Making Exhaust a Controlled Process Parameter in Single-Wafer Processing

Levitronix® CMP & Ultrapure Chemicals Conference 2026

Levitronix®
CMP & Ultrapure
Chemicals Conference
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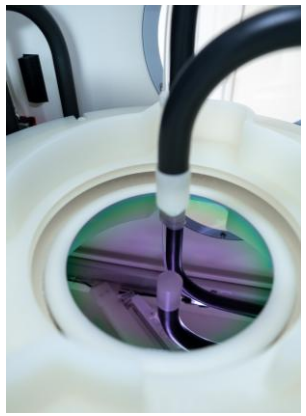
NexGen
WAFER SYSTEMS

Agenda

1	About NexGen Wafer Systems
2	Why Exhaust Matters
3	Active Exhaust Control Concept and Setup
4	Results, Takeaways & Next Steps
5	Questions

What we do in a nutshell

Wet Etch and Clean Process Solutions



Semiconductor Processing Solutions

We deliver tailored wet chemical process solutions designed to enhance efficiency, precision, and yield for semiconductor manufacturers.

Single Wafer Wet Chemical Processing

Our Single-Wafer Technology provides cost-efficient, yield-enhancing single- and double-sided Wet Etch and Clean solutions for FEOL and BEOL applications

Our global presence

Global reach. Local execution. Consistent support.

Our product portfolio

All-in-One Wet Process Solutions

MG Family

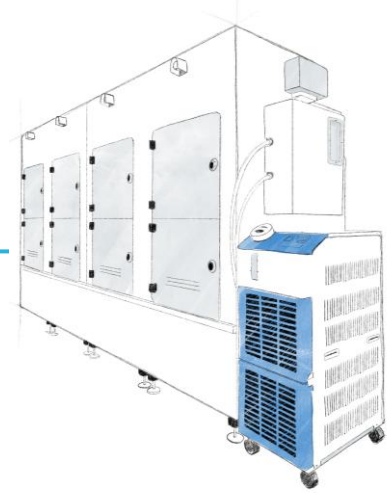
Flexible single-wafer platform for development and specialized production

- Modular single- and dual-chamber architecture
- 4”, 6”, 8”, 12” wafer capability
- Optimized for R&D, pilot lines and small–mid volume manufacturing
- Up to 4 process chemicals with full recipe-based control

SERENO™

High-throughput multi-chamber platform for volume manufacturing

- Six process chambers in a compact footprint
- 6”, 8”, 12” wafer capability
- Engineered for mid- and high-volume production
- Up to 3 process chemicals with advanced point-of-use control



Chemical Supply Systems

Integrated and stand-alone chemical management solutions

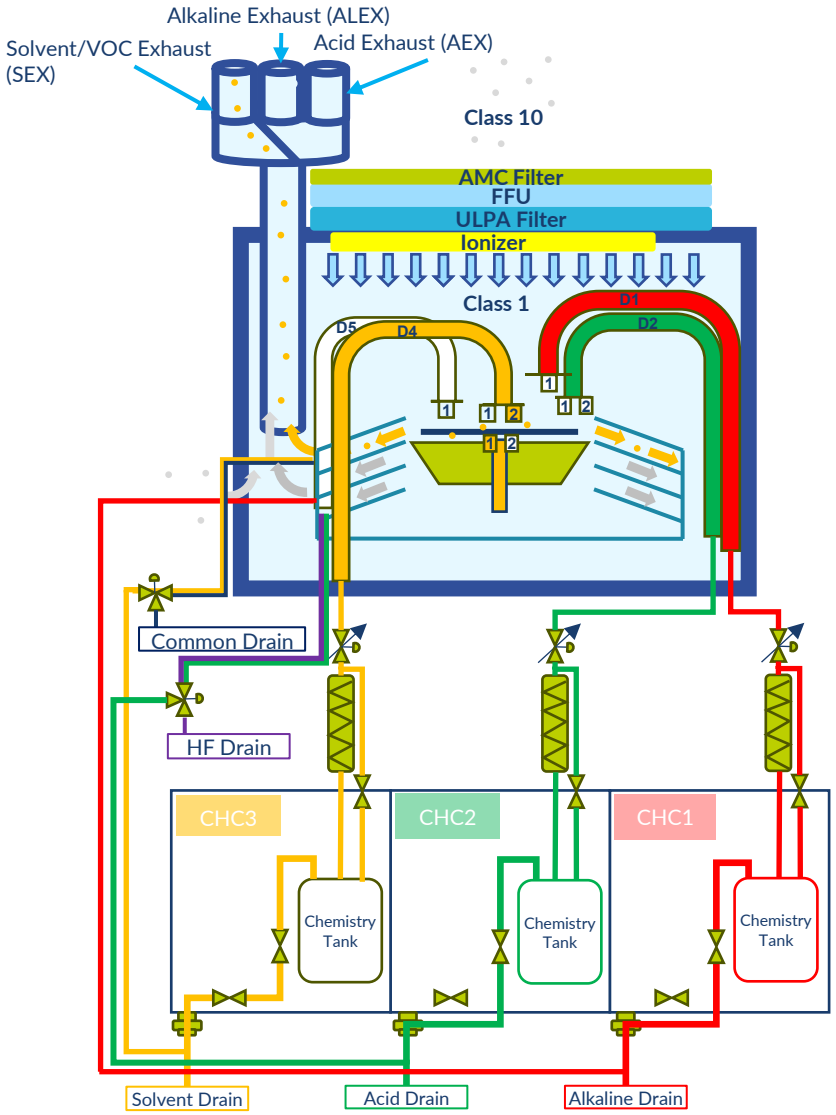
- Mixing, blending and chemical delivery systems
- Compatible with drum-, carboy- and bottle-based supply
- Flexible alternative to fixed fab chemical infrastructure
- Enables scalable fab integration with reduced facility complexity

Why exhaust matters in single-wafer wet processing

Multiple chemistries, dedicated capture zones, one shared exhaust network.

