



Chapman *Instruments*

Chapman Instruments Non-Contact Surface Profilers For Backgrind Process Control

Introduction

Chapman Instruments introduces new surface measurement capabilities for backgrind process control. Industry trends are moving toward thinner wafers for small packaging requirements and better heat dissipation, as required for fast microprocessors and smart cards.

The measurement of roughness for backgrind wafers is necessary to control die crack and wafer shear strength of these thinner wafer. Wafer die crack can be caused by too large a value of roughness. Die crack can be either due to die size surface features (e.g. mm size) or smaller micro crack (e.g. 10 μm width). Chapman's non-contact surface profilers can measure both types of surface roughness features, from mm to micrometer widths. Wafer shear strength can be characterized by the wafer roughness. A low roughness value can cause a lack of shear strength for wafer bonding.

Large Area Backgrind Measurement

As an introduction to surface topography, we examine the measurement of the surface of a backgrind wafer over a 50 mm by 50 mm area. The familiar backgrind pattern is shown, along with the roughness values. In this example we use a Chapman Instruments MP2200 non-contact surface profiler. This measurement system has the capability of measuring either small or larger areas in either linear or circular measurement geometries.

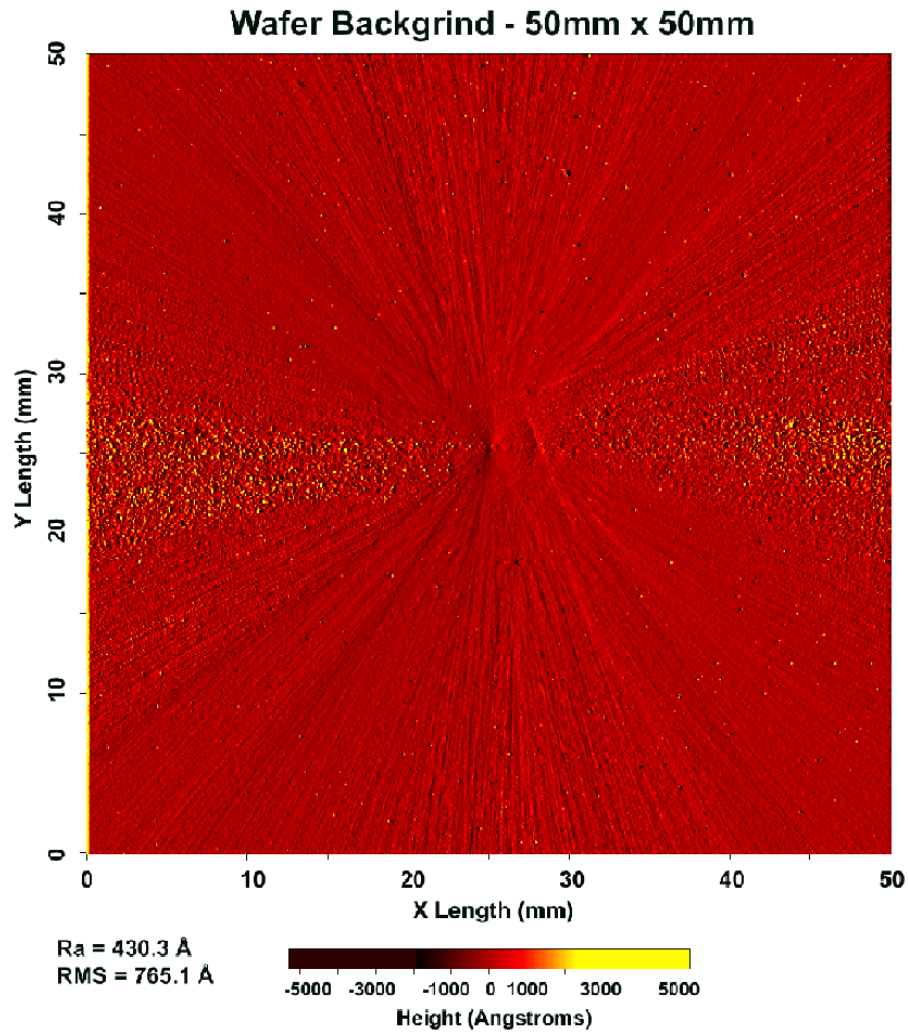


Figure 1 - 50 mm by 50 mm measurement of a background wafer. The roughness average was measured as 430.3 Angstroms (43.0 nm) using a 0.5 mm cutoff filter. The background pattern is evident in the measurement result.

