LUMETRICS®

Precision Measurement Solutions

# Glass Measurement Using White Light Interferometry

There are many issues in maximizing the glass manufacturing process. Whether producing float glass, tubing, bottles, or other products, the measurement of thickness is one of the critical parameters in a successful operation. Over the years different technologies have been tried, some to better success than others. This article describes a technology that has been very successful in many different glass applications – white light interferometry.

Common methods for measuring glass include laser triangulation, spectrometers, digital micrometers, and manual touch gauges of various types. Manual touch gauges have all the issues inherent to manual measurements including variability based on user, longer time to measure, data integrity, and operator error. Automated gauges like spectrometers, and laser triangulation gauges remove the data integrity and time to measure issues, but often bring issues such as set-up and usability issues.

**Technology:**

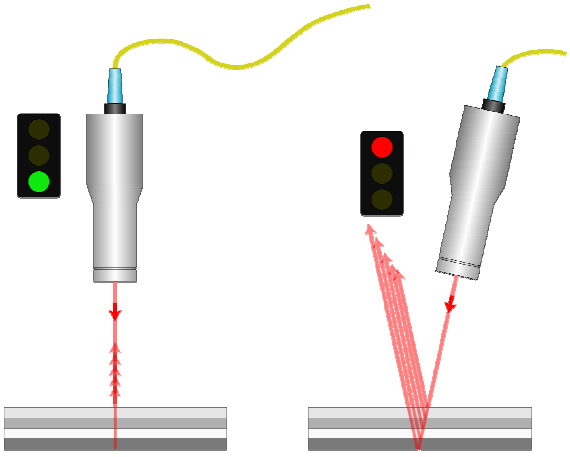
Lumetrics® has developed an all-fiber based interferometer called the OptiGauge®. In traditional white light interferometers, they use a mechanical rotating flywheel with mirrors to provide the core function of creating interference fringes - what the system measures. The rotating flywheel is used in conjunction with free space optics - which channel a light beam through a series of mirrors and prisms and then out through an optical fiber to the probe and measured surface. These mirrors are subject to alignment and use issues over time.

In the OptiGauge system, in place of the rotating mirror, Lumetrics has designed a fiber wrapped piezo coil to provide the interference fringes. The piezo coil works on the principle that when electricity is connected to it, the piezo material expands or contracts. The fiber is glued onto the coil with a special epoxy and when the piezo stretches or contracts it changes the length of the fiber. This provides the same effect as the rotating mirror with none of the moving parts and limitations. Because of the piezo coils, the Lumetrics system uses no free space optics. Therefore, alignment issues are eliminated,

motor and bearing wear are non-existent, and the system is able to withstand environmental factors easily.

The piezo coils can be operated at extremely rapid speeds in the Megahertz range. The Lumetrics system currently operates in the range of 20-200 measurements per second. Each sample in the current sampling rate is comprised of thousands of data points per sample. Data collection speed is balanced against processing speed of the collected data. The Lumetrics system does real time processing and display of the data as it is collected.

The OptiGauge directs the beam of light through a probe at the surface to be measured. Reflections from each surface the beam encounters are directed back up through the probe and into the interferometer for analysis. A critical component of the system is the relationship of the probe to the surface being measured. The probe must be positioned $90^0$ to the surface +/- the tolerance of the particular probe. Lumetrics® provides standard probes for various applications and these probes have tolerance ranges of from $2^0$- $5^0$.



Correct and incorrect alignment

Lumetrics has experienced optical engineers who can design probes for various applications. Each design takes into account the focal length, degrees of tolerance, depth of field, measurement spot size, and other factors. Probes have been designed that can look at a tube of glass the size of a soda straw from two feet away, to probes that sit very

close to sample and look at measurement spots of a few microns, and others that are small and flexible and can fit inside a bottle to measure characteristics that are difficult to access.

Large diameter 2 foot focal length probe


Small diameter probe

Positioning the probe perpendicular to the measurement surface is the art of an OptiGauge installation. Lumetrics mechanical engineers are experts at understanding a customer's problem and then designing fixturing and apparatus to position the probe correctly. Some fixturing is as simple as a lab stand with X / Y stages, and it can be as complex as robotics or other scanning system.


Probe integrated with robot

LUMETRICS®

Precision Measurement Solutions

**Markets:**

Since 2003 Lumetrics has worked with all of the leading glass manufacturers in the world in the measurement of their specialty glass products. Lumetrics' systems measure float glass and coatings at the hot end and even in a tin bath. They measure water glass and other multilayer products like safety glass without contact and non-destructively.
Lumetrics OptiGauge technology measures tubing of various sizes both on line and in the lab. Additionally, the OptiGauge measures bottles, large specialty light bulbs, and other round and shaped glass objects for industrial and medical applications. Our technology is even used for in-process glass slimming measurements. These glass slimming applications use hydrofluoric acid, an extremely dangerous process.