As single-wafer platforms **scale in chamber count and chemistry flexibility**, **exhaust control** becomes increasingly **complex** and increasingly **important**.

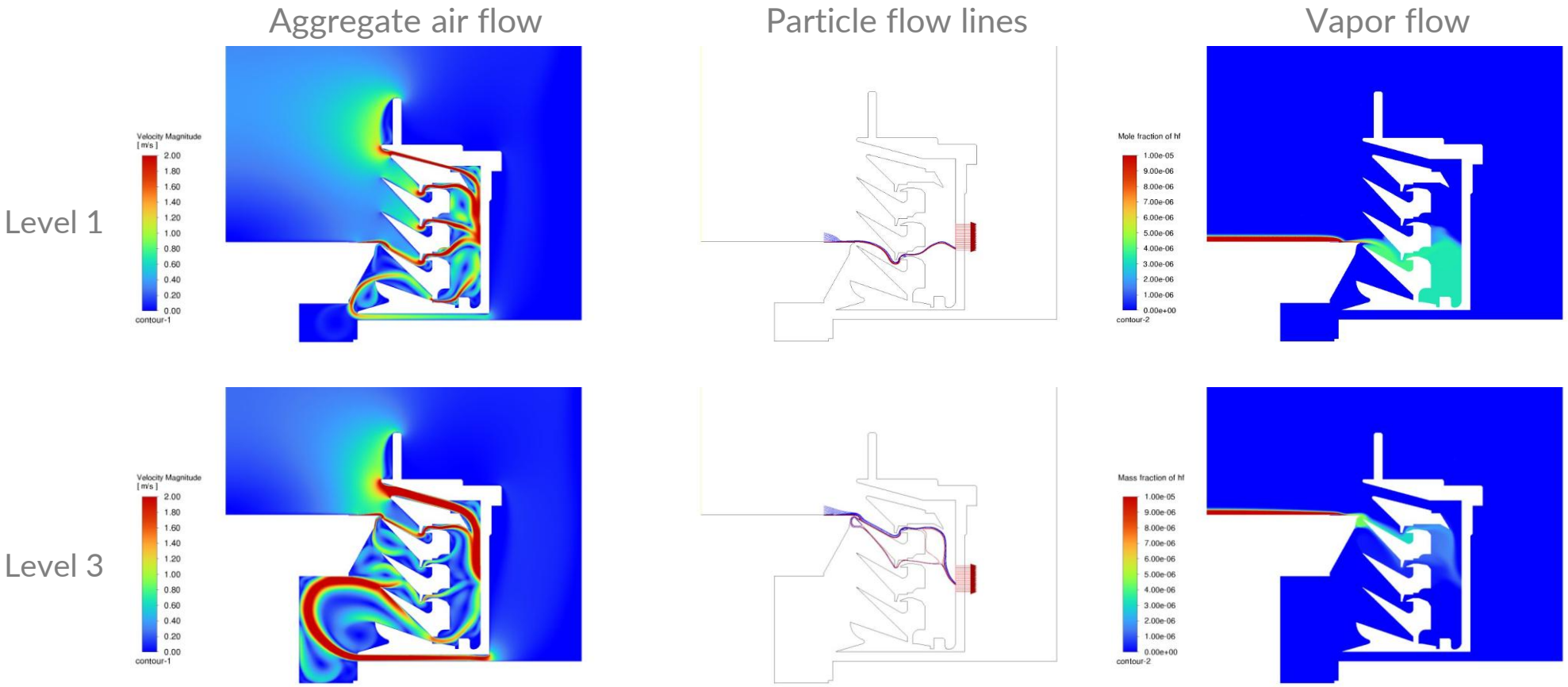
- During a process run, different chemicals are dispensed sequentially on the spinning wafer.
- Each process step generates vapors and fine droplets that must be captured reliably.
- The exhaust system must provide the required suction, pressure, and partitioning for each chemical zone.
- As chamber count and chemistry switching increase, exhaust routing becomes more complex.



In single-wafer wet processing, **exhaust is part of the process environment**, not just a safety utility.

Exhaust and particle mitigation: why small *Δp* matters

The **exhaust system establishes localized negative pressure around the wafer**, drawing away airborne particles and molecular contaminants.

