Validated for Ultra-High Purity Performance: The New Standard of Proof for Pumps in Semiconductor Chemical Delivery

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The semiconductor industry is undergoing a fundamental transformation. As device architectures continue to scale toward ever smaller IC nodes, tolerance for contamination in manufacturing processes has intensified. Ultrapure liquids used in wafer cleaning, etching and chemical-mechanical planarization must meet increasingly stringent cleanliness requirements, as even extremely small particles or trace contaminants can negatively impact yield and device performance.

A purity standard that keeps moving upstream

For the longest time, the strictest cleanliness requirements in a fab lived inside the cleanroom, at the point where chemicals actually touch a wafer. That is no longer where the scrutiny stops. Ultra-high purity requirements are increasingly extending backward through the entire delivery chain, into bulk chemical handling, facility distribution systems, and even the manufacturing processes used by the suppliers who build that equipment in the first place.

Particulate, ionic and organic contamination each carry their own consequences, from physical wafer defects to interference with surface reactions and thin film deposition to broader losses in chemical purity that are harder to trace back to a single source.

Any component that touches the fluid stream is a potential contributor to one or more of these categories. This includes the pumps, valves, fittings and tubing used throughout the system, not just the parts installed closest to the wafer. A component that appears chemically compatible on paper can still shed particles or leach ionic species into an otherwise clean fluid stream. If it happens, it can undermine process control regardless of how well every other

part of the system is managed. This is why fluid-handling equipment is increasingly held to the same contamination benchmarks as any other wetted component in the system.

From compatibility claims to measured data

For years, fluid-handling equipment was often qualified based on general chemical compatibility. If a material did not react with the chemistry running through it, that was typically considered sufficient. That standard has changed. Fabs and chemical suppliers are increasingly asking equipment manufacturers a more specific question: what is this component actually contributing to my fluid stream, and can you show me the data?

That question is pushing component manufacturers across the industry toward individual testing and documented validation, rather than relying on material specifications or general claims of compatibility. It also reflects a broader shift across UHP fluid delivery systems, where polymer components like tubing and valves have long been evaluated against specific purity benchmarks, and where that same scrutiny is now extending to more complex assemblies.

Why the whole assembly matters, not just the material

One key distinction to understand is the difference between testing a raw material and testing a finished, assembled component. A pump is a good example. Its housing might be built from a material that performs well in isolation, but a finished pump assembly is a more complex system than any single part inside it. What an assembled unit actually contributes to a fluid stream is not necessarily predictable from qualifying the housing material alone.

This is the gap that assembly-level testing is meant to close, evaluating the complete, finished unit rather than the housing material alone. Testing the actual unit that will ship to a customer, rather than a representative sample, gives the fab or chemical supplier a much clearer picture of what that specific piece of equipment introduces into the process once it is installed.

The role of SEMI F57

This shift is anchored around SEMI F57, the industry specification covering polymer materials and components used in ultrapure water and liquid chemical distribution systems. The standard sets requirements across several dimensions, including particle contribution, ionic and metallic contamination, total organic carbon, material traceability and surface roughness.

It is worth noting that SEMI F57 compliance and general claims of ultra-high purity performance are not the same thing. Full compliance with this standard covers more than particle concentration and extractable measurement alone. Manufacturers who test against specific elements of F57, such as extractables or particle concentration limits, without meeting every requirement in the full specification, need to be precise about what they are actually claiming. That precision matters most during formal qualification review, where documentation gets scrutinized closely and imprecise language can create real problems for both the supplier and the customer trying to qualify equipment for use.

How one pump line is meeting the new standard

FUTUR Series Air-Operated-Double-Diaphragm (AODD) Pumps from Almatec, a PSG brand, are engineered specifically for aggressive, abrasive and ultra-high purity chemicals. The plastic models are completely metal-free, eliminating one of the more common sources of pump-related contamination. With no rotating parts in the product stream and no O-ring sealing in wetted areas, the design limits the points through which particles or ionic species could enter the fluid stream. Housing parts are machined from solid material, and fluid moves through a straight-through pattern with a single wetted housing part, so there is less opportunity for material to collect inside the pumps. That same attention to purity extends into how each unit is finished. The manufacturing, cleaning, assembly and testing all take place inside a cleanroom.

To further support purity assurance, two configurations within the line, the FUTUR T and FUTUR H, built with a non-conductive PTFE center housing, are eligible for

individual testing and validation against particle cleanliness thresholds required for semiconductor UHP applications. Testing for FUTUR T and FUTUR H configurations includes cleaning procedures followed by leach-out testing that conforms to SEMI F40 and F57 methodology. What is documented and certifiable is specific:

- Ionic and organic extractables tested using methodologies aligned with SEMI F57-referenced procedures
- Measured particle concentration values below the limits referenced in SEMI F57
- Measured particle size distributions are significantly below the standard's prescribed maximums

Almatec does not claim full compliance with SEMI F57 for the FUTUR Series, as the full specification includes additional requirements, such as material traceability and surface roughness criteria, that fall outside the scope of this testing.

Current results for these models have measured within, and in some cases below, the contaminant concentrations published in F57 guidelines. Based on this documented testing, the FUTUR Series is the only AODD pump in the industry verified for ultra-high purity performance against SEMI F57 guidelines, using the terms "verified ultra-high purity suitability" and "ultra-high purity performance" to describe what has been specifically measured and confirmed.

Validated at the individual pump level

Testing a complete, fully assembled pump rather than a material sample has only recently been introduced to this market, and Almatec is the only pump manufacturer worldwide to do it at the individual-assembly level rather than through batch sampling. Each certified unit is tested individually, and the resulting documentation, covering particulate contribution, ionic contamination, total organic carbon and particle size distribution, is tied to that unit's serial number.

UHP
ULTRA
HIGH PURITY

All FUTUR T and FUTUR H models carry ultra-high purity potential by design, but only pumps delivered with this pre-validated data can be considered verified. For fabs and chemical suppliers managing qualification across multiple tools, that level of traceability means documentation reflects the actual equipment installed, not an inference drawn from a tested sample.

What to ask pump manufacturers

As process nodes continue to shrink and contamination tolerances continue to tighten, the expectation for measured, unit-specific documentation is likely to become standard practice across ultra-high purity fluid handling, not just for pumps but for every wetted component in the delivery chain. Continuous development in material science, manufacturing control and validation processes will keep shaping how suppliers respond to that expectation rather than simply reacting to it after the fact.

The conversation has already shifted from whether a pump can handle a given chemistry to whether there is documented evidence behind that claim. Fabs and chemical suppliers evaluating equipment for UHP applications have good reason to ask suppliers the same question the industry is increasingly asking across the board: not whether a component is compatible with the chemistry, but whether there is data to prove it.

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Bart Clerx is a Product Manager for Almatec. He can be reached at bart.clerx@psgdover.com. Almatec is a product brand of PSG, a Dover company, Downers Grove, IL, USA. PSG is comprised of several leading brands, including Abaque, All-Flo, Almatec, Blackmer, CPC Biotech, Ebsray, em-tec, Griswold, Hydro, ipp, Malema, Mouvex, Neptune, Quantex and Wilden. PSG products are manufactured on three continents – North America, Europe and Asia – in state-of-the-art facilities that practice lean manufacturing and are ISO-certified. PSG is part of the Pumps & Process Solutions segment of Dover Corporation. For additional information on PSG, please visit psgdover.com. PSG: Where Innovation Flows.