This example shows the fine spiral lines originating from the wafer center. An examination of this surface topography value is complicated by the spiral pattern. In this application note we examine several patterns for roughness measurement and recommend a new approach for obtaining the required surface data.

Chapman Profilers--Features and Benefits

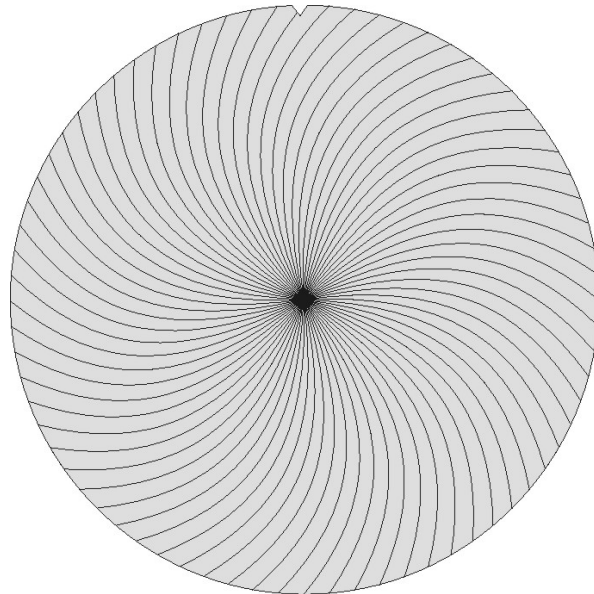
Chapman Instruments non-contact surface profilers provide a high return on investment due to its non-contact (non-destructive) and fast measurement (increased throughput) capabilities. Also, the unique measurement technology offers high resolution scans of small areas, large areas, and 360 circular scans at any radius.

Chapman systems offer the following benefits for wafer backgrind measurements:

Feature	Benefit	Specification
Non-Contact	Non-Destructive	Focused Laser Spot
Vertical Resolution	Accurate Measurement	0.01 nm
Lateral Resolution	Small Lateral Features	0.33 μm
NIST Calibration	Guaranteed Accuracy	NIST Roughness Standard Used in Calibration
Automated Backgrind Measurements	Minimize Operator Time and Increase Throughput	Wafer chuck mounted on XY-Theta Stage
100 mm Scan Length with up to 50 nm data sampling (up to 2 million data points)	Provides small feature examination over large wafer section	Can be used at any location of wafer size up to 300 mm
Circular Scan Measurement	Measure roughness more perpendicular to pattern	360 Degree Scan at any radius
Roughness and Waviness in a Single Scan	Increase Throughput, not necessary to change system configuration	Both small and wide features are measured in a single scan

We show some of these capabilities in the following example measurements of a 300 mm silicon backgrind wafer. These include measurements through the wafer center, and a full 360 circular scan around the wafer at a 30 mm radius. Video pictures were taken to show the backgrind pattern at various locations.

A concept drawing of the spiral pattern of a backgrind wafer is shown in Figure 2. This surface geometry can lead to non-uniform roughness results depending on the measurement direction.



Backgrind Spiral Pattern

Figure 2 - The typical surface topography of a backgrind wafer. The spiral pattern shows spokes originating from the wafer center.

Measurement through Wafer Center

A measurement through the wafer center will typically be the most non-uniform as the spiral pattern joins at this location. Figure 3 shows a video picture at the center of a 300 mm diameter background wafer. The video picture has been digitized directly from the Nomarski Viewing system, a standard feature of both the Chapman MP2100 and MP2200 profilers.

