SAWYER

TECHNICAL BRIEF

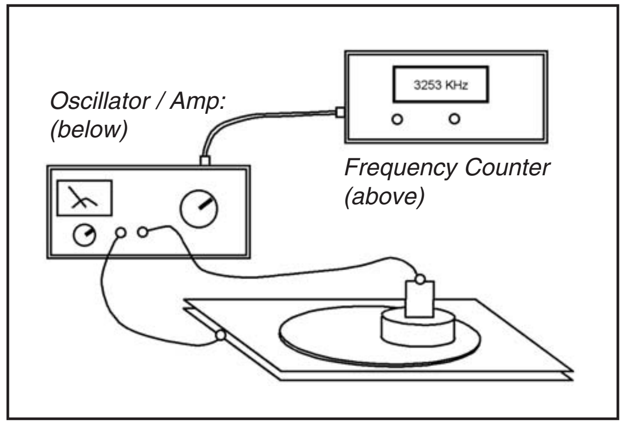
SPECIFICATION OF SAW WAFER FLATNESS

INTRODUCTION

The polished surface flatness of a SAW substrate is critical to the process used to image the devices created by the manufacturer. Fabrication imaging tools such as wafer steppers are subject to depth of field limitations. This equipment characteristic may vary by brand and model often resulting in unique customer wafer flatness requirements. The substrate's ability to perform within these limitations relates to the magnitude of its thickness variation, TTV (total thickness variation) and LTV (local thickness variation). Sawyer recognizes the importance of and the need for quantitatively defined product characteristics as the basis for communication with customers and for continuous improvement. Consequently, we use state-of-the-art tools for measuring wafer flatness and NIST-traceable standards to ensure the highest integrity in wafer quality checks and in support of our continuous improvement objectives.

THICKNESS VARIATION

Sawyer uses two basic methods for measuring thickness variation throughout the wafer fabrication process – frequency measurement and PMI (phase measurement interferometry). During the early phases of fabrication, frequency measurements in either a 5-point or 9-point pattern (depending on wafer diameter) are checked on randomly selected wafer samples to monitor process performance. A frequency generator is used in conjunction with a frequency meter to measure the resonance of a small portion of the substrate. The diagram below illustrates the set up for determining substrate thickness by resonant frequency matching.



The total variation in resonant frequency across the wafer can be readily converted to a TTV measurement. This technique provides rapid feedback during the wafer polishing process with an accuracy of ± 3 KHz or ± 0.2 microns and repeatability of ± 0.1 microns. It also avoids contact on the polished surface that may result in surface scratches or defects in the finished product.

At the end of the fabrication process, randomly selected samples are subjected to a more sophisticated measurement of thickness variation. Sawyer's process baselines for TTV and LTV have been established and are monitored in the final product state using Corning-Tropel Flat Master advanced flatness measuring equipment.

The clean polished wafer is placed on a large, very flat vacuum chuck to create a "backside referenced" measurement. Digital imaging and analysis of the optical fringe pattern created when comparing the polished wafer surface to a reference surface results in TTV and LTV measurements with an accuracy of ± 0.20 microns and repeatability of ± 0.25 microns at one sigma. This final inspection tool is also used to qualify any process changes that may have an impact on substrate flatness.

