Alignment, Standoff Distance and Offset and Multiple Scans

for EX-Q Wafer Mapping Sensors

Alignment

EX-Q wafer mapping sensors require proper alignment with respect to target wafers in order to assure optimum performance. Each sensor model has a recommended working angle range which the sensor must stay within during operation. This is defined to be the angle of the sensor face with respect to the tangent line on the wafer edge. This is equivalent to the angle between the axis of the sensor, and a line drawn to the wafer center from the point where the axis intersects the wafer edge. When the sensor is directly facing the wafer, the working angle is zero. (Refer to Figure 1).

A wide working angle range is useful for two reasons. The first is to allow two scans to be done at different points on the wafer edge. This is often done for redundancy and to give the ability to detect wafer tilt as an indicator of a misplaced wafer.

The second need for a wide working angle range is for use with flatted wafers. The wafer scanning strategy must take into account the fact that the flat may be at any orientation, so that even with the worst case flat position, the wafer edge is still within the recommended working angle of the sensor. For the EX-73Q, -83Q and -93Q distance models two scans are needed to guarantee that in at least one scan the flat will be within the recommended working angle.

The sensor optics are tilted upward 3 degrees with respect to the plane of the sensor. This is to avoid reflections from structure that may be present on the top surface of wafers, and to avoid reflections from the back of FOUPs, in the case of 300 mm wafers. To maintain this advantage, the sensor should be oriented within ±0.5 degrees of the same plane as the target wafer. This means that the wafer and the sensor need to be parallel to within ±0.5 degrees. Note that this upward tilt results in a slight offset in vertical location of the sense point as compared to earlier revision EX-Q sensors. (Refer to Section 2.0.)

In the case that the sensor is mounted on a wafer handling robot, the sensor working angle should not be confused with the robot arm angle, or the "theta motion" of the robot arm. While it is possible to convert from robot theta motion to sensor working angle, the conversion depends on working distance, wafer diameter, and robot arm extension. The exact calculation is presented in the following paragraphs. In addition the tables on page 4 present typical setups from which approximations can be derived.

For each mapping setup the working angle of the sensor should be calculated to make sure that the sensor is being used in the proper range to achieve the recommended sensing performance.

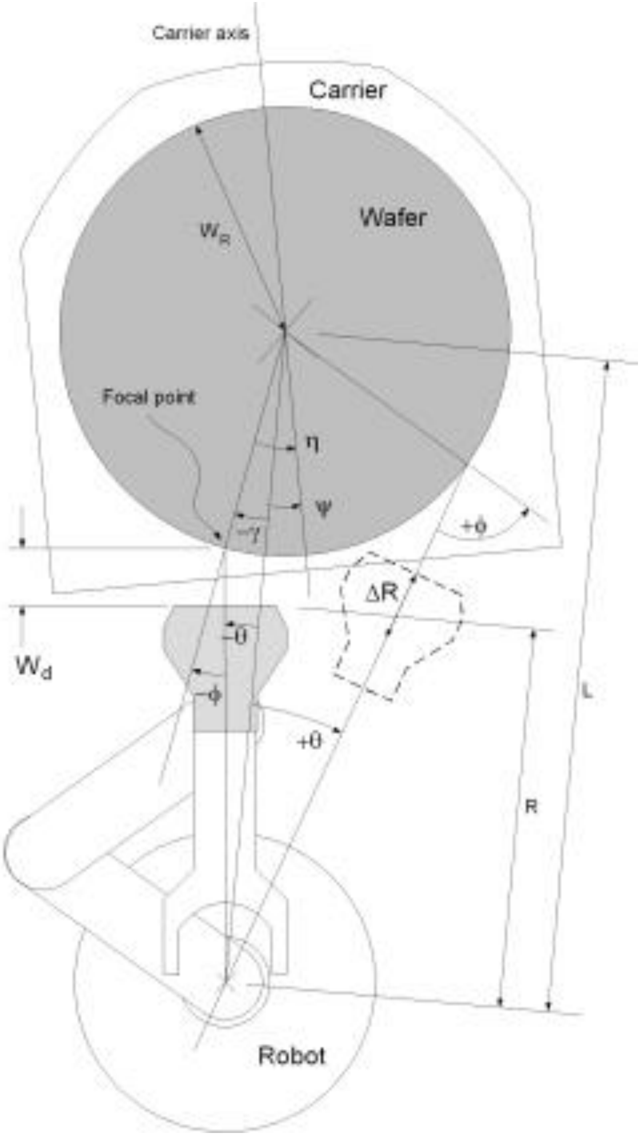

Figure 1 - Wafer Mapping Sensor Geometry (top view)

φ = Working angle: Angle between sensor axis and line between wafer center and focal point. θ =

Robot arm angle: The angle at the robot axis between the line to the sensor and the line to the wafer center. When $\theta = 0$ the sensor is pointed directly at the center of the wafer.

γ = Wafer angle: Angle at wafer center between line to focal point and line to robot center

ψ = Carrier-robot angle:Angle of carrier axis with respect to line between wafer center and robot axis.

η = Carrier-sensor angle: angle of the carrier axis with respect to line between wafer center and focal point. Carrier-sensor angle is the sum of wafer angle and carrier-robot angle. Carrier-sensor angle is negative of wafer angle when robot axis is on FOUP axis.

W_D = Working distance: This is the distance along the sensor axis from the wafer edge to the center of the front of the sensor.

R = Distance from sensor face to robot axis for $\theta = 0$. This is the distance from the center front face of the sensor to the robot arm's center of rotation.

W_R = Wafer radius. This is ½ the diameter of the wafer (i.e. 150 mm for a 300 mm wafer). L =

Distance from robot center (rotation axis) to wafer center.

