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AUTOMATED DIMENSIONAL MEASUREMENT OF MICROFLUIDIC FLOW CELLS

Kyle Hadcock, *Principal Opto-Mechanical Engineer, Lumetrics, Inc.*

***Abstract*—Lumetrics, Inc. (Rochester, NY) has made inspection of internal dimensions of microfluidic flow cells possible with low-coherence white light interferometry. The OptiGauge II can measure internal channel heights down to 12 microns with 100 nanometer precision quickly and non-destructively. Machine vision-aided inspection stations can quantify other critical dimensions of entire production runs, ensuring higher product quality and that the performance specifications are met.**

***Index Terms*—non-contact, interferometry, metrology, optical thickness measurement, cytometry, microfluidics, optofluidics, flow cell, machine vision**

I. Background

Microfluidics is the science surrounding the controlled manipulation of fluids within small, optically transparent chambers, called flow cells.

Microfluidic flow cells are integral to the life-sciences, biomedical, and optofluidics industries.

Carefully crafted flow channels are required to achieve the hydrodynamic focusing needed to ensure proper cellular alignment and speed during analysis for cytometry applications.

Practical applications take advantage of the laminar flow characteristics of the fluids as they pass through small channels to align randomly distributed particles, such as biological cells, within surrounding fluid along the flow path.

Such microfluidic cells enable sensors to count and image particles, as well as measure their optical and physical parameters as the particles flow by. In order for flow cells to function properly, tightly-held tolerances and geometries must be guaranteed in order to ensure the particles flow in an expected manner.

Manufacturers of flow cells need inspection equipment to ensure their product meets their published specifications, so end-users are able to get predictable and repeatable results.

II. Introduction

Lumetrics, Inc. is the market leader in providing high-precision, non-contact dimensional measurements to medical, scientific, and ophthalmic industries.

A unique capability of Lumetrics' thickness measurement device, OptiGauge II, is its ability to measure the individual layer thicknesses of a multiple-interface structure.

The OptiGauge II (Figure 1) measures optical thickness using low-coherence light source with its spectrum centered at 1310nm. This is an ideal wavelength for measuring through nearly all visually transparent and semi-transparent objects, like glass or plastic. Some visually opaque materials, such as silicon, are also transparent to this wavelength, and therefore can be measured.

Combining the capability of the OptiGauge II with a precision multi-axis scanner, one can characterize the

Figure 1: OptiGauge II

Figure 2: Example of a microfluidic flow cell used in flow cytometry

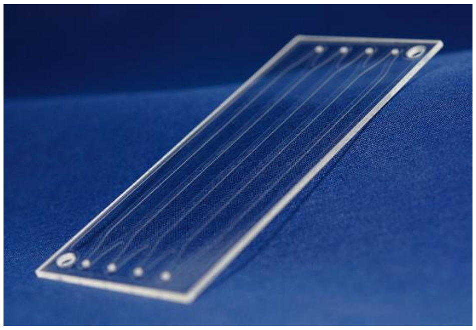

Figure 3: Example of a multi-channel flow cell

entire functional length and width of the flow channel (Figure 2).

Machine vision can also be integrated for inspection of channel paths and widths (Figure 3). This information can be used by cell manufacturers to ensure that the specifications are met, and to implement process improvements to increase yield.

Due to the high data acquisition rate of the OptiGauge II and modern motorized scanning hardware, even multi-channel flow cells can be inspected in seconds, without the need of destructive dissection methods.

III. CYTOMETRY FLOW CELL CHANNEL HEIGHT

Measuring the channel height is a straightforward application for the OptiGauge II. A simple manual scanner was set up to translate a measurement probe down the channel length while acquiring data. A thickness profile of the flow cells channel height is shown in Figure 4. Total scan time was approximately 5 seconds.

IV. MICROFLUIDICS FLOW CELL CHANNEL HEIGHT AND STRAIGHTNESS

The OptiGauge II can simultaneously measure the outer dimensions, wall thickness, and channel height. Combined with an automated scanner, a repeatable path can be programmed into the system for the measurement probe to follow to determine measured values with respect to location. Such systems offer ease of use and repeatability required for inspection of multiple components quickly and accurately. Figure 5 shows measurements of the flow cell's wall thicknesses (green and blue lines, left axis) and channel height (red line, right axis). Figure 6 shows the flow cell's overall height. Since the overall height is well-controlled (within approximately +/-0.5 microns peak-to-valley), one can determine straightness of the flow cell's channel by observing changes in wall thickness. When the wall thickness is changing, so is the straightness of the channel.

