

Wafer Roll Off Measurements for Silicon Wafers

By Thomas C. Bristow
Chapman Instruments

Abstract

We present a new method for measuring the roll off of Silicon Wafers using a Chapman Instruments non-contact profiler. Recent interest in this type of measurement has been due to the shrinking of the edge exclusion zone and adding more die to the wafer. The profile and analysis of this transition region - from flat polished surface to edge - is shown in this paper.

Wafer flatness near the edge is becoming more important - driven by smaller linewidths. The edge exclusion region has been specified as 3 mm for 200 mm wafers; however recent semiconductor industry trends are driving this edge exclusion to 1 mm to gain more area for production. The lithography process is moving closer to the edge and depth of focus issues requiring a flatter surface near the wafer edge. We present a method to measure the profile within the 3 mm exclusion length and into the wafer bevel edge region. This measurement can provide a better control of wafer flatness.

This paper is divided into several sections, including wafer edge geometry, measurement data and examples.

Wafer Edge Geometry

Figure 1 shows the wafer edge geometry. The polished area, and wafer roll off are shown in the edge exclusion region. The beginning of the wafer bevel is also evident in the Figure. The flat region normally is specified for flatness and measured using capacitive gauging. The 3 mm edge exclusion shows a roll off in the profile. The third region is the edge bevel, or actual beginning of the wafer edge. The polishing process determines the extent of the wafer roll off.

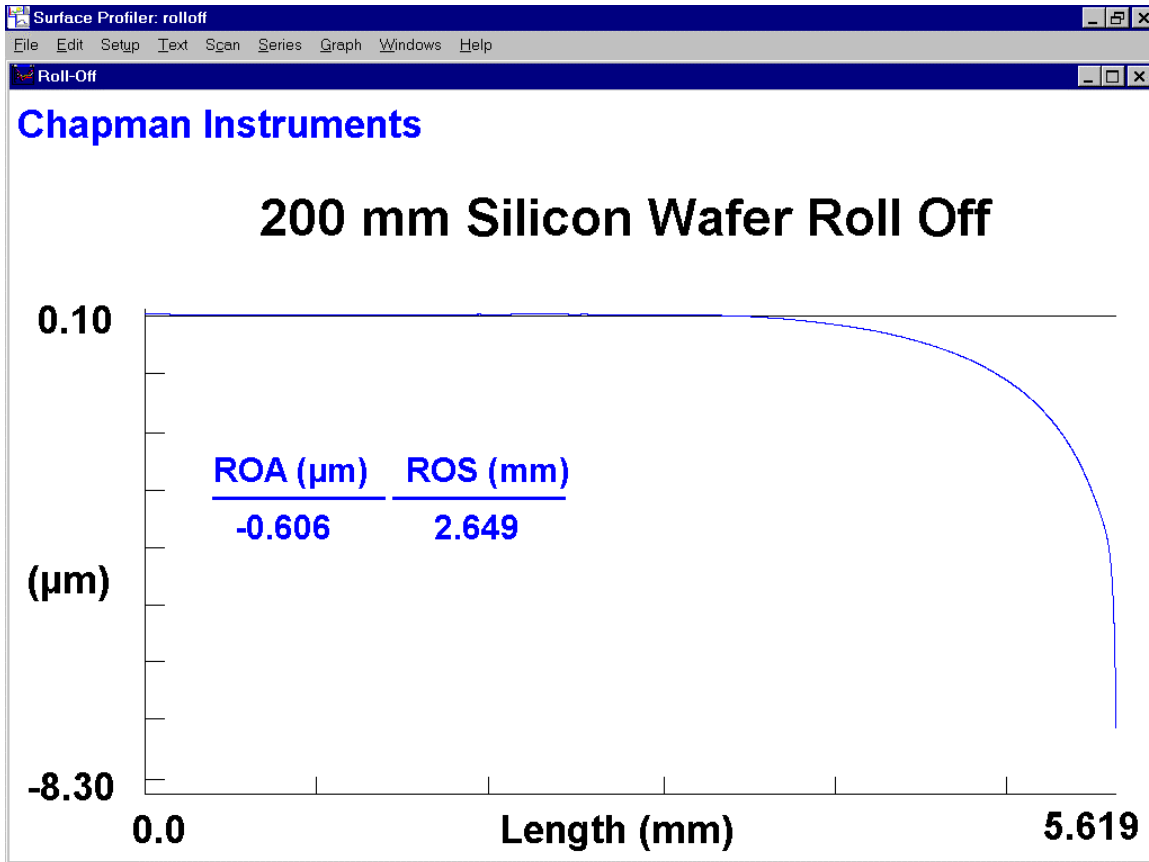


Figure 1. Measurement of the roll-off at the wafer edge. The flat polished wafer extends over the first 3.5 mm of the data. Most of the 3 mm edge exclusion shows a profile roll-off. The measurement starting point was near the edge of the wafer, including enough area over the flat wafer section. Two parameters, ROA and ROS are used to measure the extend of a non-flat wafer profile.