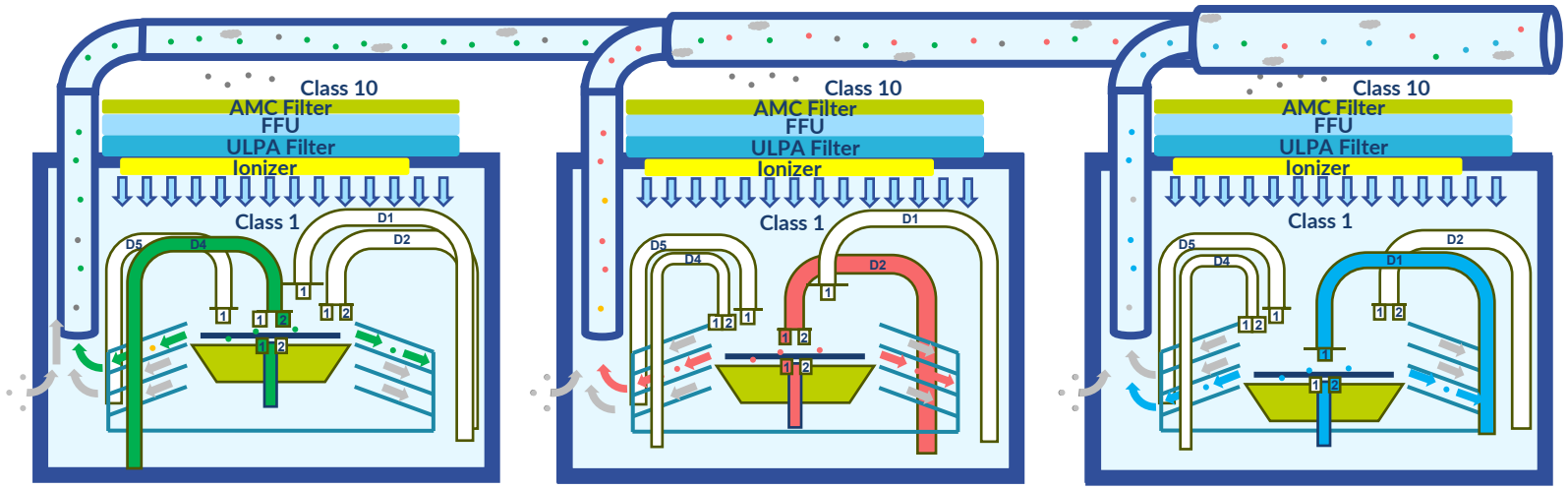


Characterization of production minienvironments finds that **pressure differentials *<0.2 Pa*** (between equipment and cleanroom) can already be **sufficient for high cleanliness**, suggesting that undershooting differential pressure ***(Δp)*** risks back-flow and contamination.

[1] S.H. Park and C. Lee, Numerical Investigation of Flow Entering the Top of the Wafer in Single-Wafer Wet Cleaner, Journal of Computational Fluids Eng., vol. 29, no. 1, pp. 45–60, 2024, doi:10.6112/kscfe.2024.29.1.045

The hidden problem: exhaust instability becomes a process limiter

Small restrictions can shift the exhaust boundary condition seen by the chamber.



Exhaust degradation can begin subtly, while its effect on chamber stability can be highly consequential.

- Shared exhaust sections can accumulate residues from different chemical compositions.
- Even small restrictions can change suction performance and chamber pressure stability.
- These shifts are not always obvious at the equipment interface.
- If left unmanaged, they can disturb process conditions and affect wafer quality.

What begins as a **small exhaust restriction** can become a hidden process limiter that destabilizes chamber pressure and impacts wafer defectivity.

[2] Kedari Matam, Brown Peethala, Charles Taft, Zachary Gardner, Chung Ju Yang, Sankar Muthumanickam, and Devika Sil, *Impact of Process Chambers Exhaust on Wafer Defectivity in Wet Clean Tools*, IBM Semiconductor Technology Research, Albany, NY, USA.

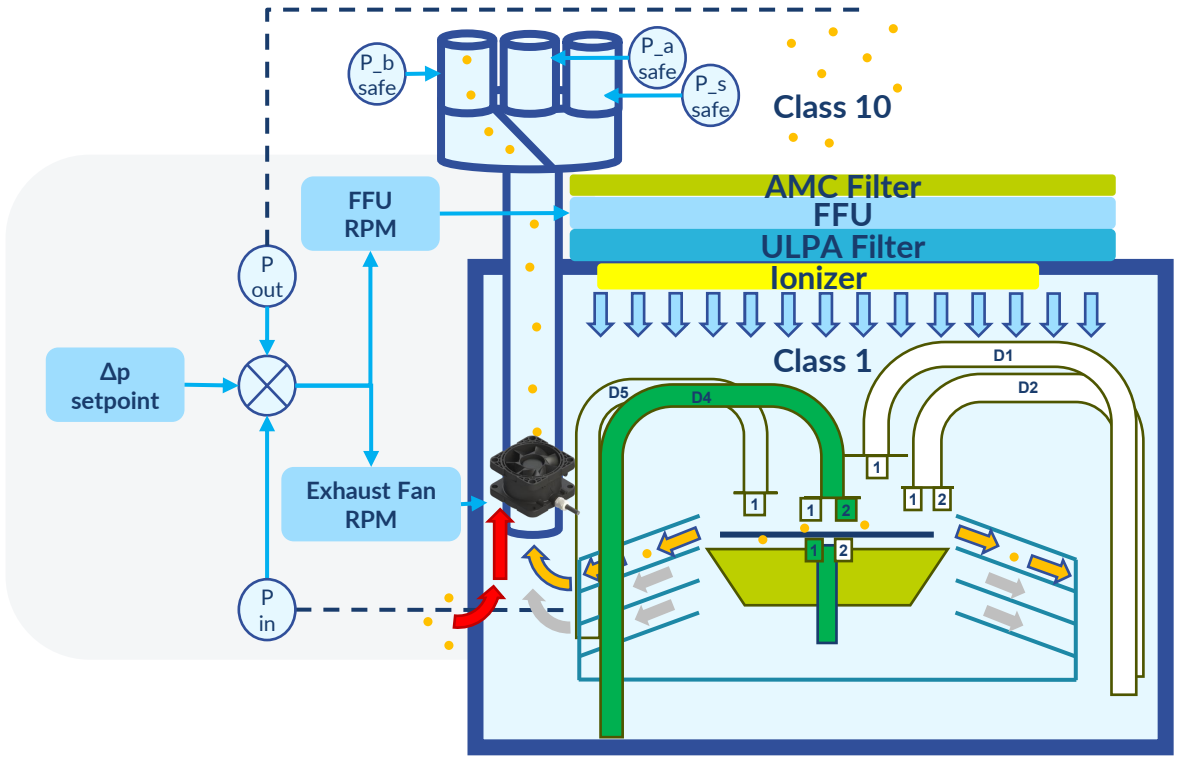
Experimental setup

Making exhaust a controlled process parameter instead of a fluctuating background variable