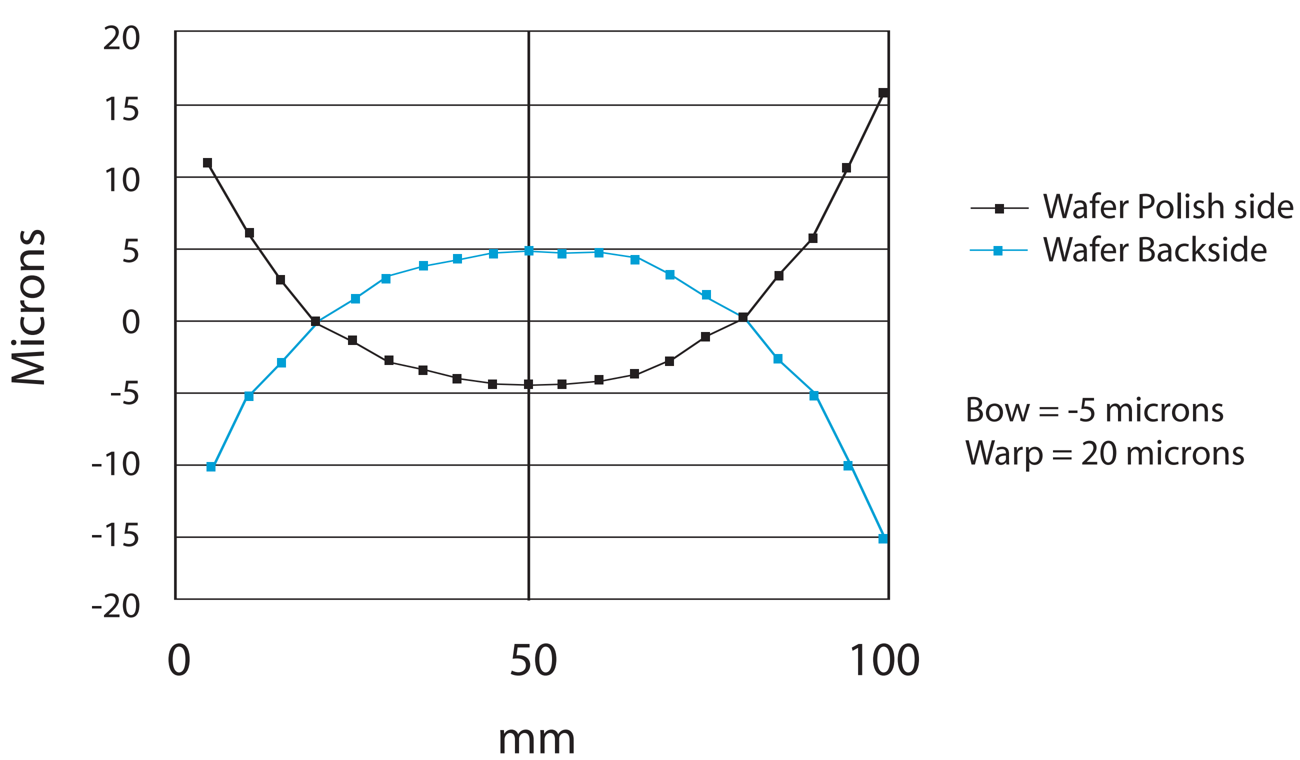
Sawyer uses the Corning-Tropel Flat Master to characterize bow and warp after polishing. This tool takes advantage of the better reflective property of a polished surface to provide higher resolution. At final inspection the wafer is held in a vertical position on a center-hold vacuum chuck that allows the wafer to remain in a "free-standing" or "unclamped" state during measurement.

We have established internal specifications for flatness described in terms of bow and warp. For 3-inch and 100-mm diameter wafers having a thickness of 0.25 mm or more, bow shall be less than ± 20 microns. Similarly, warp shall be less than 40 microns.

Very thin wafers bend easily and consequently, for them, bow and warp are less an intrinsic characteristic of the wafer and more the result of forces acting on the wafer (such as gravity).

For nonstandard size or shape wafers, bow and warp are measured using a microscope with very narrow depth of field and a stage height scale resolution of 1 micron. The surface of the wafer is put "in focus" and the height scale reading taken for a number of points in a line across the wafer. This microscope method produces data that is in very good agreement with PMI-derived values when comparison is made along a common line.

Microscope-generated Data for Bow and Warp
(polished wafer)



Revised: April 2006

35400 Lakeland Boulevard, Eastlake, Ohio 44095, U.S.A.
PHONE: 1-440-951-8770 FAX: 1-440-951-1480 EMAIL: sales@SawyerLLC.com