Measurement Configuration and Data

The measurement configuration for roll off measurements using one of Chapman's non-contact surface profilers can be set for one location, four, eight or any number. An examples of one measurement is shown in Figure 1. The set up for the measurement is configured so that the wafer is first automatically positioned in a Chapman MP3100 non-contact optical profiler. The MP3100 non-contact profiler automatically finds the notch or flat, then positions the wafer for measurement. The macro for this measurement is set up for an 8 mm scan length approximately 6 mm from the wafer edge. This setup guarantees that the measurement will extend into the exclusion zone, bevel region and off the wafer edge. An advantage of an optical profiler is that the actual edge location can be easily measured. The Chapman software automatically finds the wafer edge and eliminates the data off the wafer surface. Figure 1 shows the result of one measurement with this roll off.

Two parameters have been used to represent the wafer roll off geometry. These parameters are referenced in the paper by Masahiro Kimuar, et.al (ref.1). The two parameters are the roll off amount, ROA and the roll off starting point ROS.¹

ROA is defined as the vertical height distance from the leveled surface to the profile in the roll off region at a location 1 mm from the edge. This definition has been used previously to provide good correlation with capacitive gauge measuring equipment. (ref. 1). This parameter has been defined at the location 1 mm

from the wafer edge. Other vertical height distances can be also be calculated with simple changes to the Chapman software package.

The other measurement parameter for edge roll off is ROS. This parameter is calculated as the horizontal (X distance) location where the profile data first decreases below the level line (essentially where the roll-off starts.) Figure 1 shows an example of the ROS distance for a 200 mm polished Silicon wafer. Other location points can also be calculated from the Chapman software.

Figure 2 shows a schematic for the measurement conditions of both ROA and ROS in the wafer roll off region.

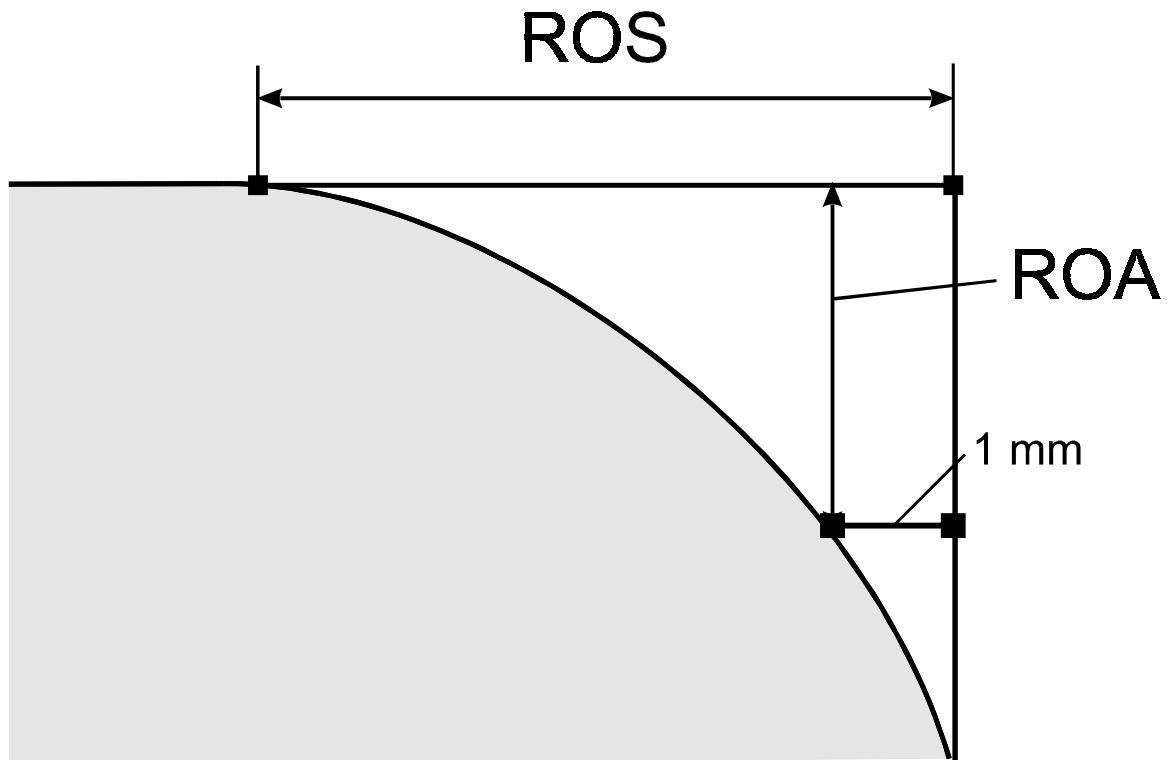


Figure 2. Diagram showing the ROS and ROA parameters. ROS is defined as the distance from the wafer edge to the point where the surface profile is zero. ROA is defined as the vertical distance from the leveled line to a location 1 mm from the wafer edge.

