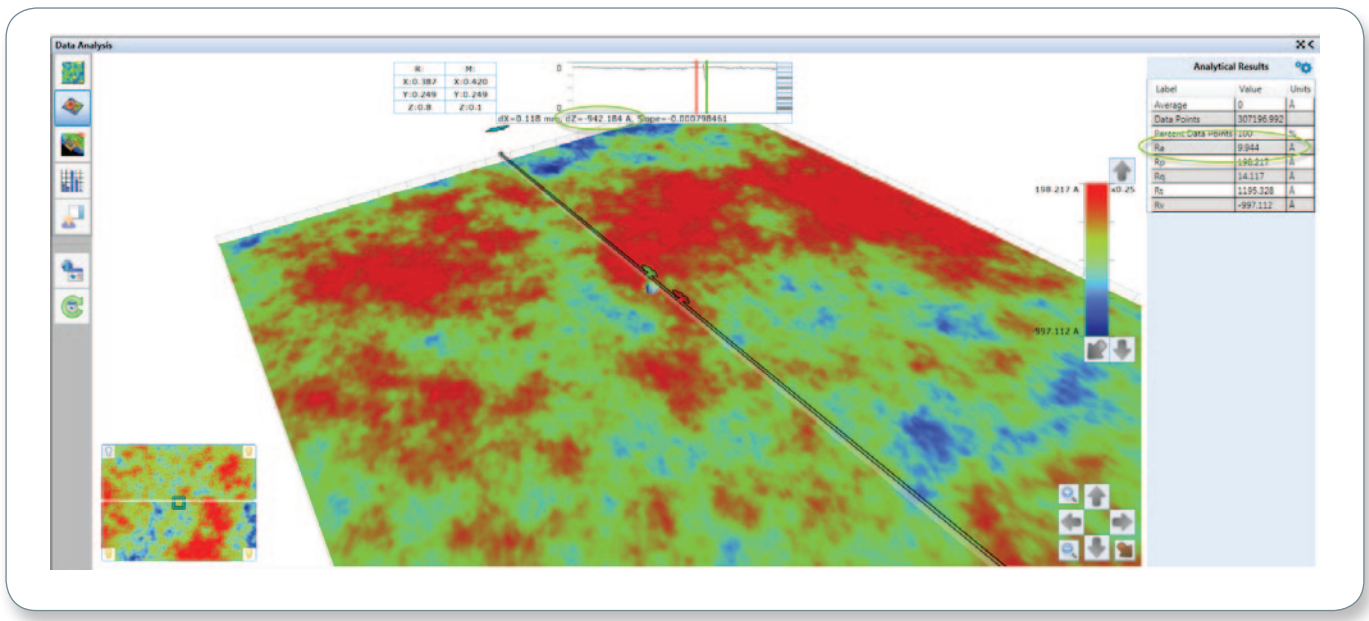

Figure 8. Zoomed view of AMOLED display substrate with ~100nm pit imaged with VXI.

Conclusion

VXI provides Bruker 3D optical microscope users with push-button access to the most accurate 3D surface topography measurements possible for the widest range of surfaces. As demonstrated, VXI produces fast, accurate results capable of providing striking details for applications such as MEMS or LED wafer device measurements, quantifying subnanometer level roughness and also defect measurements on ultra smooth AMOLED display substrates. These measurements are accomplished with a single measurement in VXI. This advancement in 3D microscope metrology produces the most easily acquired and most accurate representation of varying technical surfaces available in the market today.

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