

---

## VERISENS® APPLICATION

### STUDY

*APPLICATION: CENTER CALCULATION*

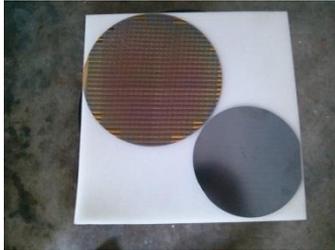
*INDUSTRY: ELECTRONICS*

*PRODUCT: SILICON WAFER*



### BACKGROUND AND CONCLUSION

A provider of equipment to the semiconductor fabrication market has asked that Baumer examine the possibility of using a low-cost vision sensor to provide location information of a silicon wafer. The information must be precise, as it will be transmitted to a device with a location specification of 50 microns (0.050 mm). The testing described in this report is theoretical in nature—the exact hardware required to functionally test the actual performance is application-specific. The purpose of this document is to describe the Baumer hardware required for an application of this sort, suggested peripheral equipment to optimize system accuracy, suggested vision tools and a calculation methodology. All of these point in the direction of a successful achievement of the required accuracy objective.



Two wafers were examined, one 150mm in diameter; the other 200mm in diameter. Figure 1 is a picture of the two wafers adjacent to one another. Note the different appearance from one to the other. The surface appearance is not a factor as the lighting methodology employs back lighting.

The vision hardware was the Baumer VeriSens® with a 2 Megapixel sensor. The vision tools employed were the “Count Areas” tool, used to calculate the center of mass near the three edges of the wafer. These three edges define an arc which corresponds to the diameter of the wafer. The raw data from the vision sensor is sent to a spreadsheet on a PC for calculations to be transmitted to the controlled device.

The conclusion is that this concept is viable with further refinement in the lighting and optics. Below is documented the test methodology and results.

The information contained in this document is the intellectual property of Baumer USA, Ltd. Any use of this information without the express permission of Baumer USA, Ltd. is prohibited.

## INSPECTION STATION OVERVIEW

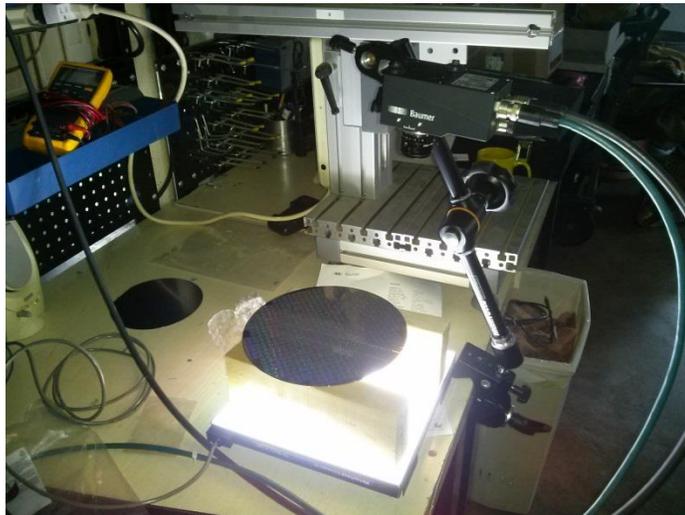
Testing was performed using a Baumer VeriSens® XF100 with a 2.0 Megapixel sensor. Wafers were placed above a white back light.

Following are specific lighting and optics parameters:

XF100 (2.0 MP)

- 50mm lens (non-telecentric)
- Working distance: 228mm;
- Field of View (FOV): 22mm
- Illumination: Back Light

VeriSens® setup/ configuration are performed on a PC connected via an Ethernet cable. Once configuration is performed, the sensor operates stand-alone and the PC is normally not required. In this application, however, the Ethernet connection shall be used for data transfer via TCP/IP to a controlled device.



**FIGURE 2: LABORATORY SETUP**

The sensor can store up to 255 configuration recipes (“jobs”). VeriSens® has 5 digital inputs and 5 digital outputs. These are used for such functions as image acquisition, job selection, part reject, etc.

