

Safety, Purity and Performance in Semiconductor Cleanroom Environments

ADVANCED ALMATEC® AODD PUMPS PLAY A VITAL ROLE IN NEXT-GENERATION SEMICONDUCTOR MANUFACTURING

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Built from high-grade, non-metallic materials, Almatec® FUTUR Series pumps are engineered for ultra-pure chemical supply and circulation in semiconductor manufacturing. Designed for long-term reliability, these pumps have become a trusted standard in fabs worldwide, helping manufacturers maintain the highest levels of safety, purity and process performance.

Introduction

The semiconductor industry is growing at an unprecedented pace, fueled by the demand for advanced electronics, 5G infrastructure, AI processing power and IoT integration. As chip geometries shrink and production volumes increase, even the smallest impurities or equipment failures can result in costly yield losses. This environment demands not only cutting-edge fabrication tools but also auxiliary equipment, like pumps, that can maintain strict purity, safety and uptime requirements throughout production.

Because semiconductor manufacturing continues to evolve in scale and sophistication, pump technologies must meet increasingly stringent demands. Whether it's transferring solvents, handling waste streams, or maintaining safety in environments with explosion risks, cleanroom-compatible pumping systems must deliver uncompromising performance without contaminating delicate processes.

One technology stands out for its ability to meet these challenges: air-operated double-diaphragm (AODD) pumps. Offering a unique combination of metal-free construction, chemical resistance, self-priming capability and ATEX compliance, AODD pumps are increasingly being adopted in semiconductor cleanroom environments, especially for niche applications involving aggressive or explosive fluids.

This white paper explores how AODD pumps, specifically those designed for conductive, solvent-handling applications, can help semiconductor manufacturers maintain safety, reliability and operational uptime while navigating the complex requirements of modern cleanroom processing.

Understanding the Cleanroom Pumping Challenge

Cleanrooms in semiconductor facilities are tightly

controlled environments. Even the most microscopic contaminants can destroy wafers or compromise yields. This puts extraordinary pressure on the materials and design of process equipment, including pumps.

In addition to purity, specific applications – such as solvent transfer, waste stream handling, or alcohol pumping – introduce an added layer of risk: flammability. In these cases, any electrostatic discharge or metal-on-metal contact within the pump could result in ignition. This is where the ability to provide explosion protection becomes vital.

Semiconductor fabrication facilities, commonly known as fabs, are required to follow global explosion protection standards, such as ATEX (ATmosphères EXplosibles) certification, for equipment operating in potentially explosive environments. Finding pumps that can meet both the cleanroom-grade purity and explosion-proof safety standards is no easy feat – yet it's where AODD technology excels.

Moreover, the pumping systems in these settings must operate reliably under fluctuating chemical conditions and temperatures, often in confined or enclosed cabinets. Maintenance opportunities are limited, so pumps must not only be durable but also easy to inspect or service with minimal disruption. At the same time, safety cannot be compromised. This combination of factors makes it critical for semiconductor fabs to specify pump technologies that are purpose-built for the unique operational and safety demands of cleanroom environments, particularly in niche or hazardous applications.

The Case for AODD Pumps in Semiconductor Applications

AODD pumps have long been used in demanding industries due to their exceptional versatility, chemical compatibility and self-priming abilities. In semiconductor applications, AODD pumps offer a range of benefits over mechanical or centrifugal pumps:

1. Metal-free, contamination-free operation:

Semiconductor-grade AODD pumps are often crafted entirely from high-grade plastics or PTFE-based materials. This design eliminates the risk of trace metal contamination, a crucial factor when handling ultrapure fluids or solvents in fabrication processes.

2. Conductivity and electrostatic discharge control:

Specialized AODD pumps designed from conductive plastics, such as carbon-filled conductive ultra-high molecular weight polyethylene (UHMW-PE), enable safe

fluid transfer in explosive or flammable environments. These materials allow for electrostatic dissipation while avoiding the use of metals altogether.

3. ATEX certification: Leading AODD pump models meet ATEX Zone 2 compliance requirements, making them suitable for solvent handling, alcohol transfer, or chemical disposal tasks in explosion-prone areas of the facility.

4. One-piece PTFE diaphragms: Modern AODD pump diaphragms are machined from solid PTFE for maximum durability and minimal delamination risk. These diaphragms offer a long service life and ensure that aggressive fluids don't compromise pump integrity or performance.

5. Straight-through flow paths and minimal bends: In some AODD designs, the liquid path is engineered for minimal bends and surfaces, reducing particle generation and improving chemical compatibility.

