Application Case Study: Vacuum Control for Semiconductor Wafer Deposition

While it isn't immediately obvious, microelectronic manufacturing is just as much a chemistry science as it is an electromagnetic science. Producing the semiconductor chips found in electronics from mobile phones to space-faring satellites today is the result of building circuits at a nanoscopic scale, where chemical reactions deposit or decompose

into desirable material films that make up switching transistors and planar conductivity circuits in silicon wafers.

A leading semiconductor equipment manufacturer recently engaged Whitman Controls to provide instrumentation for a new generation of their production machinery, specifically in the form of evacuation control for the vacuum chambers on their atomic layer deposition equipment.

About Us

As a veteran-owned small business, Whitman Controls is dedicated to supplying premium quality, reliable, technologically advanced instrumentation for use in nearly any application. Our Bristol, CT manufacturing facility embodies over 40 years of engineering, fabrication, and customer service expertise, serving both end-user and manufacturing customers nationwide through direct and distribution channels.

Application Summary

Atomic Layer Deposition (ALD) is a fabrication process used in semiconductor, microelectronic, and other nanomaterial applications. With ALD, chemical reactants are applied in quick succession, each contributing to a chemical reaction that occurs with the substrate material, slowly developing into a desirable film that provides isolation or conductive properties.

Chemicals used in the ALD process are highly aggressive, volatile, and often expensive, which leads to the need for robust, reliable instrumentation that can provide a few key benefits: long-life compatibility with these harsh vapors, very high accuracy so that chemicals are not over- or under-dispensed (especially at elevated temperatures), and high responsiveness so that fabrication time is minimized. Pressure, vacuum, flow, and temperature instruments are critical for these applications.

Challenge

Keeping up with technological demands in the semiconductor industry is more of a series of breakneck sprints than one steady race. Whitman received a call from a new customer in the middle of one such sprint, tasked with launching a new generation of ALD fabrication

equipment to keep pace with a looming increase in industry-wide wafer diameters approaching 450mm.

The customer was examining vacuum chamber improvements to incorporate into their new equipment design and realized that the larger chamber volumes and bigger wafer surface areas would also require a higher tier of vacuum evacuation control than on their smaller models.

The larger chambers needed more consistent evacuation flow from multiple draw-down ports in order to keep gas velocities uniform and in spec, which would mean that vacuum measurement now needed to be more intentionally positioned using higher accuracy, lower-dwell instruments as well. A custom vacuum sensor that offered both ultra-high purity construction and a unique sensitivity range was in order.

“Our new ALD generation needed to have vacuum switches that matched the vapor evacuation profile we needed, and stand up to our trimethylaluminium and cleaning chemistries well enough that we aren’t replacing them as often as we used to. The new [Whitman] switches exceeded those expectations.” - Lead Design Engineer, Confidential Semiconductor Equipment OEM.

Solution

Starting with specifications, Whitman Controls went to task understanding the customer’s application, and in short order, a viable product match was found. Our W117V Ultra Pure Vacuum Switch checked all of the boxes and offered features that expanded the conversation with the customer to other opportunities. Overall, our solution workflow went as follows:

- Whitman provided an application assessment review to understand specification, compliance, and performance expectations. Of note, the high-purity, elevated temperature, and aggressive media specs were the most stringent, with particular requirements for packaged conditions following suit.
- We quickly produced an engineering sample for a custom unit with application-specific setpoints, switch circuitry, and flush-mount fitting (areas prone to buildup of the reactants were especially important to avoid).
- Customer received, tested, and confirmed that the sample was acceptable. The only requested change was to use an M12 QDC cable connection instead of the provided molded wire leads, for easier installation and maintenance.

- In particular, the customer felt that the W117V's fully welded, helium leak-tested housing, along with vacuum-sealed, contaminant-free packaging, were key differentiators that set Whitman apart to be qualified for supplying into their semiconductor projects.
- Further, our ISO 9001 Quality Certification and UL/CSA compliance capabilities make it even easier to source from Whitman even easier.
- We delivered an initial product order that allowed the client to launch their first 10 machines of the new equipment generation, which have now been in the field operating without issue for some time.
- We also worked with the client to incorporate our switch's operating and maintenance instructions into their system's owner's manual, providing extra value in supporting the entire project.

Results

With a satisfied customer and multiple new equipment pieces deployed to the field, our part in the project was deemed a success. The W117V's ultra-pure stainless steel construction, quality testing, and contaminant-free packaging helped raise the customer's confidence that Whitman was the right partner to understand design and distribution requirements in the semiconductor industry. We are now discussing further application opportunities of our ultra-pure sensors in the manufacturer's wafer oven, edge cleaning, and IC packaging equipment, setting the stage for a long and positive relationship.

Data Bullets

- **1-2 Week** Custom Order Shipment
- **99.999%** process control uptime since deployment
- **20%** reduction in vapor purge turnover due to superior instrument response time
- **8%** reduction in reactant consumption due to superior vacuum-assisted deposition

Here at Whitman Controls, our values drive us to provide the highest level of servant partnership that you can find. To discuss your applications or to learn more about our capabilities, please contact us at (800) 233-4401, via email at info@whitmancontrols.com, or online at www.whitmancontrols.com.