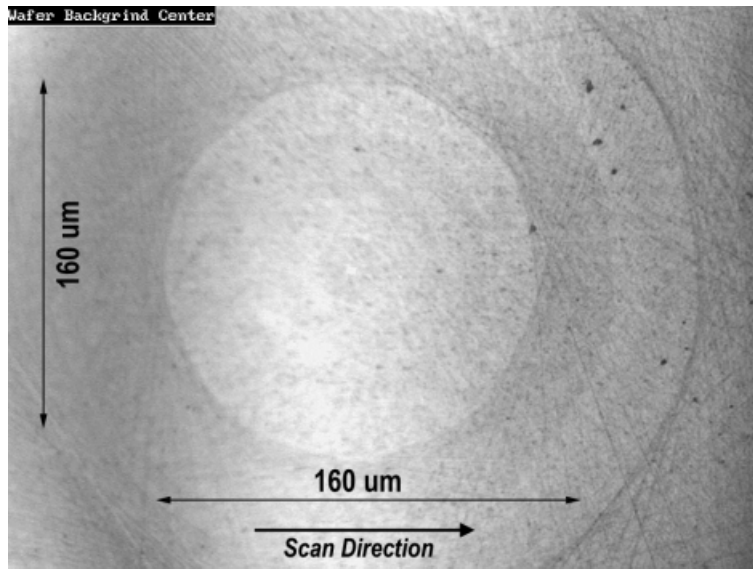


Figure 3 - Center section of a 300 mm Silicon background wafer. The center of the spiral background pattern is evident in the view.

A measurement across the wafer center will show non-uniformity due to the background geometry. An example of a measurement through the wafer center is shown using a 100 mm scan length. A digitized Nomarski view of the start position at (-50,0) from the wafer center is shown in Figure 4.

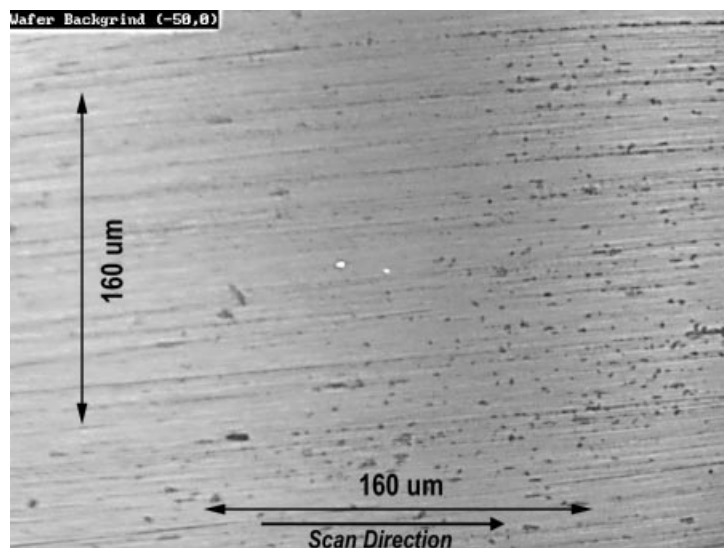


Figure 4 - Start position for 100 mm scan through the wafer center. The small background features are evident in the picture parallel to the scan direction

The roughness data for the scan starting at (-50,0) from the wafer center is shown in Figure 5. The scan length for the measurement is 100 mm. The roughness data and values were analyzed using an 800 μm cutoff filter. This roughness filter uses a long wavelength filter at 800 μm and a short wavelength filter set at the spatial resolution of the system. (This roughness filter corresponds to International standard - ISO - guidelines for measuring roughness. Additional information on roughness filters can be found in Chapman's Software Parameter Definition Application Note.). The long wavelength of 800 μm was chosen as an example to show wider surface features. Smaller surface features using the same data are shown in Figure 9.