ΔR = Radial offset of robot for given angle θ needed to maintain W_D

Often when the sensor is mounted on a robot the sensor must be positioned using robot rotational and radial coordinates, corresponding to "robot arm angle" and R. The following equations are useful for finding θ and R or ΔR.

We first define the following constant, Q.

$$Q \equiv \frac{W_R}{L} \equiv \frac{W_R}{W_R + W_D + R}$$

To calculate the working angle φ, first calculate γ for a given robot angle θ.

$$\gamma = \sin^{-1}\left(\frac{\sin\theta}{Q}\left[\cos\theta - \sqrt{Q^2 - \sin^2\theta}\right]\right)$$

The working angle φ is then calculated from γ and θ.

$$\varphi = \theta + \gamma$$

When the robot angle θ is changed it is necessary to also change the robot arm extension, R, to maintain the sensor working distance W_D. This is calculated as ΔR.

$$\Delta R = \left(\frac{W_R \sin\gamma}{\sin\theta}\right) - (R + W_D)$$

Alignment (cont.)

Below are a set of tables showing the calculated working angles for a sensor at typical set-up values. They can be used to get a rough estimate of the relationship for the various set-up parameters.

EX-43Q Example

Working distance (WD)= 38.1 mm
Robot axis distance (R) = 250 mm
Wafer Diameter = 300 mm

Robot θ (deg)	Wafer γ (deg)	Working Angle φ (deg)	Δ R (mm)
0	0.0	0.0	0.000
0.5	1.0	1.5	0.032
1	1.9	2.9	0.128
1.5	2.9	4.4	0.289
2	3.9	5.9	0.514
2.5	4.8	7.3	0.805
3	5.8	8.8	1.162
3.5	6.8	10.3	1.586
4	7.8	11.8	2.079
4.5	8.7	13.2	2.641
5	9.7	14.7	3.274

EX-73Q Example

Working distance (WD)= 55.9 mm
Robot axis distance (R) = 250 mm
Wafer Diameter = 300 mm

Robot θ (deg)	Wafer γ (deg)	Working Angle φ (deg)	Δ R (mm)
0	0.0	0.0	0.000
0.25	0.5	0.8	0.009
0.5	1.0	1.5	0.035
0.75	1.5	2.3	0.080
1	2.0	3.0	0.142
1.25	2.6	3.8	0.222
1.5	3.1	4.6	0.319
1.75	3.6	5.3	0.435
2	4.1	6.1	0.568
2.25	4.6	6.9	0.720
2.5	5.1	7.6	0.890

EX-83Q Example

Working distance (WD)= 76.2 mm
Robot axis distance (R) = 250 mm
Wafer Diameter = 300 mm

Robot θ (deg)	Wafer γ (deg)	Working Angle φ (deg)	Δ R (mm)
0	0.0	0.0	0.000
0.15	0.3	0.5	0.004
0.3	0.7	1.0	0.014
0.45	1.0	1.4	0.032
0.6	1.3	1.9	0.057
0.75	1.6	2.4	0.089
0.9	2.0	2.9	0.128
1.05	2.3	3.3	0.174
1.2	2.6	3.8	0.227
1.35	2.9	4.3	0.288
1.4	3.0	4.4	0.310

EX-93Q Example

Working distance (WD)= 114.3 mm
Robot axis distance (R) = 250 mm
Wafer Diameter = 300 mm

Robot θ (deg)	Wafer γ (deg)	Working Angle φ (deg)	Δ R (mm)
0	0.0	0.0	0.000
0.15	0.4	0.5	0.004
0.3	0.7	1.0	0.017
0.45	1.1	1.5	0.039
0.6	1.5	2.1	0.069
0.75	1.8	2.6	0.107
0.9	2.2	3.1	0.154
1.05	2.6	3.6	0.210
1.2	2.9	4.1	0.274
1.35	3.3	4.6	0.347
1.5	3.6	5.1	0.429

Standoff Distance

The distance from the wafer to the sensor should be set for use at the optimum detecting distance, as outlined below. EX-Q sensors will perform sufficiently within their specified maximum detecting range, however, the sensor performance is optimized for use at the specified optimum standoff distance.

	EX-43Q	EX-73Q	EX-83Q	EX-93Q
Optimum detecting distance	1.5"	2.2"	3.0"	4.5"
Maximum detecting range	1.4" to 1.6"	2.05" to 2.35"	2.8" to 3.2"	4.2" to 4.8"

CyberOptics Semiconductor strongly recommends that the EX-Q sensors be used only within the specified range of standoff distances. Sensor optics and geometry are carefully matched to the specified standoff distance so that the sensor will respond to wafers throughout (and beyond) the range of variations in wafer parameters. Outside the specified standoff distance sensor response to wafers is degraded, and the sensor will not respond correctly to the full possible range of wafer parameters. At other standoff distances the sensor will not respond correctly to all wafers even though it responds correctly to a test wafer

Offset and Multiple Scans

EX-Q sensors can operate pointed either to the wafer center (on-axis), or off-axis. The EX-43Q sensor will detect all standard SEMI™ flatted and notched wafers when scanning on-axis.

However, two scans separated by ½ to 1 inch (each scan ¼ to ½ inch to each side of on-axis) are recommended for robust detection and to allow for misalignment in setup. When two scans are used, the scanning algorithm should allow for, and correctly detect, a wafer that is seen on only one of the two scans.

The EX-73Q, EX-83Q and EX-93Q sensors can detect flatted wafers if multiple scans are used. For further information on offsets and multiple scans contact CyberOptics Semiconductor Technical Support at 800-366-9131 for the working angle specifications to calculate the number and positions of scans required.

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