The information contained in this document is the intellectual property of Baumer USA, Ltd. Any use of this information without the express permission of Baumer USA, Ltd. is prohibited.

## VISION 1-2-3: IMAGE- TOOLS- I/O

Inspection setup in the software for the VeriSens® from Baumer is simple and intuitive. The “AppSuite” configuration software consists mostly of drop-down menus and slide bar adjustments. There are few text entries required, and no programming or scripting. There are three steps to configuring the VeriSens® vision sensor, each of which is described in detail for this application below:

- 1) Adjust Image
- 2) Select the appropriate vision tool
- 3) Configure Input/ Output Interfaces

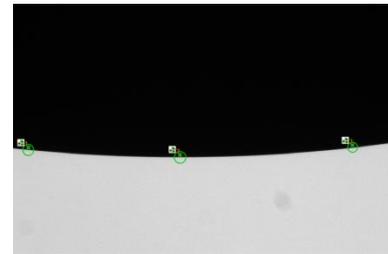
When these three steps are completed, simply download the configuration parameters from the PC to VeriSens®.

### STEP 1: ADJUST IMAGE

The first step of any automated visual inspection is to establish proper part positioning, lighting and lens focus. Figure 3 illustrates the raw image applying a back light.

The intent at this step is to obtain a lighting scheme appropriate for the following inspection algorithms (“Tools”).

Because the lab does not possess the ideal method to image the part accurately, a standard (non-telecentric) 50mm lens with 15mm of extension tubes was used to achieve a Field Of View of 22mm. This Field Of View was applies for both the 150mm and the 200mm diameter wafer. Optimally, a monochromatic backlight would be employed (preferably red), however, for demonstration purposes a



**FIGURE 3: ADJUST IMAGE**

white back light was used and a standoff distance between the wafer and the backlight was 95mm.

**STEP 2: CHECK FEATURES**

Step 2 is to select the proper software tools to perform the required inspection(s). VeriSens® is equipped with a complete software library of powerful vision algorithms including:

**100 Series:**

- Pattern Recognition
- Normalized correlation
- Edge Detection
- Connectivity Analysis
- Grey scale Histogramming

These algorithms permit functions such as:

- 360 degree part location
- Image template matching
- Measurements and Dimensions
- Feature extraction (area, x/y location, brightness)

**200 Series:**

- All 100 Series tools described above
- Bar code read and quality
- Matrix code read and quality
- Optical Character Recognition (OCR)
- Optical Character Verification (OCV)

The information contained in this document is the intellectual property of Baumer USA, Ltd. Any use of this information without the express permission of Baumer USA, Ltd. is prohibited.

In this application only one software tool was used, the “Count Areas” Tool. The Count Areas Tool has four primary adjustments: Bright on Dark/ Dark on Bright, Binary Threshold and an Area Filter with high and low adjustments.

Figure 4 is a screen capture from a 150mm wafer. Note that three Count Area tools are applied. The intent is to calculate the center of the “great circle” defined by the three points of the arc. The reason for using the Count Area tool instead of an edge-based algorithm is illustrated in Figure 5. Even under the best of circumstances (which the current test procedure is not), “true” edge location is difficult to determine. Edge detection algorithms make assumptions about the gray scale gradient across the defined tool and perform a statistical

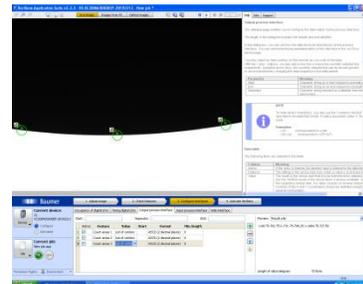
calculation regarding the location of the edge. The Count Areas tool illustrated in Figure 5 is also affected by the gradient, but The actual calculations include all dark pixels within the Region Of Interest green circle). Its resultant calculation is the center of mass of the total number in the area of dark pixels. This statistical sampling is far greater than that at the gradient alone, and yields greater

measurement repeatability.