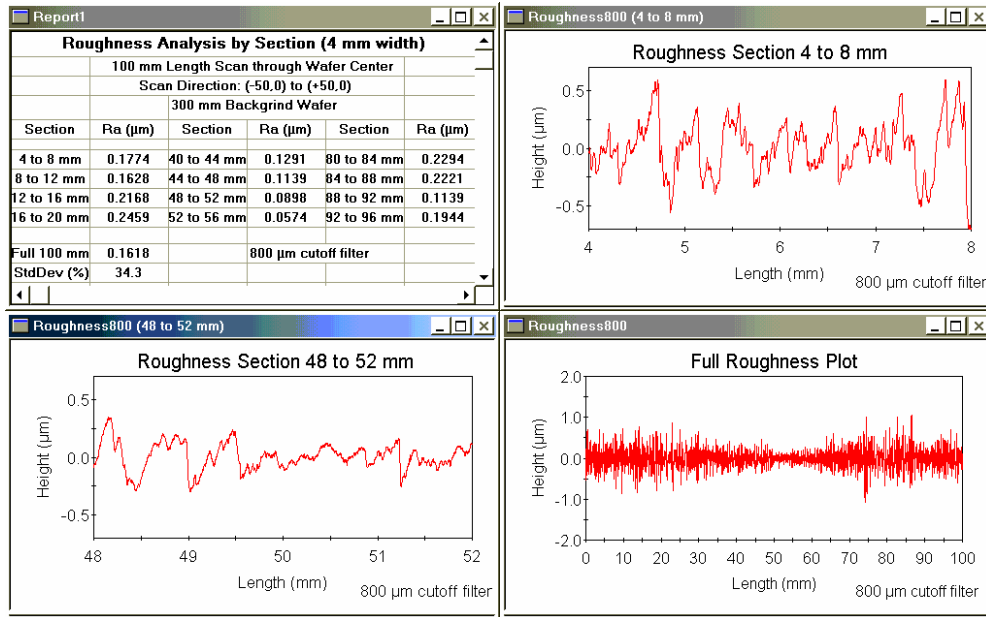


Figure 5 - Roughness result by measuring a 100 mm scan through the wafer center. The beginning of the scan is at (-50,0). The data analysis uses an 800 μm cutoff filter. The wafer center background pattern is evident in the center of the trace.

The data in Figure 5 is organized with four windows:

- The data in the lower right corner shows results of the full 100 mm length. The lower roughness data in the wafer center is evident in the figure.
- The upper right window shows a data section from 4 to 8 mm.
- The lower left window shows a data section from 48 to 52 mm. The roughness in the beginning of the trace (4 to 8 mm) is evidently higher than that through the center (48 to 52 mm).
- The upper left window shows a summary of the data organized by 4 mm length sections. The 100 mm long original data was divided into twenty-five 4 mm length sections. The 4 mm length was chosen because this represents five times the long wavelength filter of 800 μm . Five sections of the filter width are often used as a good representation of the average surface roughness. Many other surface roughness measurement systems would only show one or two such measurement sections. In this data window, we show the values of 12 such measurement sections out of a total of 25. Also, the mean value and standard deviation across all sections are shown. The mean value of roughness in this case is 0.162 μm and a standard deviation of 34.3%. A measurement across the wafer center would be expected to show such a standard deviation due to the spiral pattern geometry pattern shown in Figure 2.

Measurement in Circular Geometry

An alternate method to measure the wafer roughness is in a circular geometry. Chapman offers a unique circular path measurement that provides for more uniform roughness measurements. In this geometry, the measurement path is more perpendicular to the wafer background marks.

An example of the measurement pattern is shown in Figure 6. This digitized Nomarski picture was obtained at 30 mm from the wafer center, or (0,30).

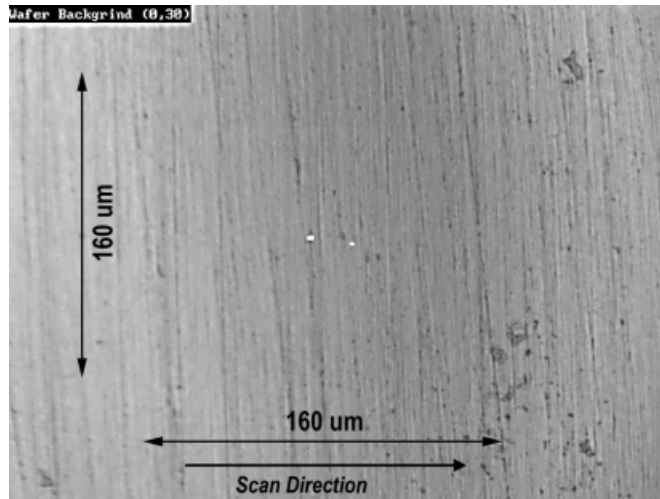


Figure 6 - Nomarski Viewing picture showing the start point (at 30 mm from the wafers center) of a 360-degree circular roughness measurement around the wafer.