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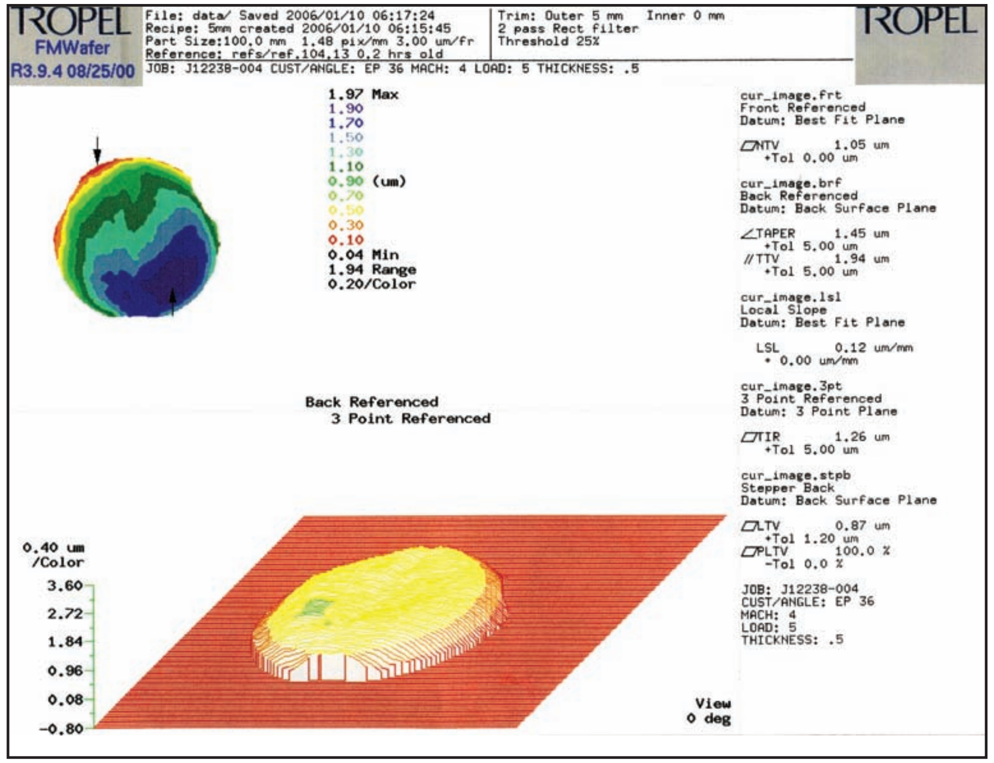
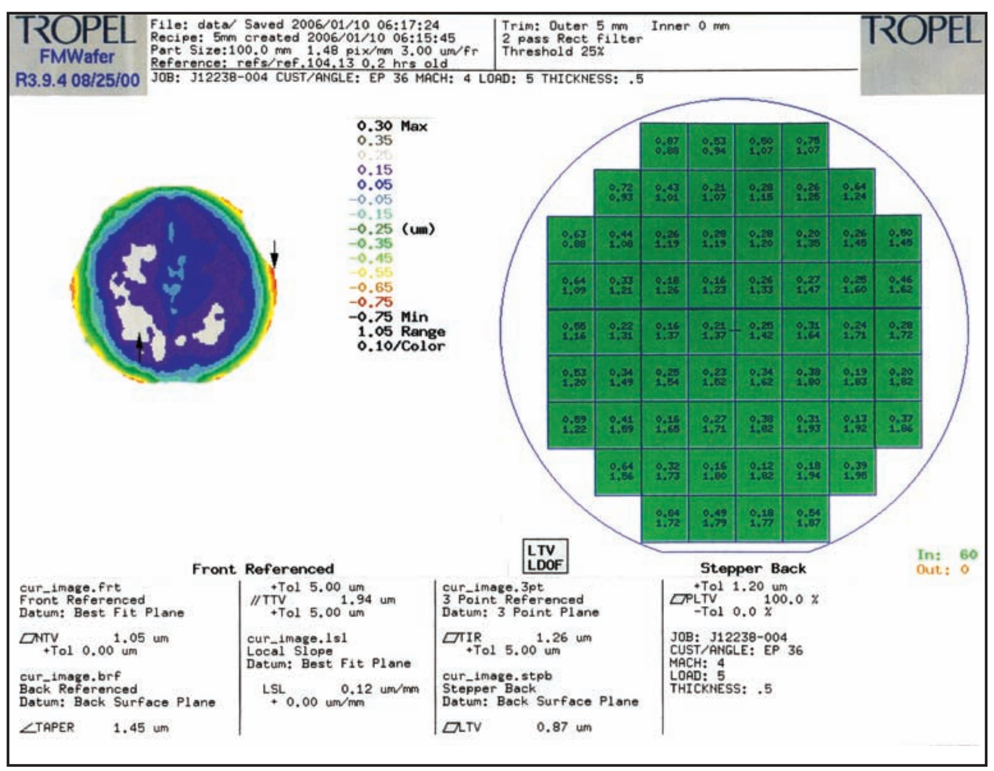
TTV is defined as the difference between the highest and lowest elevations of the usable polished front surface of the substrate with respect to its backside. LTV is the difference between the highest and lowest elevations of the front surface with respect to the back surface within a well-defined area, usually specified as a 5 mm x 5 mm or 10 mm x 10 mm “site”. The area near the substrate edge not used for device fabrication is usually excluded from the measurement (typically 3 - 5 mm).

Sawyer has established internal specifications for flatness expressed in terms of thickness variation. For 3-inch and 100-mm diameter substrates having a thickness of 0.25 mm or more, TTV shall be 4.0 microns or less based on a 3 mm edge exclusion. Similarly, LTV shall be 1.5 microns or less for > 95% of the sites based on a 10 mm x 10 mm site size and a 3 mm edge exclusion. See the Tropel Flat Master output for LTV and TTV measurements illustrated at the right.



