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High-Level Inline Quality Inspection in Mass Production of 3D Glass for Consumer Electronics

Optical chromatic and interferometric sensors ensure fast and contactless geometry, thickness and cosmetic defect inspection at minimum cycle times in mass production.

Abstract

Nowadays a continuously increasing number of products is made of glass or consists of glass components. This trend is mostly apparent in the fast growing consumer electronics industry, where for example smartphones, tablets and televisions incorporate various glass parts of highly complex and structured geometries, so-called 3D glasses.

These 3D glasses put high demands on the manufacturing processes, in particular on the quality inspection. As the goods are mass products, the quality inspection has to be suitable for mass production in terms of speed and stability.
This article describes the broad field of application of optical confocal sensors in the inline quality inspection of 3D glass products in the consumer electronics market. It is shown that the new sensor products of Precitec Optronik are the cutting-edge solutions for inline quality control in 3D glass mass production.

3D glass: a high-tech product in consumer electronics

Today in nearly every industry glass has become an indispensable product component. It is not only processed for architecture glass, windshields or panoramic roofs in the automotive industry or container glass, but also used as wafer substrates in the semiconductor industry and notably increasingly processed in consumer electronics. Here it is used for smartphones, displays or televisions in highly complex and structured geometries that are no longer limited to plane 2D geometries. Thus the term **3D glass** has emerged.
The technical requirements on the material are very high and are still growing. For example, it has to be very thin (down to 2 µm) but stable, elastic or foldable, or of small size but with a complex 3D-geometry like curved edges to meet the demands of the new trends in consumer electronics i.e. like roll-up displays or curved ultra-thin TVs.

Quality inspection of 3D glass in mass production

Consequently, a high-level quality inspection is required in the 3D glass manufacturing as well as in the assembly of the end-user products. At the moment only offline inspection using dedicated inspection machines or CMM based ones is customary. However, as smartphones and displays are mass products, an inline quality inspection is preferred to reduce cycle times and costs, but increase the end-product quality by a 100% inspection. Thus, a suitable sensor technology is required in terms of speed and stability.

Optical confocal sensor technology made by Precitec Optronik

The optical confocal sensors of the **CHRocodile** product line, developed and manufactured by Precitec Optronik, are designed to allow contact-free, fast and precise distance and thickness measurements of any materials. Two measuring technologies are incorporated in the sensors i.e. the chromatic confocal, which is based on the physical principle called chromatic aberration, and the optical coherence tomography (OCT) based on the principle of broad-band interferometry:

Chromatic confocal sensors

These sensors use white light to split via a chromatic lense in its spectral components and focus these onto the surfaces to be measured. Depending on the height position of the reflecting surfaces to the sensor, only one color / wavelength per surface is reflected back into the lense. The sensors analyse the reflected light and compute the corresponding distance and /-or thickness values with nanometer resolution.
By this, tiniest changes in, for example surface height or material thickness, can be detected, where at the same time the high maginification of the chromatic lense resolves lateral structures with micrometer resolution. Due to the high numerical aperture of these lenses, measurements are also possible on steep angles or round geometries with high accuracy. Optical chromatic sensors are available as point or line sensors, where the point sensors can also be designed in multi-channel configurations.

Interferometric confocal sensors

The interferometric sensors use a broad band light source (white light or infrared). The emitted light is reflected back from the surfaces of the substrate into the detector in two light beams: one from the top surface and one from the backside surface after passing the material. The two beams intefere and due to the resulting difference in travelled disctance a spectral signal is created that represents the thickness of the material.
This principle allows an axial resolution down to nanometers. Distances are measured using a reference surface within the light path.

Geometry inspection by CHRomatic-Line-Sensor (CLS)

Outer dimensions of 3D glass parts like length, height and width as well as curvature and radius are important measuring features. Using the chromatic line sensor (**CLS**) with an acceptance angle of up to 45°, accurate measurements are possible even on curved glass surfaces without tilting the sensor or the sample, respectively. Due to a line length of up to 5 mm, that is composed of 192 measuring points, dimensions of surface grooves and gap sizes between e.g. display glass and surrounding frame can be detected at one shot. Together with a sample frequency of 6 kHz i.e. 1.3M measuring points per second even 100% inspection is possible at shortest cycle times (figure 1).