Closed-loop controlled mini-environment to **sustain airflow balance** around the wafer by **recipe-defined exhaust setpoints.**

Intended to **compensate for:**

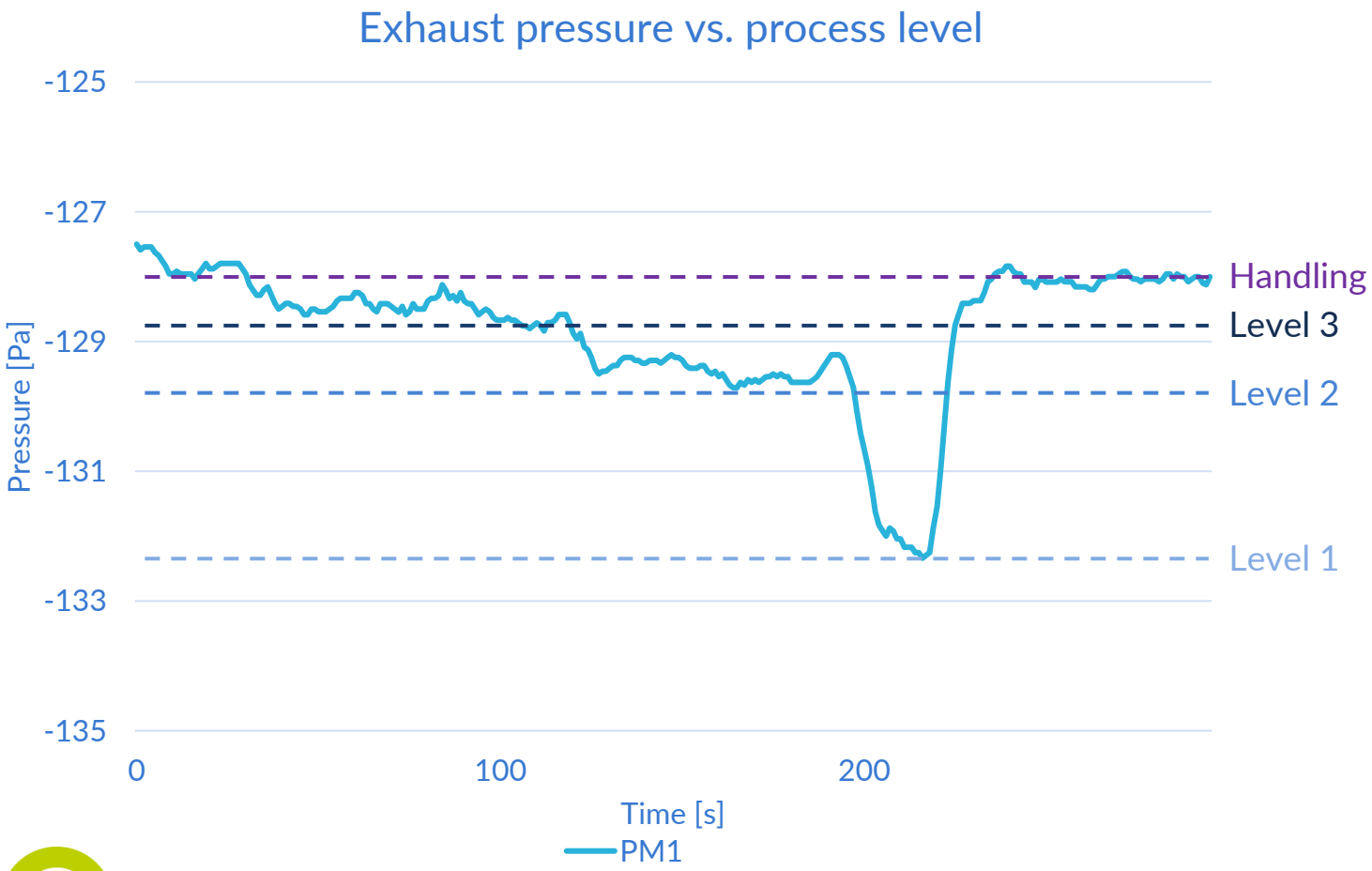
- **process-state changes**
- chamber-to-chamber exhaust **crosstalk**
- exhaust performance **drift**