**Float Glass:**

Lumetrics systems provide real-time, accurate, online measurements for float glass lines. Measuring glass both in the tin bath and just outside on the hot end is critical to plant efficiency because it allows for the fastest feedback to the plant operators.

Lumetrics can position their OptiGauge system thousands of feet away from the oven and run fiber optic cables to the probe or probes doing the measurement at the line. Up to 8 probes can be connected to a single OptiGauge for any configuration need.
The probe is the size of a magic marker and can be mounted in a fixed location or on a scanner. Some customers have mounted multiple probes within a cooled chamber located in the tin bath itself. In other installations the probes are located on scanners right outside the bath, but still in the hot area. Heat and ambient light do not affect the operation of the system or its accuracy.

With an accuracy of .1 microns (0.000004") the OptiGauge provides users with the ability to track their production and bring glass thickness tolerances to unprecedented levels. One plant is saving 2% on raw materials by being able to consistently operate at the lower edge of a tolerance range. Plants using Lumetrics equipment are saving hundreds of thousands to millions per year by fine-tuning their lines. The OptiGauge helps plants bring lines up to specification faster and keep them there. The systems are also easy to set up with very little alignment needed. Rapid setup, easy operation, and reliable results make the OptiGauge the choice among online users.

LUMETRICS®

Precision Measurement Solutions

Additionally, the OptiGauge is ideally suited for off line inspection of finished or in-process products. Customers are using the OptiGauge with scanners and manual fixtures to test thickness variability, coating thickness, multi-layer structures, and other features of their glass while in the production process. Coated glass, water glass, multi-layer composites – the OptiGauge can measure any thickness from 0.025mm – 35mm.

In-process float glass measurement locations for Lumetrics OptiGauge

**Glass Slimming:**

Lumetrics provides specialized OptiGauge systems to manufacturers who use hydrofluoric glass slimming operations. A specially coated probe is inserted into the chamber in an alignment system that keeps the probe perpendicular to the glass being treated. Customers have many advantages by measuring the glass in situ.

Processes can be monitored in real-time allowing the customer to reduce the risk to personnel and the product that can occur with traditional operations. Today a slimming system would be shut down part way through the process, a measurement taken, calculations performed, and then the glass reinserted and process started up again for a pre-determined time.

This start – stop process takes time and subjects operators to the risks of hydrofluoric acid leaks and injury. Operators have estimated that the in-process OptiGauge system saves them 30% in production time, while reducing risk!

**Glass Bottles and Globes – Industrial and Medical:**

The OptiGauge is ideal for measuring objects of miscellaneous shapes and sizes. Glass measurements include wall thickness and concentricity, Inside Diameter, Outside Diameter, neck indent and more. The OptiGauge is an ideal instrument for various types of glass from bottles to bulbs to florescent tubes. OptiGauges have been installed on production lines for florescent tubes and light bulbs. For bulbs the critical dimensions were the wall thickness at specific locations. The bulbs were spun and the probe was located at a specific angle and position. This gave readings at multiple locations and average thickness readings were produced.

There are many glass medical products which have tight tolerances and require more thorough dimensional measurement than that provided by manual methods. In addition to ampoules mentioned below, glass vials, tubes, and bottles require strict adherence to standards. With the correct fixturing, the OptiGauge can measure any of these products either on the production line or in the QA lab.

Glass bottle production

LUMETRICS®

Precision Measurement Solutions

Large light bulbs with critical dimensions

Early bottle testing

**Glass Tubing and Ampoules:**

Lumetrics provides thickness measurement for a variety of glass manufacturers including ampoule and tube manufacturers. The reasons for needing an OptiGauge are many and range from on line gauging to maintain specification tolerances, to incoming inspection of preliminary tubing, to measurement of the ampoules after they've been sealed. Many of these customers are in the medical market and their needs may center on quality as well as scrap and throughput.

The OptiGauge reduces variability and improves yields in the production of Glass tubing. Using an online multi-probe fixture, customers are able to track wall thickness, ID, OD, concentricity, ovality, and other variables while the tubing is being extruded. These measurements are fed back to the control system for rapid real-time adjustment of the process. Whether it is capillary tubing, florescent lights, or anything in between, the OptiGauge provides the accuracy that is needed to increase quality while reducing scrap and improving yields.

LUMETRICS®

Precision Measurement Solutions

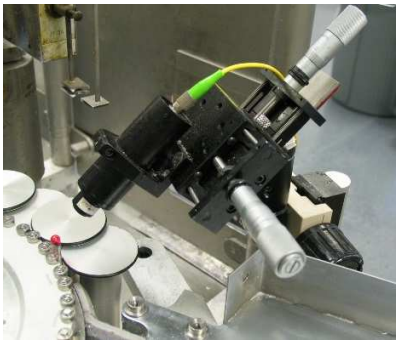

4 probe online tubing fixture.