TTV Contour Plots from Tropel Flat Master (polished wafer)



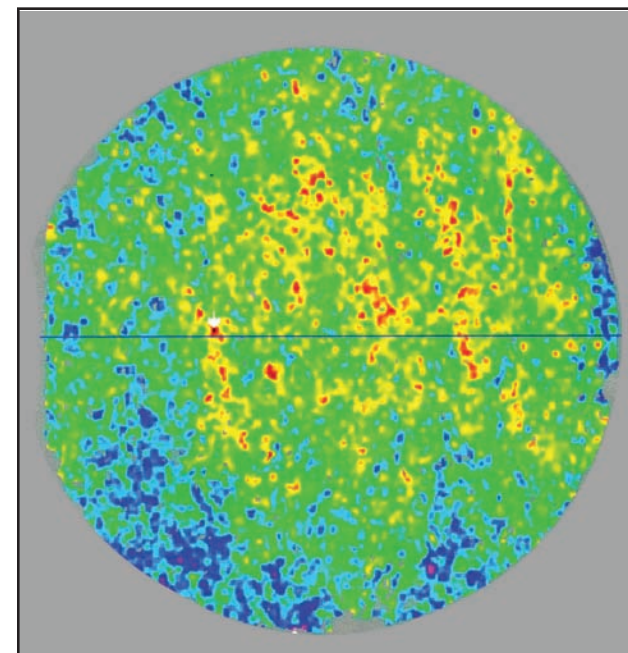
LTV Contour Plot and Site Map from Tropel Flat Master (polished wafer)

BOW AND WARP

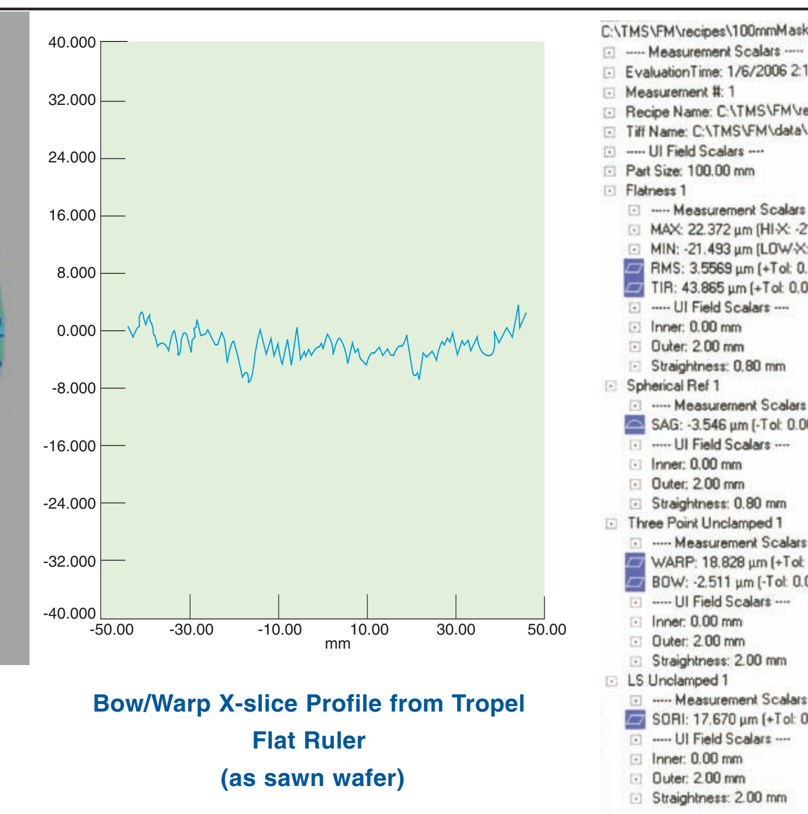
The bow and warp of a SAW substrate can also be critical to the process and equipment used to image the devices created by the manufacturer. Bow and warp both measure the flatness of an unclamped wafer relative to a median reference plane. Bow describes the deviation of the center of the wafer from the reference plane. A positive value indicates the polished surface is convex. A negative value indicates the polished surface is concave. Warp describes the total deviation of the entire wafer surface from the median plane. It is the sum of the maximum absolute values of the deviations above and below the plane.

To characterize wafers for bow and warp during and following the wafer fabrication process, Sawyer uses instruments based on PMI (phase measurement interferometry). The phase difference between light reflected from the wafer surface and light reflected from a flat reference surface creates a fringe pattern. Digital imaging and analysis of this pattern provide bow and warp measurement accuracy within ± 5.0 microns.

Bow and warp can first be introduced during the wafer slicing process. The Corning-Tropel Flat Ruler 200 has a high dynamic range that allows characterization of the unpolished wafer as it comes off the saw. Below are illustrations of the Tropel Flat Ruler data for bow and warp measurements.



Bow/Warp Contour Plot from Tropel Flat Ruler (as sawn wafer)



Bow/Warp X-slice Profile from Tropel Flat Ruler (as sawn wafer)