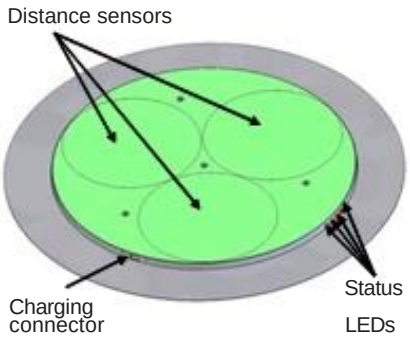
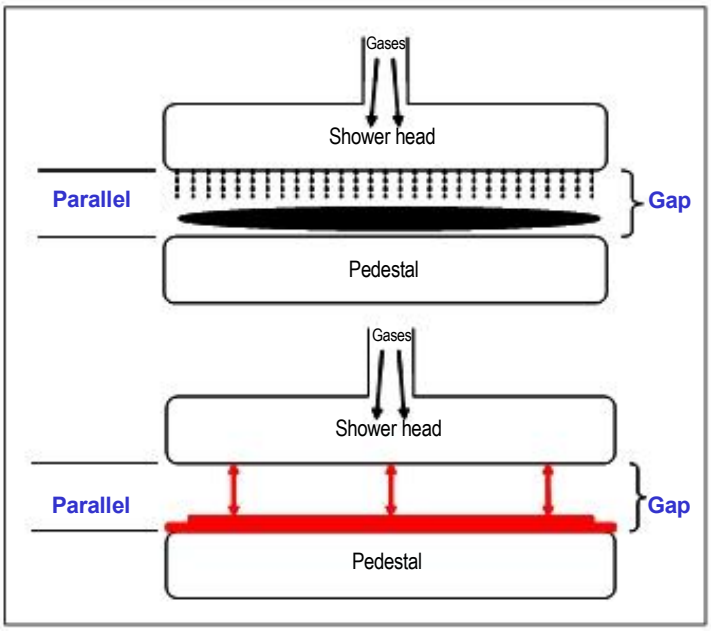
# WaferSense™ Auto Gapping System Theory of Operation

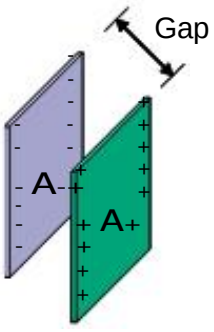
WaferSense AGS is a sensor, shaped like a semiconductor wafer that measures three gaps between two nominally parallel surfaces. The gap information is wirelessly transmitted to a computer for display. A technician uses the displayed gap information to determine when the gaps are satisfactory. AGS may be used during setup, maintenance and troubleshooting; and for process control of Plasma Enhanced Chemical Vapor Deposition (PECVD) process chambers. AGS may find similar applications in general automation and in other types of process chambers.




In a PECVD chamber there is a pedestal that supports the wafer being processed and a "showerhead" which dispenses process gases onto the surface of the wafer. The showerhead may also serve as one of the electrodes used to excite the plasma. Most PECVD chambers provide adjustment for the position and attitude of the showerhead relative to the pedestal. Either the pedestal inclination and height are adjusted or the showerhead inclination and height are adjusted. In both cases process control engineers wish to control the gap between the showerhead and the pedestal in order to optimize the film deposition process.

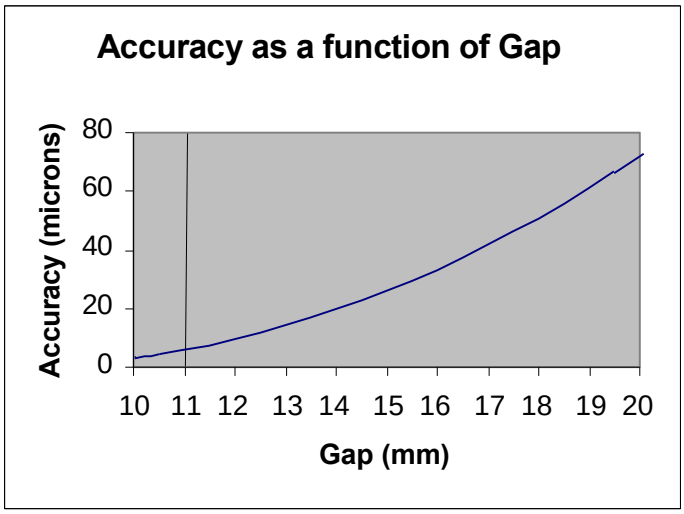



The AGS sensor wafer measures the gap at three locations by sensing the capacitance from the top of the AGS to an electrically conductive surface nearby. As shown in the equation below, Capacitance is an electrical property of two conducting plates separated by an insulator. It is proportional to the area of the plates and the dielectric constant of the insulator separating them. It is inversely proportional to the gap separating the plates. Metallic and semiconductor surfaces conduct well enough to form capacitor plates. Pure insulators are not recommended for use with the AGS.




$$\text{Capacitance} = \frac{\text{Area} * \text{Dielectric Constant}}{\text{Gap}}$$

Finally, the gap may be calculated from the measured capacitance. AGS plate area is designed to optimize measurement range and resolution. Measurement accuracy is a function of the gap. Accuracy is generally better with smaller gaps. The following table shows how the worst case gap measurement accuracy depends on the gap.