For ampoules, traditional testing techniques center on drop tests to check for weakness and breakage but these tests are crude and inaccurate. Many other tests are strictly destructive and subjective. Breaking open ampoules and then trying to measure corners with micrometers, magnetic current testing, and other methods are used by industry today.

Lumetrics' OptiGauge combined with customized fixturing can provide a manufacturer with the tools to monitor in-process thicknesses on incoming inspection of tubes, and can also provide real time thickness measurement of multiple ampoules while they are being made and sealed. Lumetrics' OptiGauge directs an infrared light beam at any location on the tube and is able to determine thickness. Obtaining 200 samples a second allows the OptiGauge to measure multiple ampoules while they are spinning and obtain thickness measurements around the dome of the ampoule at any angle. This same system can be used to measure tube walls before the ampoule is sealed.

LUMETRICS®

Precision Measurement Solutions



Online testing of ampoule dome thickness

Off-line testing fixture

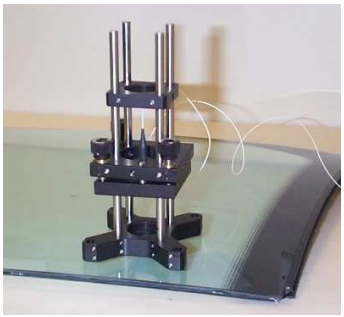
**Auto and Architectural Glass:**

One of the most prolific uses of glass is in architecture and automotive products. Many of these are composites of glass and some sort of polymer. One of the problems companies have experienced over the years is how to determine whether there are air pockets or gaps between the layers. This makes them unstable and subject to catastrophic failure. Additionally, some functionality, such as the use of heads-up display, requires specific dimensional forms in the polymer.

Lumetrics has been working with glass and polymer companies over the last 10 years to identify and solve various issues associated with glass and polymer bonding. With a simple hand held device and gathering data at 200 samples per second an operator can scan a sample and determine any voids or defects. Combine this same probe with a robotic arm and a CAD drawing and any piece can be examined and mapped in seconds. The OptiGauge systems are in use on the production line, in QA facilities, and in R&D centers solving problems every day.

LUMETRICS®

Precision Measurement Solutions



Early windshield testing

Windshield probe

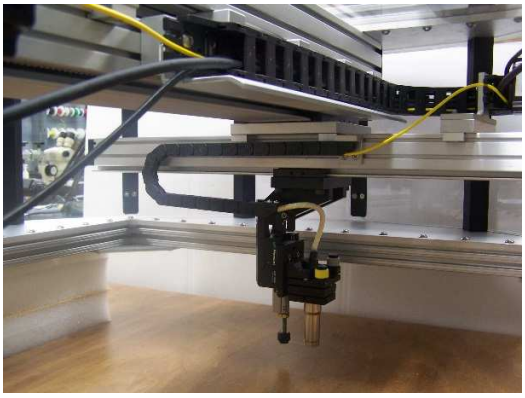
Windshield probe side view

**Optics and Glass Flats:**

Optics and glass flats of most any size and shape can be measured by the OptiGauge. Lumetrics provides fixturing for typical optical components and then, if needed, teams with other mechanical design groups to produce a system tailored to a customer's design. Lumetrics first customer was Corning Tropel and their system was designed to measure the air gaps on multi-lens stacks. Corning Tropel and Lumetrics presented a joint paper that discussed the accuracy and repeatability of the OptiGauge as well as its method to ensure the accuracy of each system before it leaves the factory floor.

Some of the various fixturing solutions are shown below.

Large Optics scanning system

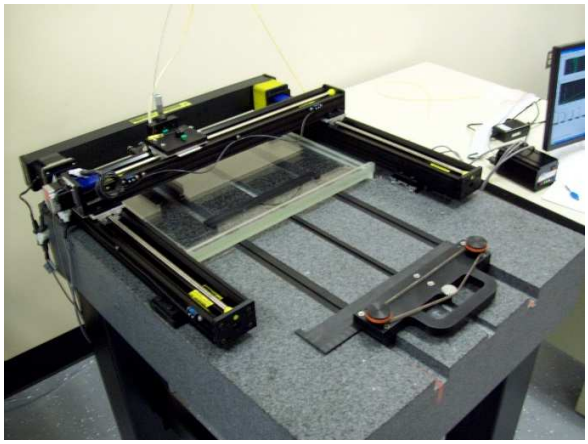


Scanning system inside

LUMETRICS®

Precision Measurement Solutions

Silicon / glass bonded wafer scanner



Precision glass scanner

For more information on these and other glass applications contact us at **sales@lumetrics.com**.