V. ENHANCED MEASUREMENT CAPABILITIES

In addition to thickness, machine vision systems can

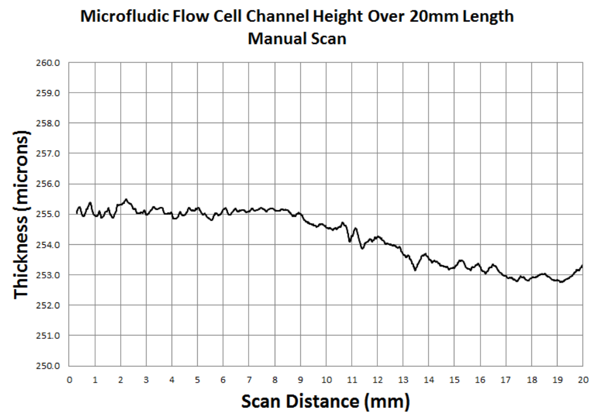

Figure 4: Thickness profile of a flow cell's channel depth

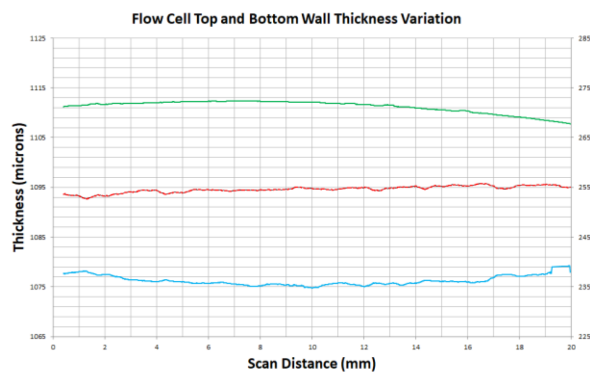

Figure 5: Wall Thickness and Channel Height

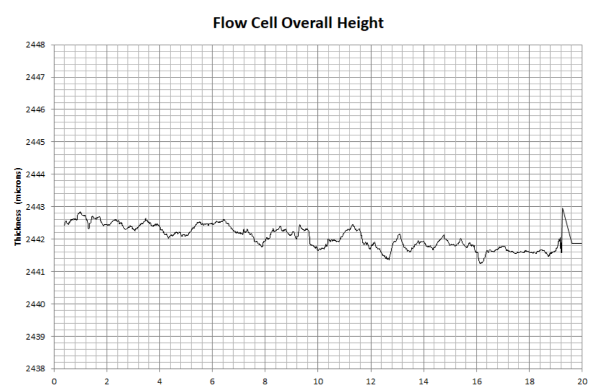

Figure 6: Overall Height

be integrated into an inspection station to add the ability to examine channel widths, lengths, and other path geometries.

VI. Real-World Applications

Using simple manually-actuated linear stages, an operator can take a single flow cell and manipulate its position below a fixed inspection sensor to acquire the desired dimensional measurements. This cost-effective hardware solution will provide immediate improvement in accuracy over existing test methods.

To increase throughput and increase overall return-on-investment (ROI), Lumetrics can design an automated test workstation capable of providing a single operator the ability to examine thousands of parts over a given shift, allowing 100% inspection of product. For example:

1. Operator loads a production-lot of parts into one or more trays near the inspection station.
2. A tray is taken and loaded into a safety-guarded robotic test cell and a door closed.
3. The operator starts the automated inspection of all pre-identified dimensions and channel paths contained within the tray.
4. The cycle completes and data is uploaded to a server database; the inspection report printed.
5. The operator unloads the measured tray and loads in the next tray, repeating the cycle until the entire production lot has been inspected.

VII. Conclusion

Lumetrics' team of scientists and engineers continue to develop inventive ways to inspect precision-manufactured parts.

Microfluidics industries and the manufacturing of cytometry flow cells are expected to continue rapid growth over the next decade. Manufacturers taking advantage of the most sophisticated inspection technologies will be able to better innovate and meet the demand of this increasingly competitive market.

By more efficiently characterizing part variation and using more accurate inspection techniques, suppliers will be better equipped to diagnose production issues early and significantly reduce scrap and ensure non-compliant parts do not reach their end customer.

VIII. Special Thanks

Lumetrics would like to thank FireflySci, Inc. of Staten Island, NY (http://www.fireflysci.com) for their assistance in providing a cytometry flow cell for testing.

Contact Lumetrics for additional information

Email: sales@lumetrics.com or engineering@lumetrics.com