Case Study

Edwards turbomolecular pump

Case study developed by Hana Majad, Business Development Specialist, Edwards, in collaboration with plasway-Technologies

The main objective of the plasway-Technologies and Edwards collaboration is to demonstrate that advanced vacuum technology can actively enable high-speed PEALD and ALE by delivering low-pressure performance, rapid gas exchange and long-term reliability required for industrial atomic layer processing.





The need for atomic-scale process control

As semiconductor devices become more complex, the processes used to build them must deliver ever greater precision, uniformity and speed. This is especially true for thin-film deposition and surface modification, where atomic-scale control is increasingly essential. In this environment, Atomic Layer Deposition (ALD) and Plasma Enhanced Atomic Layer Deposition (PEALD) have become key technologies for next-generation manufacturing.

What is ALD?

ALD is a thin-film deposition process based on self-limiting surface reactions. Instead of depositing material continuously, ALD introduces reactants in separate pulses, with purge steps in between, so material grows one atomic or molecular layer at a time. This approach enables very accurate thickness control, excellent conformality and high uniformity, even on complex three-dimensional structures.

These advantages are highly relevant in semiconductor production, were advanced device architectures demand extremely consistent films across increasingly challenging topographies. ALD is valued because it offers the kind of repeatability and precision that conventional deposition methods can struggle to achieve at very small scales.

What does PEALD add?

PEALD builds on the same cyclic principle as ALD but uses plasma during one part of the reaction sequence to activate the surface chemistry. This makes the process more reactive and can improve film quality, broaden the process window and support lower-temperature deposition.

PEALD is particularly attractive where manufacturers need the combination of precision, material quality and higher throughput. In other words, it preserves the atomic-scale control of ALD while helping overcome some of the speed limitations associated with purely thermal processes.

The challenge

For Stephan Wege, CEO and owner of plasway-Technologies the challenge has never been only about achieving atomic-scale control. It has been about making those processes faster and more practical for industrial use. His objective has been to develop a platform capable of combining PEALD and Atomic Layer Etching (ALE) in a single chamber while exchanging gases at very high speed and maintaining excellent uniformity across the wafer surface.

That objective reflects a wider challenge in semiconductor manufacturing:

➢ *Increasing throughput without losing the process precision that advanced applications demand.*

Plasway-Technologies has created the world's first integrated high-speed ALE/PEALD system with its FALP chamber – featuring two ultra-fast gas inlets (precursor and reactant), perfectly symmetric gas flow, and an Edwards turbo pump that together deliver exceptionally rapid gas exchange. A technological original that sets new benchmarks in ALE/PEALD processing.
Stephan Wege

What is FALP?

That vision is embodied in FALP, plasway-Technologies' FAST Atomic Layering Process platform. FALP is designed to integrate high-speed PEALD and ALE within the same process chamber, enabling fast gas switching, precise pressure control and highly uniform gas distribution.

In simple terms, FALP is intended to bring together the two qualities that advanced semiconductor production increasingly demands, which is speed and precision. According to Plasway's broader development work, the limiting factors in making these processes faster are clear. Gases must be brought in efficiently, distributed uniformly across the wafer and then removed quickly again. FALP is designed around exactly those requirements.

Scaling the process platform

This process philosophy is also reflected in Plasway's work on gas distribution hardware. Together with Alumina Systems and Lithoz, plasway developed a 500 mm dual-channel alumina gas distribution ring for the FALP platform using ceramic additive manufacturing. The purpose of this component is to enable high-speed PEALD and ALE in the same chamber while maintaining highly uniform gas distribution across large wafer substrates.

This is an important part of the overall story because it shows that FALP is not only about vacuum speed or plasma capability. It is a broader platform concept in which gas delivery, pressure control, chamber design and process uniformity all have to work together.

plasway® Technologies GmbH

Edwards role

This is where the collaboration with Edwards becomes especially important. Advanced plasma-based atomic layer processes place demanding requirements on vacuum performance. Efficient purging, clean chamber conditions, fast pressure transitions and long-term reliability are all essential to process stability.

In many cases, there has been scepticism about whether a turbomolecular pump can withstand such harsh plasma process conditions over extended periods. For that reason, the Edwards-plasway collaboration is significant not only as a technical partnership, but also as a practical demonstration that this vacuum approach can work in a demanding PEALD environment.

Why the Edwards turbomolecular pump matters

Plasway's experience with an Edwards STP-iXA3306CV turbomolecular pump provides a strong answer to that concern. After four years of continuous experimentation, the pump remains fully operational in the PEALD environment (Figure 1). This long-term result is significant not only because it demonstrates durability, but because it shows how the pump contributes directly to process performance.