The roughness data for the circular scan geometry is shown in Figure 7.

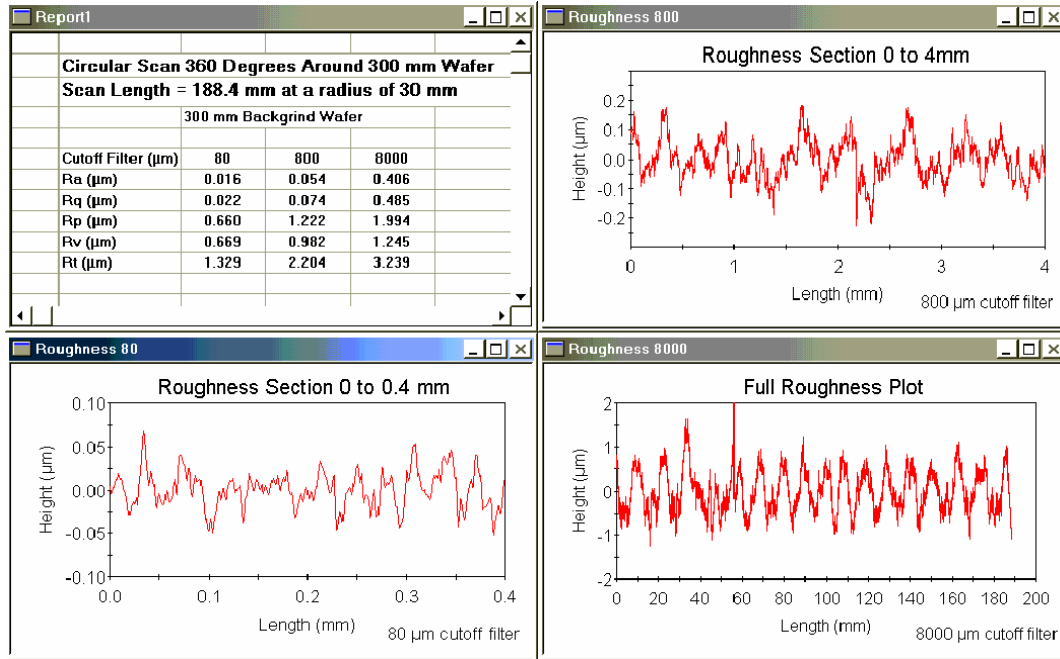


Figure 7 - 360-degree circular scan around the wafer. The scan length is 188.4 mm corresponding to the circumference at a radius of 30 mm. The larger wavelength grinding marks are evident in the full roughness data shown in the lower right data window.

The data in Figure 7 is organized in four windows:

- The lower right data window shows the full roughness plot over the 188.4 mm scan length using an 8000 µm cutoff filter. The regular pattern of the backgrind features is evident in the plot with a periodicity on the order of 11 mm.
- The upper right data window shows a data section from 0 to 4 mm with the roughness analyzed using an 800 micrometer cutoff filter. The vertical scale extends over a smaller height (-0.3 to +0.3 µm) than the full roughness plot (-2 to +2 µm).
- The lower left data window shows a section from 0 to 0.4 mm with the roughness data analyzed using an 80 µm cutoff filter. This smaller cutoff filter can be used to show the finer, smaller width features in the backgrind pattern. The vertical scale extends from -0.10 to +0.10 µm.
- The data report in the upper left window shows a summary of the three cutoff filters and roughness statistics Ra, Rq, Rp, Rv and Rt. Ra is the roughness average, Rq the RMS roughness, Rp the largest peak above the mean, Rv the deepest valley below the mean and Rt, the peak to valley. Many other roughness statistics are also available. (A complete list of roughness statistics is shown in Chapman's application note on Parameter Definitions.)

Another analysis of the roughness in the circular geometry is shown in Figure 8. This data presentation is similar to the analysis shown in Figure 5 for the linear 100 mm scan.

