NOT ONE FAILURE YET:

Cambridge NanoTech Finds Dependability in Swagelok® ALD Valve

When Cambridge NanoTech Inc. first started manufacturing atomic layer deposition (ALD) systems in 2003, the company was experiencing frustrating clogs in the system's valves, which were also underperforming when exposed to heat. The result was lots of downtime.

"The first valves we were using needed to be replaced once a month," explains Dr. Jill Becker, founder of Cambridge NanoTech. "That meant operators had to cool the system down, go in there with wrenches, take everything apart, and replace the valves with ones that were sure to cause downtime again in the future. When you think about manufacturing efficiency, you just can't have this sort of maintenance headache."

To extend the life of Cambridge NanoTech's ALD gas delivery assemblies, Becker turned to local Swagelok Company distributor Cambridge Valve & Fitting. There, she found the answer to her company's valve failure issues – the Swagelok® ALD valve, which provides a highly improved cycle life and better temperature compatibility. These valves and other Swagelok components enabled Cambridge NanoTech and its customers to dramatically reduce the overall cost of ownership for ALD processing.

Cambridge NanoTech's atomic layer deposition (ALD) systems feature precise, controlled delivery of precursor gas to reduce gas use and thereby cost of ownership for users in the semiconductor industry and other fields.

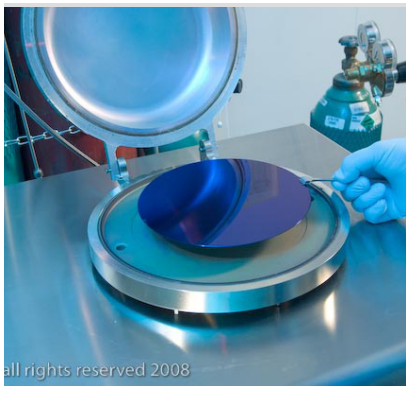
Conserving Precursors.

Cambridge NanoTech's ALD systems are used in research and development and manufacturing operations around the world for semiconductor wafers, nanoelectronics, optics, and microelectromechanical systems (MEMS), in addition to novelty applications such as coatings for drill bits, router bits, and even butterfly wings.

These systems are highly valued not only for their dependability but also for efficient use of expensive precursor gas.

The ALD process deposits thin films of precursor materials onto substrates one atomic layer at a time to impart such properties as conductivity, chemical resistance and strength. With help from Swagelok ALD valves, Cambridge NanoTech has designed gas delivery assemblies that achieve precise, controlled delivery of precursor gas.

One reason for the precise timing is the ability of one ALD valve to perform two functions – precursor delivery and purging. The alternative would be to construct a subassembly of several valves, which can introduce timing variability. Inconsistent precursor and purge gas delivery times result in an increase in the quantity of precursors consumed, which, in turn leads to higher cost of ownership.



Cambridge NanoTech's ALD systems have been used to coat semiconductor wafers (shown), nanoelectronics, flat-panel displays, organic light emitting diodes (OLEDs), and even food packaging, jewelry, drill bits, and dental implants.

In its most basic form, the ALD valve design consists of three ports. Carrier gas enters through one port and exists through another. Precursor gas enters through a third port, which is a small, precise orifice that delivers minimum chemical volume. This three-port configuration works by delivering a steady flow of carrier gas into the ALD chamber. At precisely timed intervals the carrier gas flow is interrupted by a brief pulse (<15 milliseconds) of precursor gas. The carrier gas moves the precursor into the deposition chamber where precursor atoms attach to the substrate being coated.

"Through precise delivery of precursor gas, nearly all of the gas is used in the deposition process," Becker said. "The delivery is so precise that a system running at full capacity 24/7 may take three months or longer to use a 25-cc cylinder of precursor."

Custom Configurations.

An objective of Cambridge NanoTech is to provide ALD tools that are versatile, expandable and tailored to the specific needs of the customer.

Cambridge NanoTech's gas delivery assemblies feature Swagelok® ALD valves connected to a carrier/purge gas source and stainless steel cylinders filled with precursors.

"It doesn't matter if we offer 25 different configurations. There will be customers who want a different version. The fact that Swagelok will move a gland and reconfigure the valve is huge and allows for us as a vendor to offer these solutions to our end customers," Becker explains.

For example, Cambridge NanoTech offers its customers the option to expand the number of heated precursor lines in an ALD system without increasing the unit's footprint. The company's Savannah family of ALD systems typically accommodates up to six precursor lines all capable of handling gas, liquid or solid precursors. However, these lines may be subdivided, enabling users to experiment with up to 12 precursors in a single system.

This versatility is made possible through custom-engineered Swagelok components, such as valve manifolds. Swagelok has designed manifolds for Cambridge NanoTech and other customers that accommodate multiple process lines. Multiple manifolds may be connected to multiple precursors but may draw from a common purge line. Swagelok engineers also adjust port sizes to provide the most efficient delivery of chemistries. A small port may be appropriate for liquid precursors, while a larger port may be appropriate for a precursor with low vapor pressure.

Within the ALD valve, carrier gas enters through one port and exits through another. The precursor enters through a third port, which is a small, precise orifice that delivers minimum chemical volume.

ALD technology is undergoing rapid evolution, which means that the components that service it must evolve as well. For example, increased use of liquid precursors prompted Swagelok to develop the liquid injection valve, which vaporizes liquid precursors inside the valve body. Precise heat control – without cold spots or temperature variability – has for some time been a critical ALD valve specification. More recently, customers are demanding a valve that can be completely immersed in a high temperature environment. In some ALD systems, the entire gas system, including valve actuators, may be placed inside a heated enclosure, which requires high-temperature rated valves tested up to 220°C (428°F).

Swagelok's attentiveness to these market trends has contributed to the company's long-standing relationship with Cambridge NanoTech.

"I think it'd be impossible, really, for us to be doing the work that we're doing if we didn't have the quality of parts that we have right now from Swagelok," said Ganesh Sundaram, Ph.D., Vice President of Technology at Cambridge NanoTech. "The catalog itself is really a thing of wonder. The work of a research scientist is made much, much easier by the fact that there's such a wide selection of products available, and that the people who support those products are knowledgeable and can really help."

Swagelok

Low-Maintenance Designs.

In Cambridge NanoTech's ALD tool, the ALD valves are part of a subassembly that also employs Swagelok VCR® end connection fittings, ball valves or bellows valves, and stainless steel tubing links. This subassembly is dependable and low maintenance, and, if necessary, easily serviceable.

"It is very important for us to make tools that are easy to service," Becker explains. "We want people to recognize parts, like VCR fittings and ball valves, and be able to adjust or replace components easily. For example, the Swagelok cylinders that hold precursor gas take less than two minutes to exchange."

When Cambridge NanoTech made the switch to Swagelok ALD valves, the company added significant life to its gas delivery assemblies. The valves are rated for >50 million cycles. Among the valve's design features that enable extended life, high performance, and dependability in ALD applications are the following:

- High-purity grade PFA seats for a broad range of chemical compatibility and excellent resistance to swelling and contamination;
- Uniquely non-hemispherical shaped diaphragm made of Elgiloy® superalloy material;
- Temperature tolerance to 200° C; and
- Consistent flow rates from cycle to cycle and valve to valve.

"With Swagelok's ALD valves, we are getting millions of cycles without any problems. In fact, we have yet to break one," notes Becker. "The lifetimes of these valves are phenomenal. We also appreciate the fact that you can heat them. It's the perfect ALD valve."