The measurement of the wafer profile can also be set up at several locations of the wafer. One example is the measurement of the wafer at eight locations in 45 degree increments. Figure 3 shows the geometry for this type of roll-off measurement.

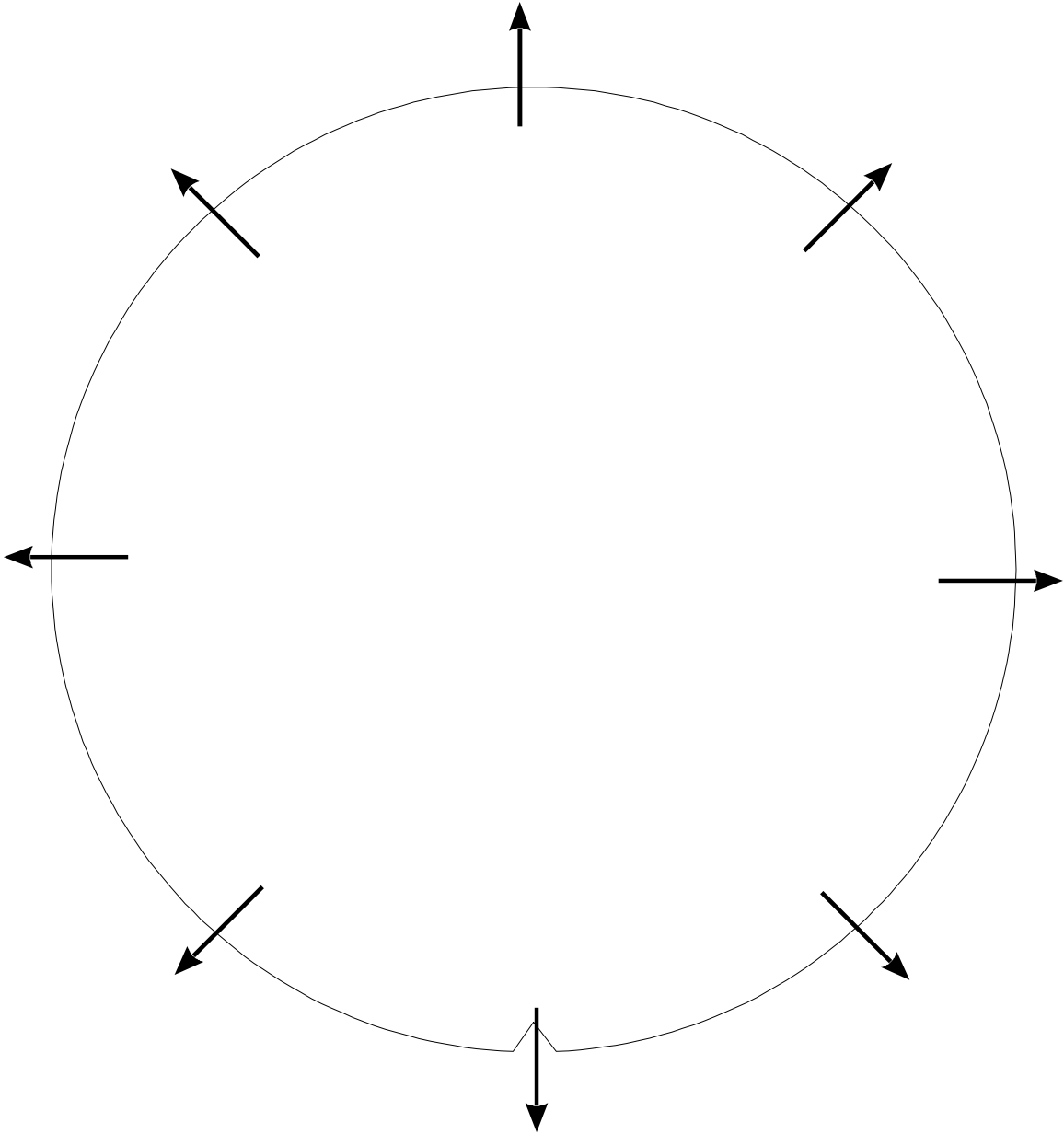
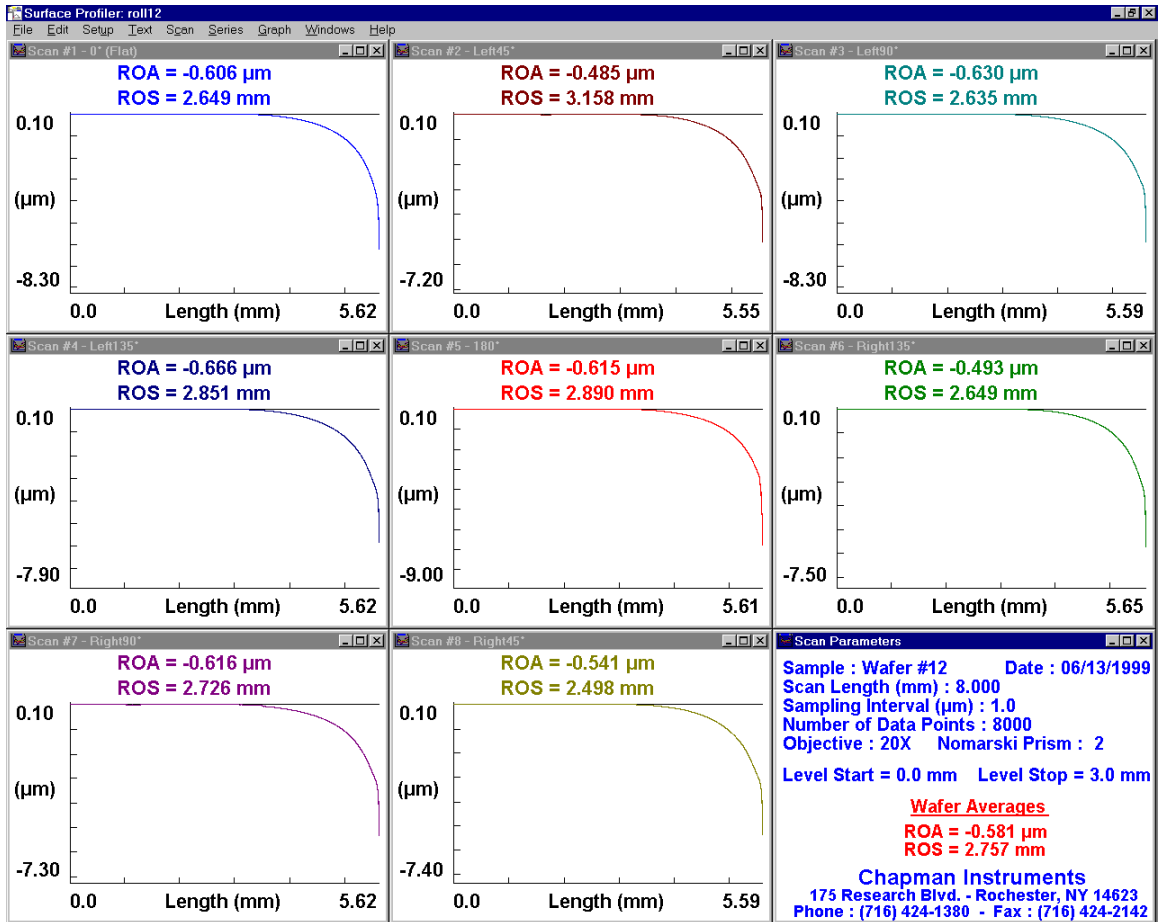


Figure 3. The geometry for a measurement at eight locations, each separated by 45 degrees.

Figure 3 shows the geometry for measuring eight locations on a silicon wafer. The geometry is shown with a measurement at 45 degree increments. This provides a measurement at eight locations around the wafer. Other measurement geometry's can be chosen with either more of fewer locations.

Figure 4 shows eight profiles from the same wafers taken at 45 degree increments. This analysis shows that there is a similar shape around this one wafer. The different values of the ROS and ROA are all relative to the edge location.



In conclusion, we show a new method for analyzing the wafer profile in the exclusion zone. This method uses a non-contact surface profiler with no damage to the wafer surface, and the capability of a fast accurate measurement. Complete measurement systems are available with full automation, including cassette to cassette handling for production operation.

-
- 1 Masahiro Kimura, Yasuo Saito, Hiroshi Daio and Kenji Yakushiji, Jpn. J. Apple Phys. Vol 38 (1999) Pt.1, No.1A.