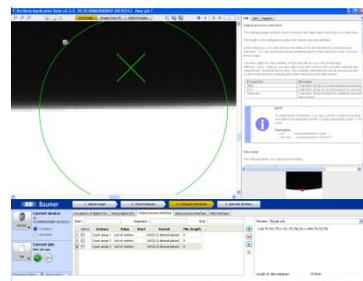
Note in Figure 5, however, that the reference value, Center Of Mass, does not necessarily appear at the edge. So, while repeatable, it is not accurate. This accuracy error will need to be addressed in the calibration procedure as a constant offset. It appears in the calculations below as approximately a 12mm offset.

Figure 6 illustrates the image of a 200mm wafer. Note that the slope of the arc is greater. The Field of View is identical to that with the

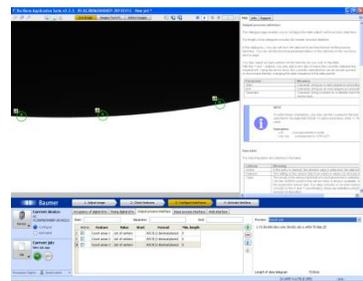
150mm wafer.



**FIGURE 4: COUNT AREA TOOL APPLIED TO 150MM WAFER**



**FIGURE 5: IMAGE ZOOM OF 150MM WAFER**



**FIGURE 6: COUNT AREAS TOOL APPLIED TO 200MM WAFER**

### STEP 3: CONFIGURE INTERFACES

Step 3 is to configure the outputs. VeriSens® has 5 digital inputs and 5 digital outputs.

Additionally, the VeriSens® has the ability to transmit via TCP/IP ASCII data corresponding to results values, positional information, good and bad images, etc. Table 1 illustrates the x,y data capture points inserted into a spreadsheet for further calculation of the center of the circle. Note the error in Diameter 3 of .1328mm, about 2.66x the required 0.05mm. It is the opinion of the writer that this is attributable to angular displacement of the vision sensor, parallax and other optical attributes (note that diameters 1 and 2 calculate the same to seven decimal places).

The Baumer VeriSens® has as a standard feature a calibration function that is able in some cases to compensate for lens distortion.

TABLE 1

	x	y	Radius (pixels)	Diameter (pixels)	Diameter (mm)
1	68.75	762.75	5048.773759	10097.54752	138.8412784
2	731.75	798.25	5048.773759	10097.54752	138.8412784
3	1484.75	727.5	5043.943075	10087.88615	138.7084346
Center	669.6132	-4250.14			

### STEP 4: ACTIVATE VERISSENS

Step 4 is to simply download the configuration parameters to the VeriSens®. The job may also be stored on the configuration PC prior to activation. Once activated, VeriSens functions as a stand-alone sensor and the PC can be disconnected.

### OPERATION

No operational criteria were submitted.

## DELIVERABLES (SOME ITEMS BY OTHERS)

A typical system contains the following (one per lane):

- (1) Baumer VeriSens® XC-100: VC XC100M20X00EP
- (1) Baumer Connector Cable for power and I/O: ESG 34JP0200G Flying Lead
- (1) Baumer Ethernet cable: KSG34A/KSG45AP0200G/E
- Baumer VeriSens® Installation assistance and training: one day- no charge
- Red LED collimated back light (by others)
- Telecentric optics (by others)

Please contact your Baumer representative for a budget estimate.

---

## CONTACT

Baumer, Ltd. USA

Pete Kepf, Vision Products Field Application Engineer

[pkepf@baumer.com](mailto:pkepf@baumer.com)

865-518-1985

Baumer USA, Ltd.

Doug Erlemann, Vision Products Business Development Manager, West

[derlemann@baumer.com](mailto:derlemann@baumer.com)

Baumer USA, Ltd.

Jon Chouinard, Vision Products Business Development Manager, East

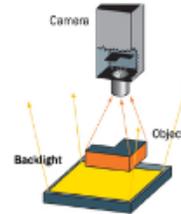
[derlemann@baumer.com](mailto:derlemann@baumer.com)

The information contained in this document is the intellectual property of Baumer USA, Ltd. Any use of this information without the express permission of Baumer USA, Ltd. is prohibited.