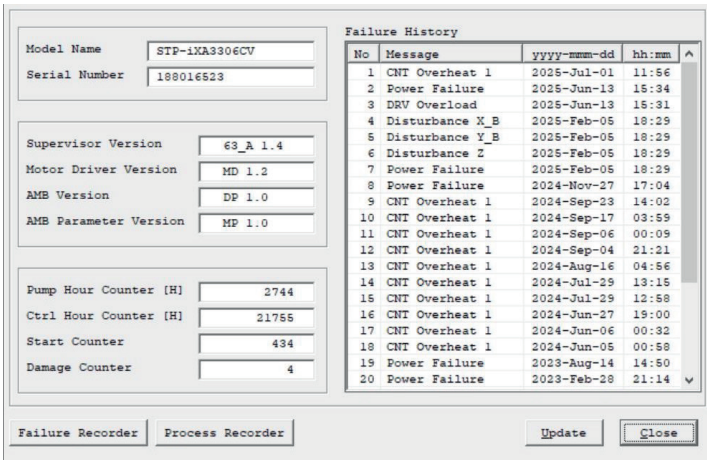


Figure 1. STP Link information window displaying the operational status and fault history of an Edwards STP-iXA3306CV turbomolecular pump after 2,744 hours of operation in a PEALD environment. The screenshot shows the STP Information interface within the STP Link diagnostic software. The left-hand side displays the pump identification details, including the model name (STP-iXA3306CV), serial number, firmware versions for the Supervisor, Motor Driver, and Active Magnetic Bearing (AMB) controller, as well as pump operating statistics, including total pump operating hours (2,744 h), controller operating hours (21,755 h), number of pump starts (434), and damage counter (4). The right-hand panel presents the Failure History, listing the most recent twenty recorded faults with their corresponding date and time stamps. The recorded events include controller overheating alarms (CNT Overheat 1), power failures, motor driver overloads, and magnetic bearing disturbance alarms (Disturbance X_B, Y_B, and Z). Investigation of the fault history showed that the controller overheating and magnetic bearing disturbance events were associated with interruptions to the cooling water supply and power failure, which resulted in elevated controller temperatures and transient disturbances to pump operation rather than internal failures of the controller, magnetic bearings, or turbomolecular pump itself. This diagnostic information, obtained using the STP Link software, provides a comprehensive overview of the pump's operating condition and historical fault events, enabling maintenance engineers to identify recurring issues, assess equipment health, and support root-cause analysis during troubleshooting.

One of the main reasons for using the Edwards turbo pump is to achieve lower operating pressure and very fast chamber gas removal, especially during purge phases. In ALD and PEALD, every half-cycle must be cleanly separated from the next. Residual gases left in the chamber can reduce process selectivity, increase contamination risk and compromise repeatability. High pumping speed therefore becomes a process enabler, not just a vacuum specification.

Pressure transition performance in the plasway process

The pump's ability to support a clean low-pressure atmosphere is particularly relevant in a system like FALP, where fast cycle execution is central to the concept. Pressure transition data from the plasway process (Figure 2) show a reduction in chamber pressure from the gas shoot-in peak to the plasma operating pressure within approximately 100 ms. This is supported by the combined action of the turbo pump and the fast slot valve actuation. This fast evacuation capability matters because the speed of gas exchange directly influences both throughput and chamber cleanliness.

Why this matters for PEALD and ALE

In PEALD and ALE, process success depends on controlled, repeatable surface chemistry. That means gases must arrive quickly, interact in the intended step of the cycle and then be removed before the next stage begins. If any of these transitions is too slow, throughput suffers. If gas distribution is uneven or residual gases remain in the chamber, process quality suffers.

The significance of the Edwards-plasway work is therefore broader than pump lifetime alone. It shows that Edwards vacuum technology can actively support the requirements of next-generation atomic layer processing: fast purging, low-pressure operation, clean chamber conditions and stable long-term performance.

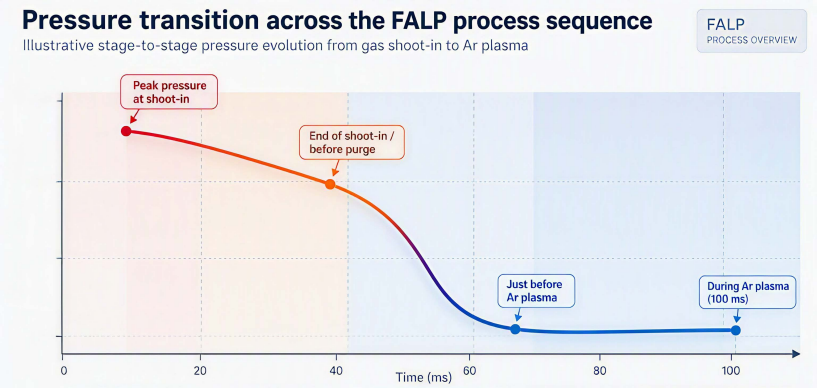


Figure 2

Pressure evolution during the FALP process sequence.

Simplified representation of the corresponding pressure transition, illustrating the rapid decrease in chamber pressure following gas shoot-in and the stabilization of pressure at the required operating conditions for plasma generation. The pressure profile demonstrates effective transition from the elevated-pressure gas delivery phase to the low-pressure plasma processing regime, with stable pressure control maintained throughout the Ar plasma step.

Conclusion

Therefore, For Stephan Wege and his team, the goal is clear: a platform that combines PEALD and ALE, switches gases rapidly, controls pressure precisely and maintains the clean environment needed for repeatable surface chemistry. The Edwards turbomolecular pump has become an important part of making that possible.

The result is a strong joint story. Plasway brings the process vision and platform innovation through FALP. Stephan Wege brings the long-term drive to combine speed with atomic-scale precision. Edwards brings the vacuum performance and reliability needed to support fast, contamination-sensitive plasma processing over years of operation.