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Semiconductor Manufacturing Processes and Laser Displacement Sensors

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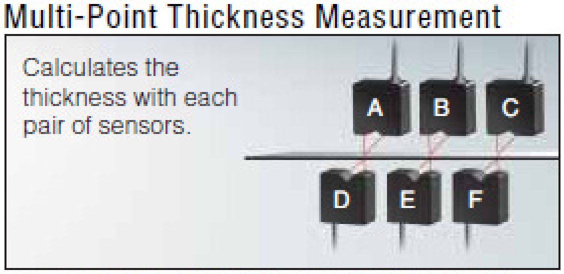
Introduction

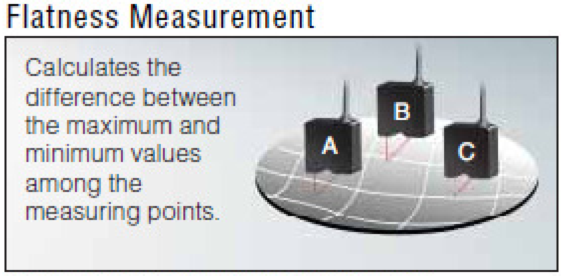
One of the driving forces in the semiconductor manufacturing industry today is to reduce manufacturing cost and increase efficiency. In the past, laser displacement sensors have been used infrequently due to lack of speed, accuracy and flexibility. Recently, laser displacement sensors have become more accurate (0.02 µm repeatability), faster (392 kHz sampling rate) and more flexible. Because of their greater speed, accuracy and flexibility, these sensors can be used in a wider variety of applications ranging from wafer production and handling all the way to wire bonding and final packaging. Some common applications of laser displacement sensor, specifically when producing semiconductor wafers are non-contact thickness, flatness, perpendicularity, and warpage.

Multi-Point Thickness Measurement



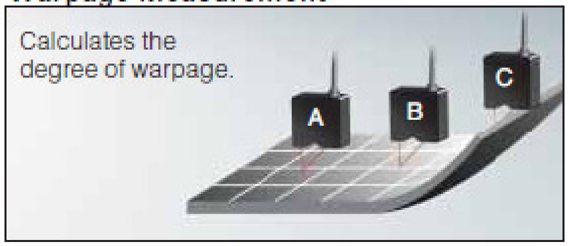
Measured value1=X+(A+D) Measured value2=Y+(B+E)
Measured value3=Z+(C+F)...

Flatness Measurement



Measured value1=MAX(A,B,C...)−MIN(A,B,C...)...

Warpage Measurement



Measured value1=B-(A+C)/2...

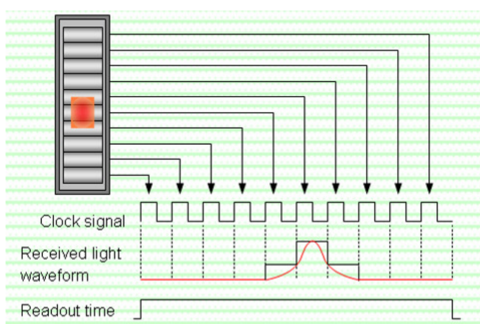
Speed can be explained as a measure of how often a sensor takes measurements on a target (sampling rate). The advantage of high speed is the more measurement samples the sensor makes on a target, the more averaging of these measurements can occur, giving a more stable reading.

Accuracy can be thought of as if you take a measurement anywhere in the measuring range of the sensor, how much error there can be. This number is the total error, including the error caused by the sensor (linearity), caused by temperature fluctuations, sensor mounting errors, etc. By understanding and limiting these sources of error, more accurate measurements can be made. When gauging the accuracy of a measurement, the accuracy of the sensor itself is only one component. Depending on the required tolerances, this may or may not be significant. In many cases, full scale linearity may not be as important as resolution and repeatability. Resolution is the smallest amount of change the sensor will register. Repeatability of the sensor is a measurement of differences seen when a target is measured over and over again in the same position under the same conditions. If the part is placed in the same spot in the sensors measuring range over and over again, this is a measure of the sensor repeatability and what ever method of placing the parts' repeatability. To make a long story short, by increasing the resolution and repeatability, the sensors accuracy can be improved.