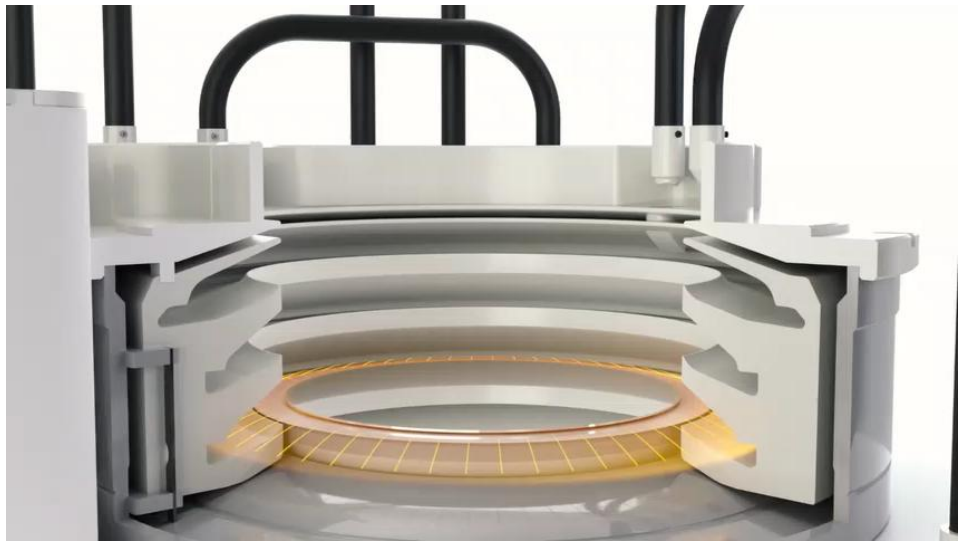


Exhaust conditions in single-wafer processing are typically **treated as facilities constraint-driven**, even though literature suggests that chamber exhaust pressure, flow, and ductwork condition can influence gas and vapor flow fields above the wafer that correlate with process result excursions.

Exhaust pressure across process levels

Different chuck positions, slightly different exhaust pressures.