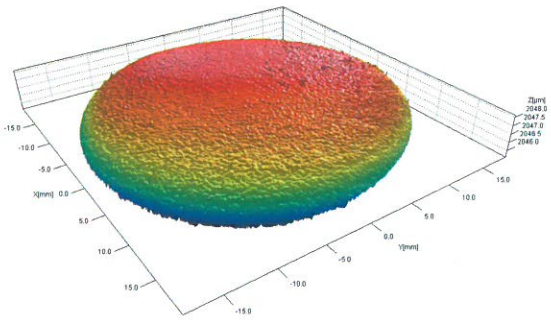
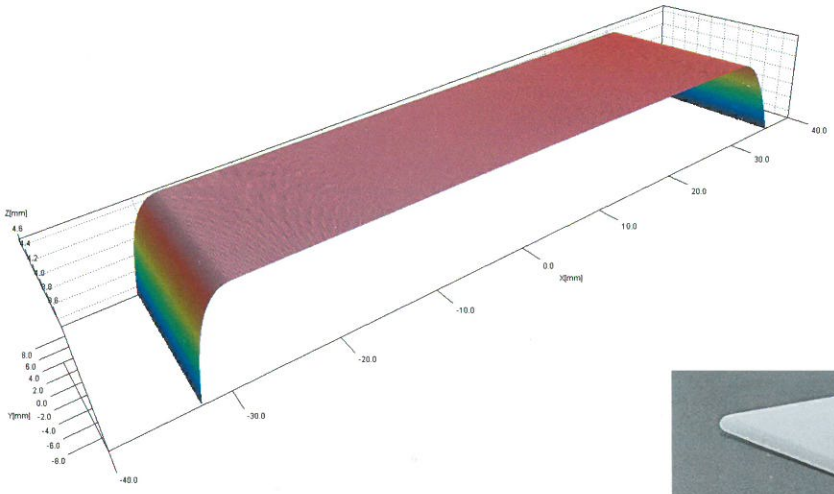


Figure 2: Measured topography in nanometer resolution of curved watch glass for planrity inspection using the Flying-Spot-Scanner (FSS).

Fast 100% - ROI – inspection by Flying-Spot-Scanner (FSS)

Fast planarity inspection of glass surfaces, measurements of glass or coating thicknesses and stepheight and air gap analyzation can be realized in inline quality control using an interferometric sensor combined with an optical scanning probe i.e. the Flying-Spot-Scanner (**FSS**).

The **FSS** incorporates two galvo-driven mirrors and a telecentric lens to focus the measuring spot perpendicular to the inspected surface and at a lateral position that is programmed by the user. Any type of trajectory like squares or spirals is possible and also the region that shall be measured is chosen by the user. By this ROI-based approach only the problem areas are measured at rates of 70.000 points per second to minimize inspection cycle times.