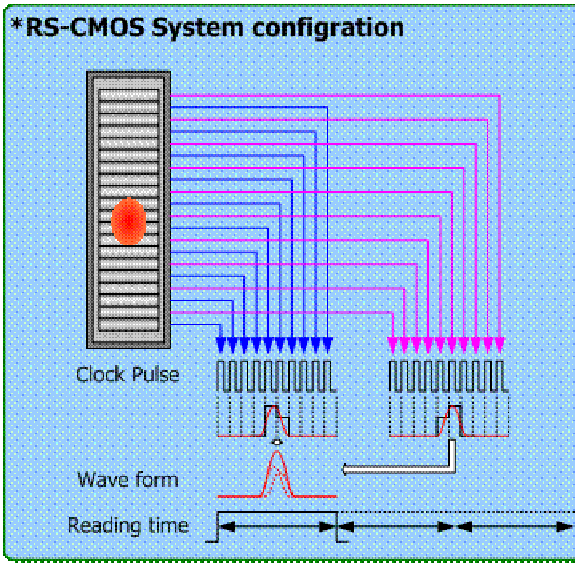
Flexibility can be observed in the many different ways the same sensor head can be configured. By utilizing one common part for several dimensional measurements a substantial cost savings and increased efficiency can be realized.

Speed

The typical limiting factor for measurement speed is the rate at which information is collected from the receiving CMOS sensor. A conventional sensor diagram might look like:



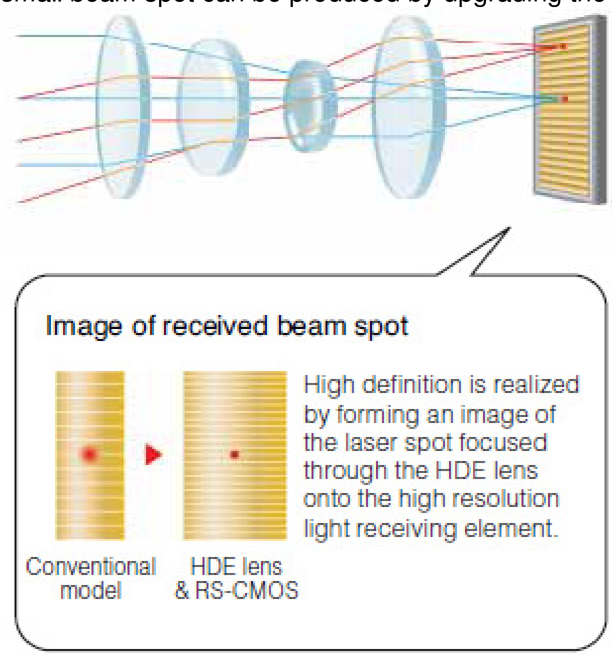
Factors affecting the readout time are the number of pixels and the clock speed. The higher the number of pixels to be read out, the longer the readout time, the slower the measurement sampling rate. A more advanced sensor diagram might look like:



In this example the clock pulse is increased by 4 and the pixels are read out in parallel (2x as fast). Thus, by increasing the clock pulse by a factor of 4 and reading the pixel information twice as fast, the sampling rate is increased by a factor of 8. What this means is that over the same target area in the same amount of time, the newer sensor can make 8 measurements where previously on one measurement could be made.

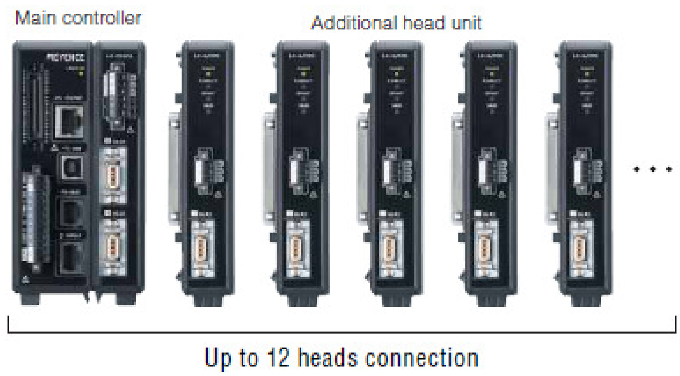
Resolution and Repeatability

The resolution and repeatability of a laser displacement sensor can be improved by several methods. One improvement can be accomplished simply by doubling the number of available pixels on the CMOS receiver without increasing the total size of the sensor head. However, at the same time the effective beam spot size will have to get smaller in order to keep the resolution at a maximum. The small beam spot can be produced by upgrading the optics in the sensor head.



Flexibility

Flexibility of a laser displacement sensor can bring many ideas to mind with respect to the semiconductor manufacturing industry. This paper will briefly mention some of the capabilities applicable to this particular industry. Historically, each displacement sensor would give an analog output; the analog signal would then be input into some type of system to make an evaluation. Each interface is an opportunity to induce noise and thus error into the system. Improved systems allow several sensor heads to be connected simultaneously. Numerous calculations can then be done within controller and the resulting output sent to a data collecting device.



Conclusion

Many companies are increasingly relying on non-contact laser displacement sensors to improve quality, feedback information for critical processes, detect defects early, reduce scrap and increase throughput.

For LK-G5000 Series Laser Displacement Sensor specifications
and applications please go to: http://www.keyence.com/WPLKG5