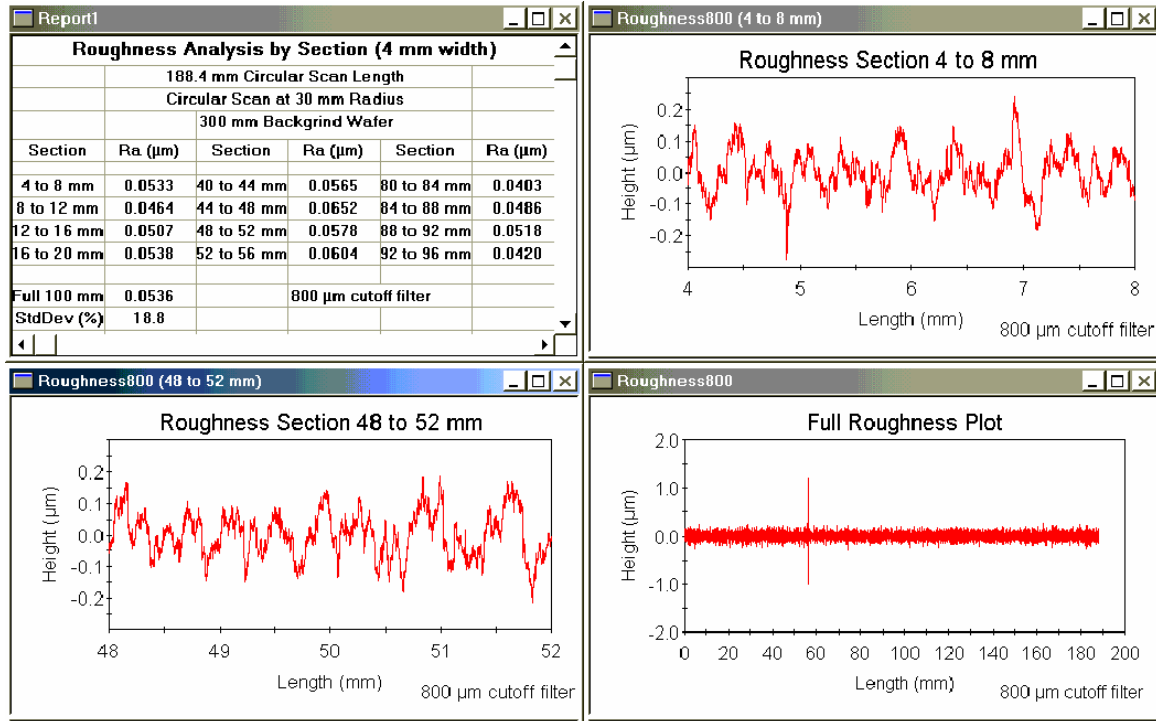


Figure 8 - Same roughness data as displayed in Figure 7. The data has been analyzed over 4 mm sections, corresponding to 5 times the 800 μm cutoff filter. The data shows a Ra of 0.0536 μm and an 18.8% standard deviation over the 4 mm sections

The data result in Figure 8 consists of four windows; all data analyzed with an 800 μm cutoff filter.

- The lower right data window shows the full roughness plot over the 188.4 mm scan length using an 800 μm cutoff filter. The roughness result is more uniform than the linear result. A defect at approximately 60 mm from the scan start point is also evident.
- The upper right data window shows a data section from 4 to 8 mm. The vertical scale extends over a smaller height (-0.3 to +0.3 μm) than the full roughness plot (-2 to +2 μm).
- The lower left data window shows a section from 48 to 52 mm. The vertical scale extends from -0.3 to +0.3 μm, the same as the data section from 4 to 8 mm. This shows the overall uniformity of roughness in each section.
- The upper left window shows a summary of the data organized by 4 mm length sections. The Ra values of a few sections are shown in the data window. The mean value and standard deviation across all sections is also shown. The mean value of roughness in this case is 0.0536 μm and a standard deviation of 18.8%. A measurement around the wafer in this circular pattern is expected to show a lower standard deviation than the linear scan through the wafer center.