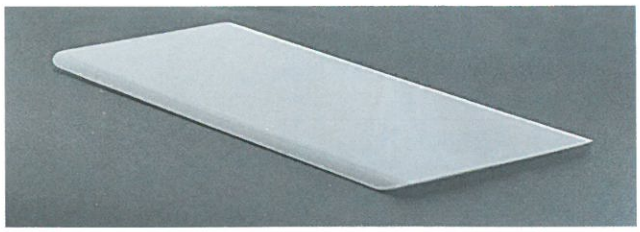


Figure 1a (l): Topography section 3D mobile phono cover glass; 1b (r): 3DGlass

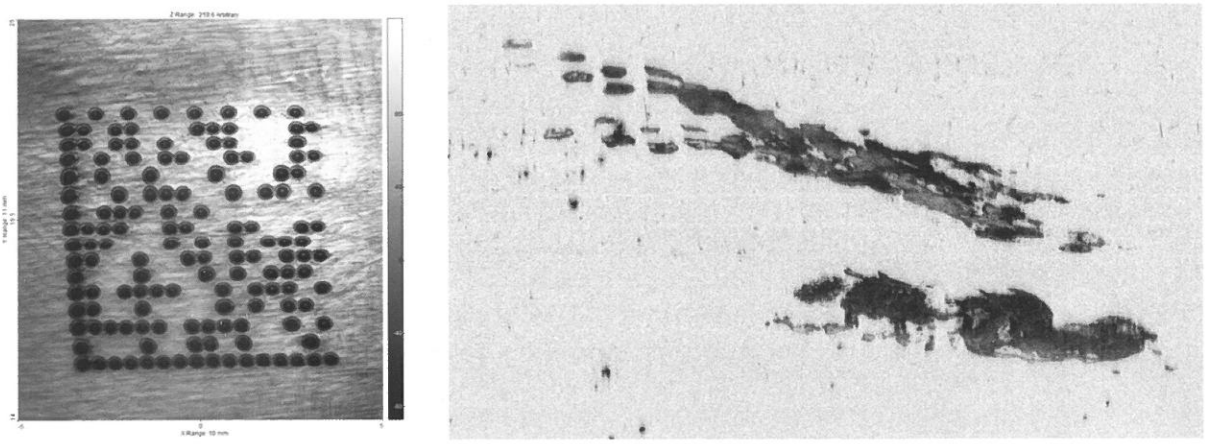


Figure 3a(l): 2D image of laser-engraved data matrix code in container glass; 3b(r): 2D image of surface defects on glass surface.

2D surface inspection by CHRomatic-Vision-Camera (CVC)

The CHRomatic-Vision-Camera (CVC) is a 2D camera-based inspection system. It uses the principle of chromatic aberration to achieve a highly extended depth of focus. Depending on the used chromatic objective the depth of focus varies from 150 µm to 3000 µm. This reduces inspection cycle times drastically, as no time-consuming auto-focus adjustment is necessary anymore as when using conventional microscopes. 2D surface images even of curved and complex geometries like edges of scratches or glass burst can be recorded at up to 140 kHz with a micrometer lateral resolution. Due to the incorporate confocal light source a separate external illumination is not required.

Precitec Optronik is exhibiting on the 25th glasstec trade show in Düsseldorf this year and presents the CHRomatic-Vision-Camera (CVC), the recently released Compact-CHRomatic-Line-Sensor (CLS C) as well as a new version of the Multi-Point-Sensor (MPS) with a concept of maximum flexibility for container glass inspection.

Conclusions

3D glasses in the consumer electronics indsutry put high demands on the manufacturing as well as assembly processes, and in particular on the quality inspection. As the final goods like smartphones and television devices are mass products, the quality inspection has to be suitable for mass production in terms of speed and stability in order to reduce cycle times and costs, but increase the end-product quality by a 100% inspection.

It has been shown that fast optical chromatic and interferometric sensors are the technological inspection solution for the broad field of inspection tasks. The new sensor products of Precitec Optronik are here the cutting-edge solutions for inline quality control in the 3D glass mass production.

You are welcome to visit the Precitec Optronik booth in Hall 14, Stand-number G22.

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Non-contact measurement technology saves time, lowers costs and optimizes end-product output.

Mass production of 3D glass for consumer electronics requires a completely new level of quality inspection. Speed and stability are the key criteria – and Precitec Optronik's sensor technology is the cutting-edge solution. Chromatic confocal and interferometric sensors allow fast, contact-free, high-precision inline measurements of 3D glass dimensions, topography and possible defects. Whatever your measuring task, our product portfolio delivers the ideal solution:

- CHRocodile Chromatic Vision Camera: Perfect for quick and reliable cosmetic inspections. The combination of chromatic technology with a line scan camera delivering extreme depth of field and sharp, high-contrast imaging means no refocusing is needed.
- CHRocodile Chromatic Line Sensor: The ideal tool for measuring curved glass surfaces without tilting the sample. By coordinating 192 measuring points into one line, it can simultaneously measure the geometrical shape of display glass and the surrounding frame.

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