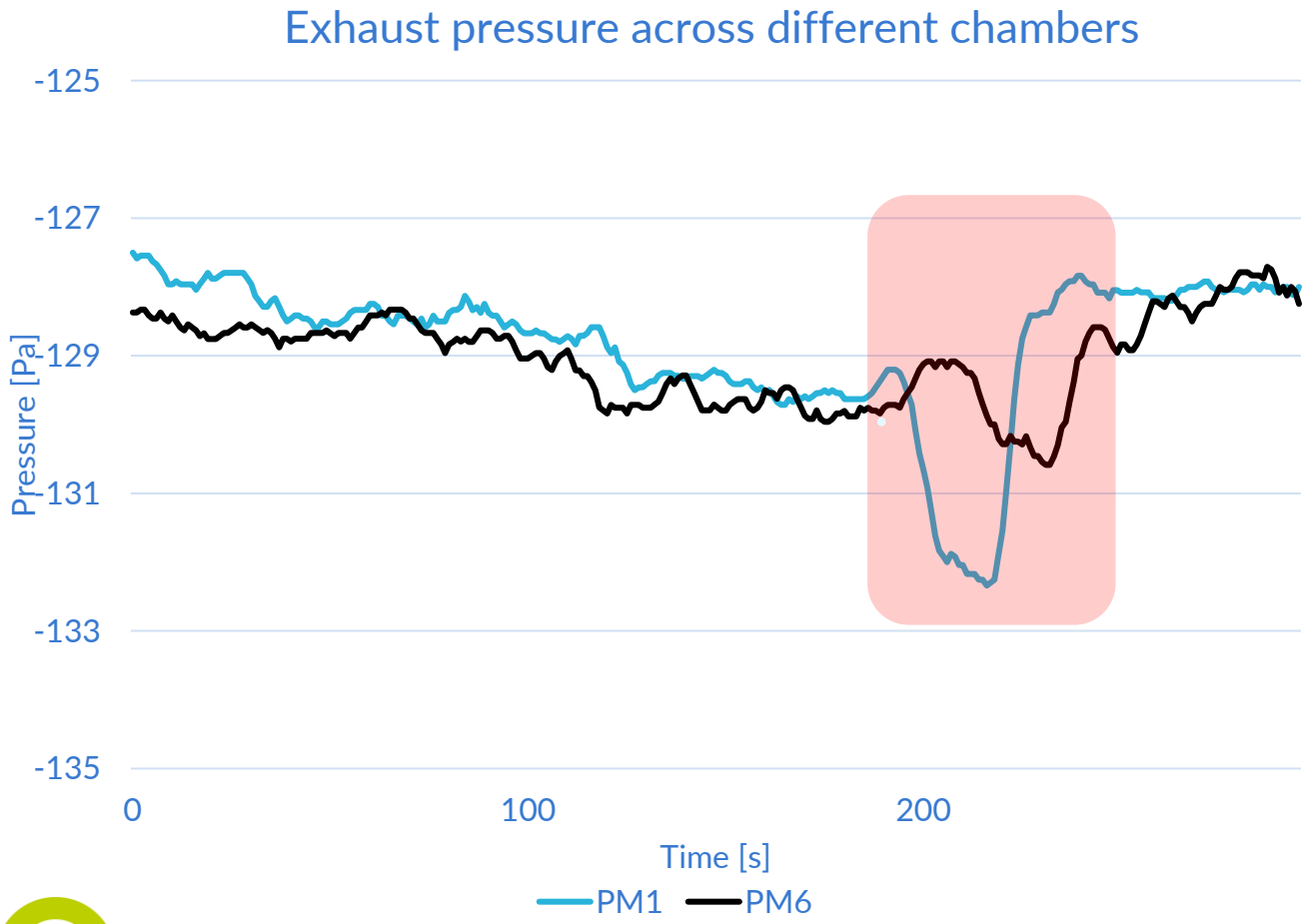


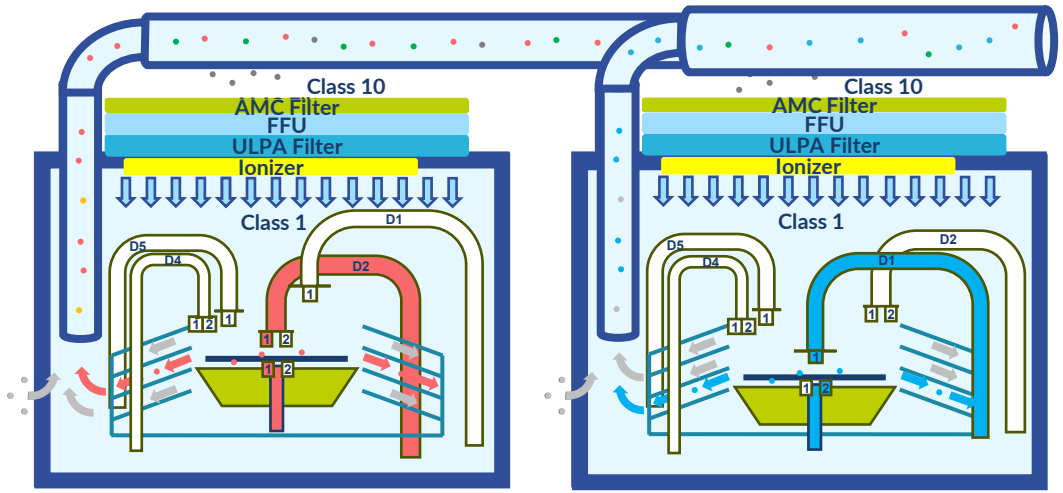


Within a process chamber, each process level experiences a slightly different exhaust condition, mainly because the chuck sits at a different position relative to the chamber.

Chamber-to-chamber exhaust pressure crosstalk

Process-state transitions in one chamber inherently create pressure fluctuations in the other chambers.



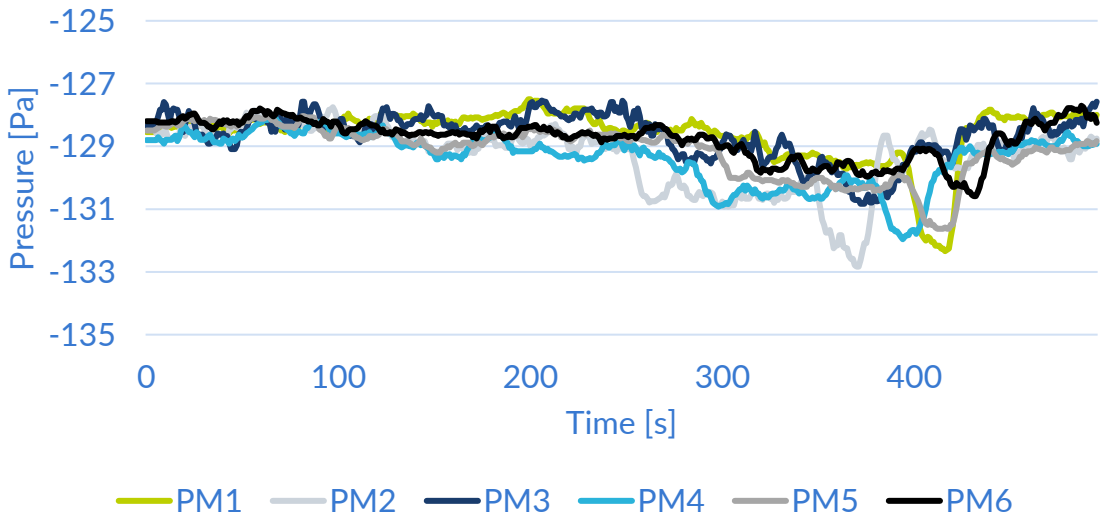


Changing process levels in one chamber produces **unpredictable pressure swings** on other process chambers.

Exhaust fans reduce chamber-to-chamber crosstalk

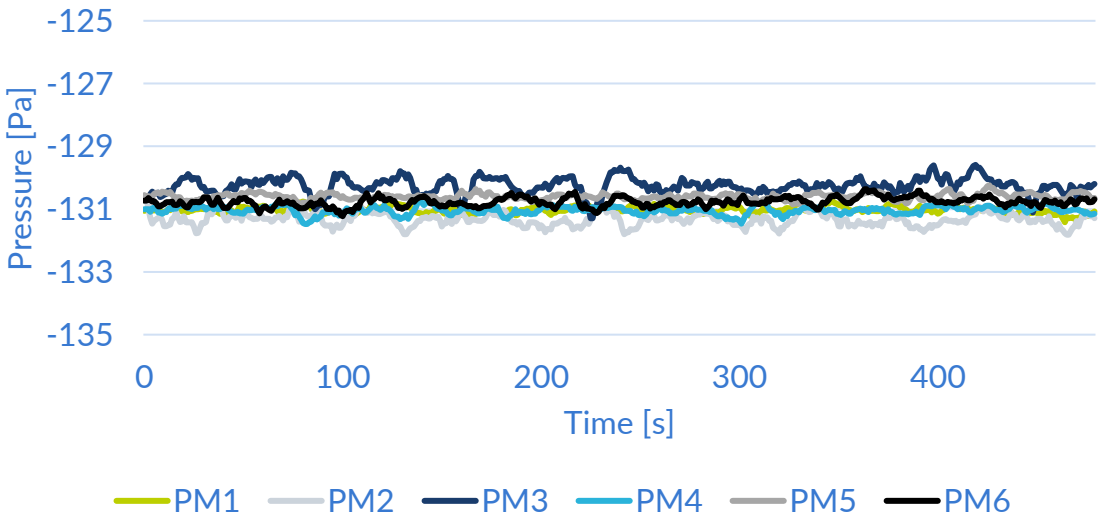
Dedicated fan control holds all chambers near setpoint and reduces disturbance-driven variation.