6. Self-priming, low-shear and maintenance-free:

AODD pumps are self-priming and capable of dry running. They are low-shear by design, protecting sensitive fluids, and they often incorporate maintenance-free air control systems, which require no external lubrication or electronics.

7. Cost effectiveness: AODD pumps are often more cost-effective over the long term compared to other pump types. Their robust construction, minimal



Designed specifically for high-purity and ATEX applications involving solvents, the Almatec® FUTUR 100F is made from electrically conductive ultra-high molecular weight polyethylene (UHMW-PE), offering outstanding chemical resistance, abrasion resistance and conductivity.



Every Almatec® FUTUR Series component is repeatedly cleaned and assembled in ISO-class cleanrooms to ensure contamination-free performance.

maintenance requirements and compatibility with a wide range of chemicals help reduce downtime and simplify spare parts inventory. These factors contribute to a lower total cost of ownership, making them a wise investment for fabs focused on long-term operational efficiency.

Alcohols, Solvents and Waste Streams

While most semiconductor-grade AODD pumps are used in ultra-pure chemical loops, a specific subset of applications presents a different challenge – safely transferring potentially explosive or aggressive media in cleanroom environments.

These include:

- Alcohol transfer for cleaning and rinsing processes
- Solvent and stripper circulation in lithography and etching steps
- Chemical waste and solvent recovery systems
- Tank or cabinet venting and draining in explosive atmospheres

In many of these applications, the implementation of ATEX-compliant pumping systems is not just a safety best practice; it's a regulatory and insurance requirement. Yet, meeting these standards without compromising cleanroom compatibility can be difficult.

The availability of a fully non-metallic, conductive and ATEX-approved AODD pump bridges this gap, enabling facilities to adhere to explosion protection standards without sacrificing chemical purity or uptime. FUTUR Series AODD pumps from Almatec®, a product brand of PSG, a Dover company, are designed precisely for such environments.

Conductive, ATEX-Certified FUTUR AODD Pumps

The development of the Almatec FUTUR Series was directly driven by requests from semiconductor customers. These users wanted the proven benefits of the Almatec non-conductive FUTUR pumps, particularly the one-piece PTFE diaphragm. Still, they needed a version that could be safely deployed in ATEX-regulated environments. The result was the Almatec FUTUR: a carbon-filled pump combining cleanroom compatibility with explosion protection.

Available in different sizes, the Almatec FUTUR is one of the only pumps on the market offering the rare combination of ATEX certification, fully metal-free construction and a machined, one-piece PTFE diaphragm. This makes it particularly valuable in fab processes where contamination, sparking, or chemical degradation simply cannot be tolerated. Its conductive plastic construction eliminates the risk of static discharge without relying on any metallic components, aligning with the most stringent cleanroom safety protocols. Additionally, its straightforward installation

and proven long-life design make it a reliable solution for operations that cannot afford downtime or maintenance interruptions. The Almatec PERSWING P® air control system, which requires no lubrication or maintenance, adds an extra layer of operational efficiency.

Optional accessories such as stroke counters and membrane break sensors add further value, enabling real-time monitoring and predictive maintenance capabilities that help fabs stay one step ahead of unexpected failures or costly disruptions.

As a testament to the trust that semiconductor manufacturers place in the reliability of Almatec AODD pumps, more than 400 units have already been successfully installed at companies throughout Germany's Dresden region – widely known as "Silicon Saxony." This region has emerged as Europe's leading hub for semiconductor manufacturing and microelectronics, where global players operate alongside a robust network of medium-sized companies and cutting-edge research institutes.

With its unique ecosystem of suppliers, universities and applied research centers, Dresden seamlessly blends industrial strength with scientific expertise to drive breakthroughs in chip design and production. The strong presence of Almatec in this innovation-rich environment underscores its reputation as a trusted partner for high-performance, reliable pumping technology.

Conclusion

In a semiconductor industry defined by precision, purity and safety, selecting the right pumping technology for niche applications is critical. AODD pumps, especially those engineered with conductive, non-metallic materials and certified to ATEX standards like Almatec FUTUR pumps, offer fabs the ability to transfer aggressive or flammable media without compromising cleanroom integrity.

As fabs strive to scale production, minimize contamination risks and comply with stringent safety standards, advanced AODD pumps are poised to become more than just a utility. They will serve as a critical enabler, driving the next generation of semiconductor manufacturing with precision and reliability.

As the industry continues to evolve, the role of versatile, safe and contamination-free pumping technologies will only grow more critical. By choosing the Almatec FUTUR today, fabs secure unmatched reliability and the confidence to meet tomorrow's technological and regulatory challenges without compromise.

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