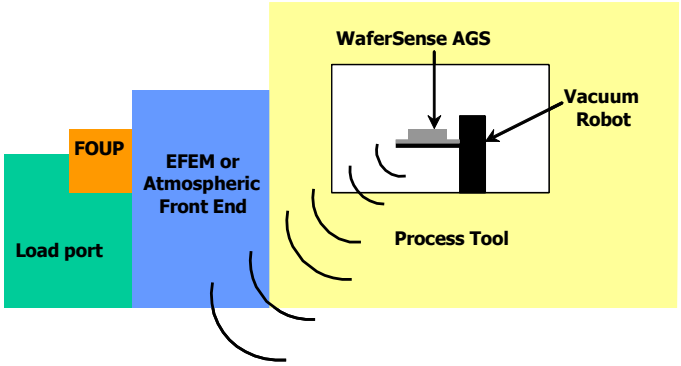

Films which may develop on the showerhead do not affect the capacitance significantly because they are thin relative to the total gap between the AGS and the showerhead. The effect of such films is smaller than the sensor accuracy. In practice, showerhead flatness issues tend to be larger than showerhead surface film issues.

Capacitance is a property of an area, not a single point; so warp and bow do not affect the measurement significantly. The AGS is not designed to measure concavity, convexity, ripple and twist or other flatness characteristics of either showerheads or pedestals. The measured gap is the composite gap over the area of each distance sensor. It is representative of the distance over which the process gas flows to reach the wafer.

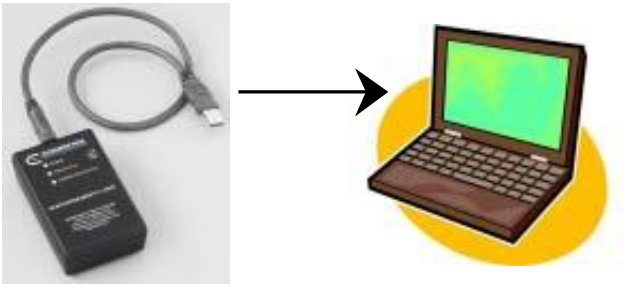
Holes in the showerhead may affect gap measurement accuracy, but do not affect gap measurement resolution or inclination accuracy significantly. Small aperture holes have a negligible affect on accuracy. Large holes make the showerhead seem farther away than it truly is. In this case, technicians may place the AGS into a chamber that is working well to determine its apparent gap. Thereafter, each chamber can be adjusted to that set point.

The AGS converts raw capacitance data into gap information using an internal computer that references sensor calibration data and sensor temperature data. Calibration is performed at the CyberOptics Semiconductor factory using a computer controlled gap between two temperature controlled flat plates. Annual sensor calibration is recommended to assure long term measurement accuracy.

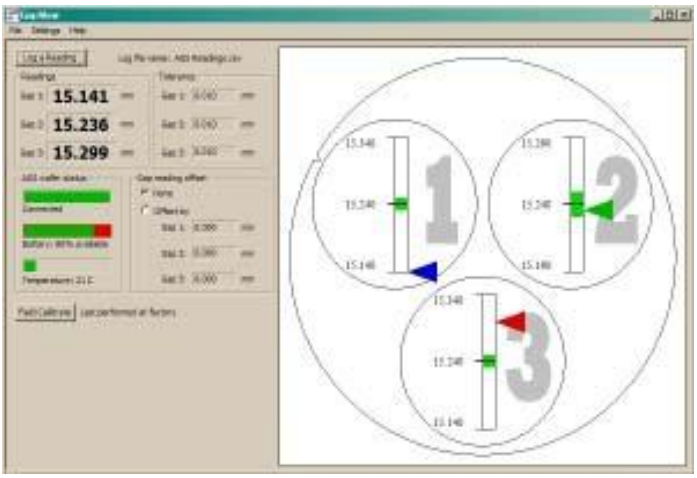
The AGS is powered by a rechargeable battery with a 10 year shelf life. The battery is capable of storing at least 80% of its original power after 500 full discharge-recharge cycles. Storage and/or operation of the AGS battery at temperatures higher than 80C will decrease the amount of power that the battery can hold. The AGS battery temperature should never exceed 100C. The battery is not user serviceable. It is replaced during the calibration service.




**Wireless Communication:** WaferSense AGS uses 2.4 GHz RF (Bluetooth®) wireless communication between the wafer and the link that is connected to a PC. WaferSense AGS uses a Class 1 Bluetooth device, rated for unimpeded communication up to 100 meters. Metal enclosures specific of a semiconductor use environment do not inhibit this communication.



**Link & Laptop:** The link is a compact USB 1.1 compliant device that connects to a laptop to enable wireless communication with the teaching wafer.




**GapView™ Software Application:** GapView displays numerical and graphical gap information. Each graphic is color-coded to make it easy to see whether it is above, below or within the selected target gap range.

Gap View can log time-stamped measurements to a CSV (comma separated values) file for documentation and/or analysis.

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For information about CyberOptics' offices and global support network, please visit www.cyberoptics.com.