Open loop: chamber-to-chamber variability



Without exhaust fans: -130 Pa

Closed loop: stable pressure near setpoint



With exhaust fans: -130 Pa

- Sigma: 0.824 Pa → 0.170 Pa (**4.85x lower**).
- Peak-to-peak: 3.94 Pa → 1.33 Pa (**66% lower**).
- Closer to -130 Pa target: average absolute error 1.04 Pa → 0.83 Pa.

Each chamber naturally sees a different flow-pressure point depending on branch position and facility stability.

Experimental setup

Chamber-to-Chamber Matching of Exhaust Pressure

A **Sereno™**, 6-chamber single-wafer wet processing equipment, has been equipped with *dual-exhaust system* (acid + alkaline) and ***active exhaust control*** consisting of:

a) 10 differential (Δp) pressure sensors from SMC **PSE550**

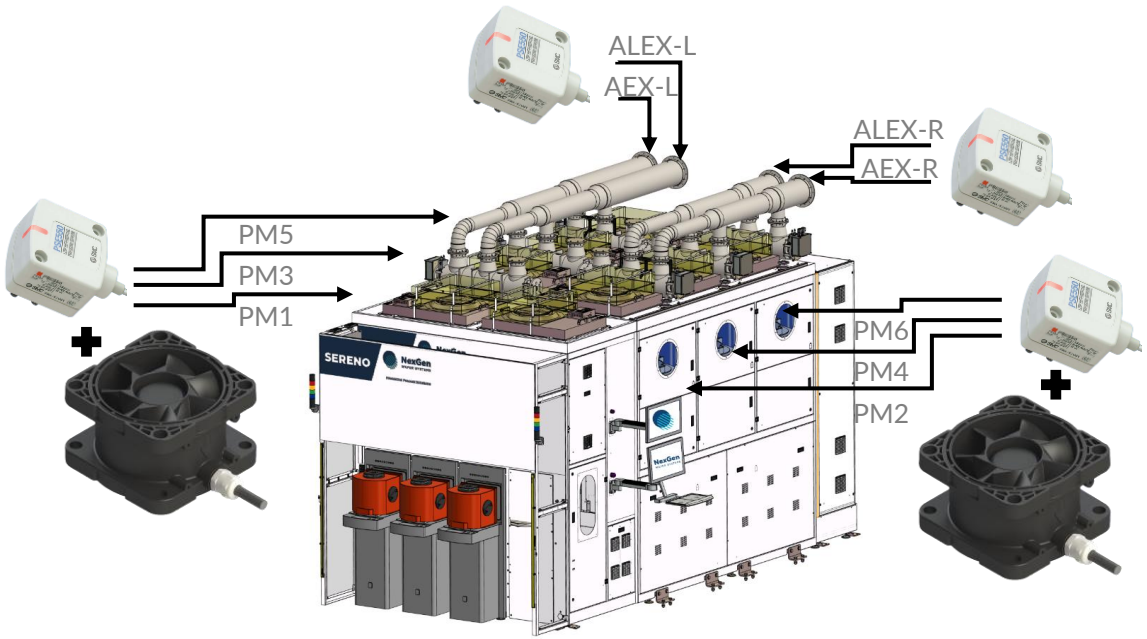
- 1 per process chamber (PM1-6)
- 1 per manifold exhaust line (AEX + ALEX)

b) 6 Levitronix® **BSF-i06** maglev fans

- 1 per process chamber, installed in between process chamber and shared duct to exhaust switch (PM1-6)

c) 6 point-of-use exhaust switching valves

- 1 per process chamber, installed directly outside the equipment and connected to the exhaust manifold lines

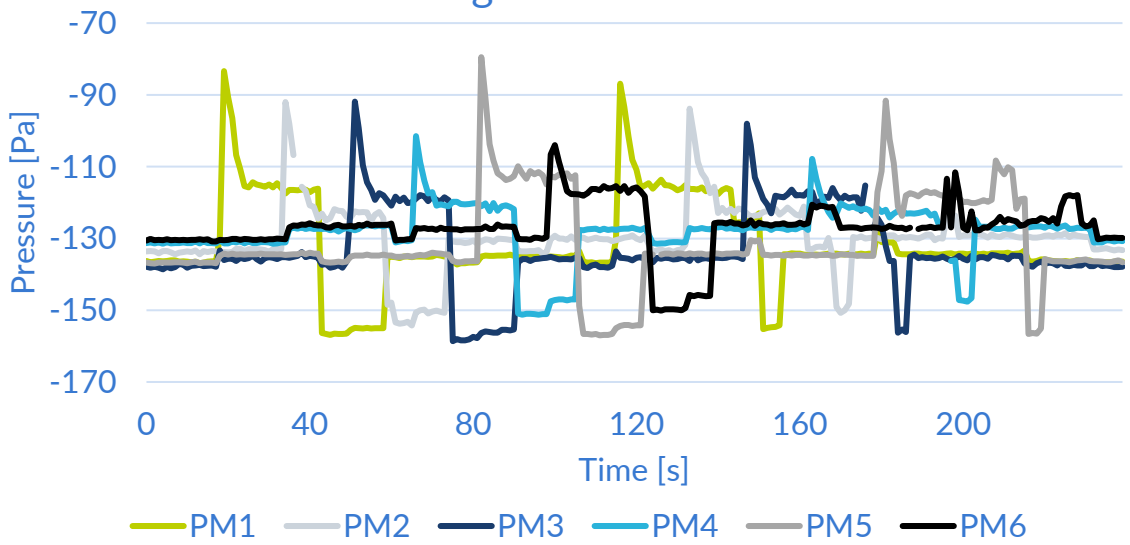


A point-of-use exhaust switch valve with make-up-air decouples chambers, reducing cross-talk and simplifying exhaust pressure tuning.