## GLOSSARY

**Back Lighting**

Lighting technique in which the light source and the camera are on opposite sides of the part to be inspected.



**Contrast**

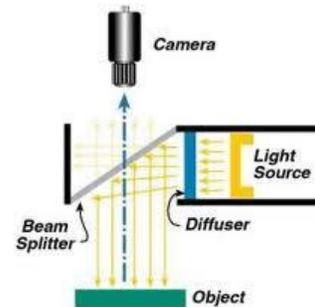
Measured in grayscale (Black = 0; white = 255).

A minimum contrast must be present in order to differentiate a feature from its background.

**BACKLIGHT**

**Dual On Axis Light**

(DOAL) On Axis illumination uses beam splitting techniques to enable the illumination to be positioned between the camera and the object so that the camera is situated behind the light. Note: Due to light loss in the beam splitter the unit generally needs to be positioned as close as possible to the object.



**Edge Detection**

A software tool that calculates the gradient location across a pixel matrix based upon the difference between the grayscale values. Typically, a nearest line fit is calculated across several pixels within the maximum gradient and this line is determined to be the edge.

**Feature Extraction**

The ability of machine vision software to separate a feature from its background and determine some attribute (area, brightness, etc.)

**Front (or Top)**

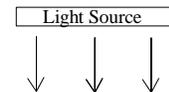
**Lighting**

Lighting technique in which the light source and the camera are on the same side of the part to be inspected.



**Gray Scale**

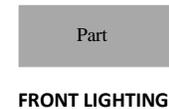
In an 8 bit monochrome system, black =0 and white = 255 with values between depicting varying shades of gray.



**Optical Character**

**Recognition (OCR)**

The ability of machine vision software to determine the value of a string of previously unknown characters.



**Optical Character**

**Verification (OCV)**

The ability of machine vision software to determine whether or not the value of a string of previously taught characters matches the current image.

**Resolution**

Measured in Units of measure per pixel.

Field of View ÷ minimum number of pixels on the sensor. For example, a 1" FOV with a VGA sensor has a resolution of approximately .002"

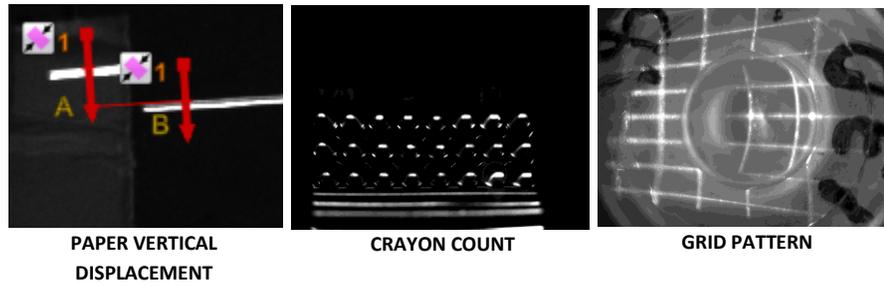
$$\text{Resolution} = \text{FOV}/\text{pixels} \quad \text{Resolution} = 1''/480$$

$$\text{Resolution} = .002''/\text{pixel}$$

The information contained in this document is the intellectual property of Baumer USA, Ltd. Any use of this information without the express permission of Baumer USA, Ltd. is prohibited.

**Structured Lighting**

Lighting technique whereby the illumination source has a defined geometry: line, grid, pattern, etc. It is often employed to obtain geometric information about a part that is inspected. The vision system measures attributes of the light pattern in order to obtain information about the part. Below examples are: (1) Line used to determine vertical displacement on a paper feed; (2) three line pattern used to count crayons in a box; (3) Grid used to detect 3D contour information.

**Threshold (Gray Scale)**

With binary algorithms, the gray scale value above or below which the pixel values will be recognized.