Linear versus Circular Comparison

Finally we show a comparison of linear versus circular geometry using a finer 80 μm cutoff filter. This cutoff filter can be used to examine the effects of a micro crack on the wafer. Figure 9 shows the data comparison between linear and circular scan geometries.

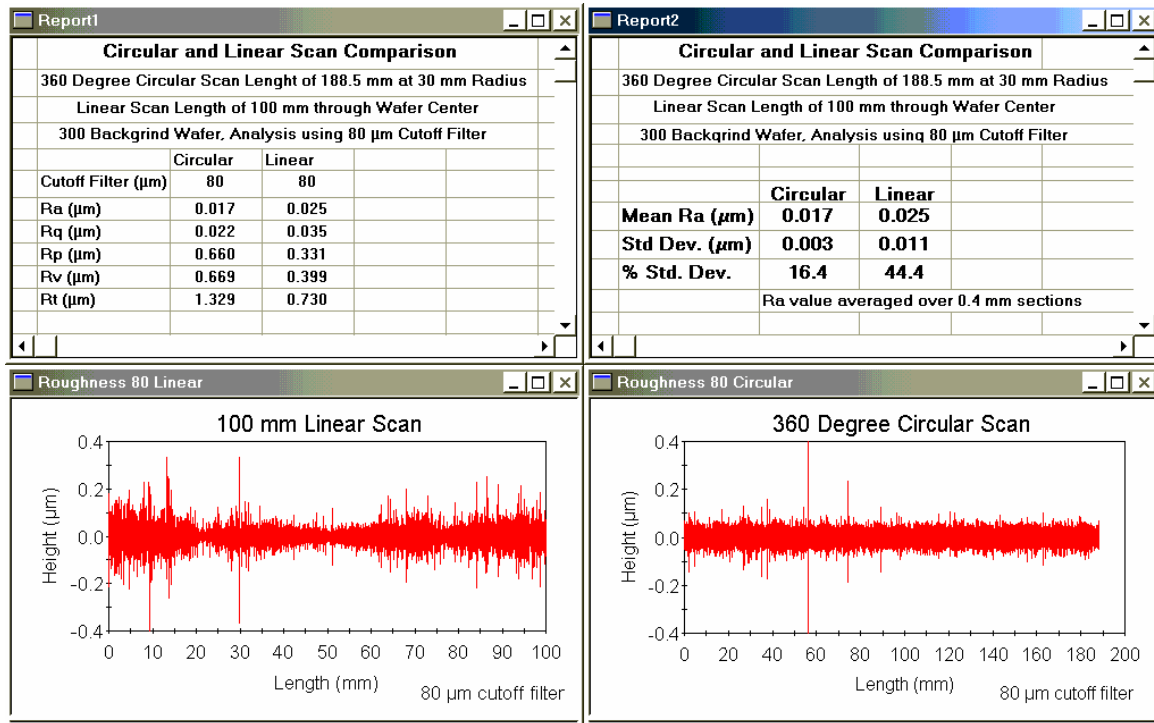


Figure 9 - Comparison between the linear and circular scan geometries. The roughness data has been analyzed with an 80 μm cutoff filter to show the finer surface features on the backgrind wafer.

The data in Figure 9 consists of four windows:

- The lower right data window shows the full 188.5 mm length circular scan analyzed with an 80 μm cutoff filter.
- The lower left data window shows the full 100 mm length scan through the wafer center analyzed with an 80 μm cutoff filter. The non-uniformity of the roughness result due to the spiral pattern is evident in the result.
- The upper left data window shows a comparison of several roughness statistics for both linear and circular scan patterns. The roughness result for the linear scan is higher than the circular scan. The Rt value (peak to valley) is higher in the circular scan result because of a scanning across a bigger defect.
- The upper right window shows an analysis of both circular and linear scan geometries using 0.4 mm sections. The standard deviation of roughness calculated over sections is lower for the circular than linear geometry.

Conclusions

Both linear and circular scan patterns can be used to measure the roughness of a backgrind wafer. The digitized Nomarski view of the surface is also available to document particular features on the wafer. Chapman offers a number of advantages for backgrind roughness measurements, including non-destructive, long scan measurement, broad and fine surface feature analysis, and 360 circular scan geometry at any radius.