Closed-loop exhaust control improves pressure reproducibility

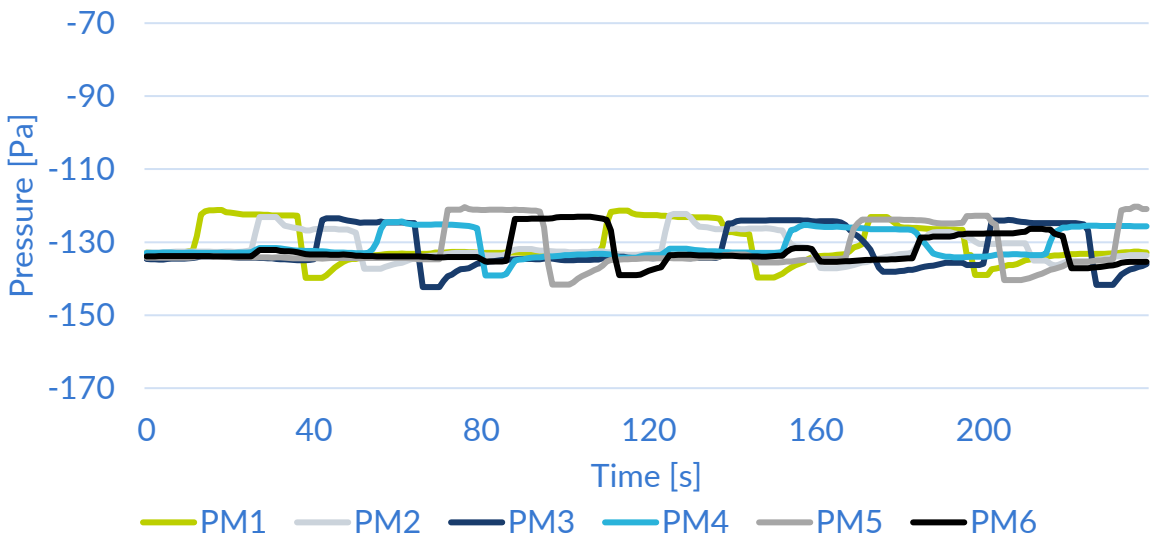
Active exhaust control suppresses switching-induced crosstalk

Without exhaust fans:
switching-induced crosstalk



Acid: -130 Pa, Alkaline: -120 Pa

With closed-loop fans:
reduced transient disturbance



Acid: -130 Pa, Alkaline: -120 Pa

- Sigma: 15.36 Pa → 4.74 Pa (**3.24x lower**).
- Peak-to-peak: 62.9 Pa → 17.8 Pa (**72% lower**).
- Chamber mean spread: 5.89 Pa → 1.70 Pa (**71% lower**) → **indicating reduced crosstalk**.

Chamber-based exhaust switching introduces transient disturbances into neighboring chambers; closed-loop exhaust fans dampen, but do not fully eliminate, this switching-induced cross-talk.

Conclusion and next steps

Active exhaust control makes chamber pressure reproducible at equipment level.

Takeaways

1. *Exhaust* is part of the process environment in single-wafer wet processing.
2. Exhaust performance can become **a hidden source of** process result **variability**.
3. ***Active exhaust control*** can reduce chamber-to-chamber crosstalk and can **make exhaust pressure more reproducible** at equipment level.

What comes next

1. Validate long-term stability under broader operating conditions.
2. Correlate exhaust stability with particle behavior, defectivity, and wafer-level process results.

References

[1] S.H. Park and C. Lee, Numerical Investigation of Flow Entering the Top of the Wafer in Single-Wafer Wet Cleaner, Journal of Computational Fluids Eng., vol. 29, no. 1, pp. 45–60, 2024, doi:10.6112/kscfe.2024.29.1.045

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[3] H.-H. Lu, *Continuous Improvements and Future Challenges of Air Pollution Control Strategy in an Advanced Semiconductor Fab*, Aerosol and Air Quality Research 23, 230034 (2023).

[4] Osburn, C M, et al. "Effects of contamination on semiconductor manufacturing yield." J. Environ. Sci.; (United States), vol. 31:2.

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[6] M.G.L.C. Loomans, T.B.J. Ludlage, H. van den Oever, P.C.A. Molenaar, H.S.M. Kort, and P.H.J. Joosten, Experimental investigation into cleanroom contamination build-up when applying reduced ventilation and pressure hierarchy conditions as part of demand controlled filtration, Building and Environment, vol. 180, 2020, 106861.

[7] Kwang-Chul Noh, Hyuk-Soon Kim, and Myung-Do Oh, Study on contamination control in a minienvironment inside clean room for yield enhancement based on particle concentration measurement and airflow CFD simulation, Building and Environment, vol. 45, no. 4, pp. 825–831, 2010, doi:10.1016/j.buildenv.2009.09.001.

[8] Baltzinger Jean-Luc and Delahaye Bruno, Contamination Monitoring and Analysis in Semiconductor Manufacturing, in Semiconductor Technologies, Jan Grym (ed.), InTech, 2010, ISBN 978-953-307-080-3.

[9] Wang, D.H. et al., “Insights into HF-Last Processes and Particle Performance in a Single Wafer Spin Cleaning Tool,” Solid State Phenomena 134, 15–20 (2008)

[10] Kwang-Chul Noh, Hyuk-Soon Kim, and Myung-Do Oh, Study on contamination control in a minienvironment inside clean room for yield enhancement based on particle concentration measurement and airflow CFD simulation, Building and Environment, vol. 45, no. 4, pp. 825–831, 2010, doi:10.1016/j.buildenv.2009.09.001.

Questions?

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