CRITICAL PARAMETERS FOR EQUIPMENT USED ON NEW HARSH PROCESSES

Alan Brightman explores how broad application coverage and optimised packaging are emerging as *critical parameters* for equipment used on new harsh processes.

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HOW BROAD APPLICATION COVERAGE AND OPTIMISED PACKAGING ARE EMERGING AS CRITICAL PARAMETERS FOR EQUIPMENT USED ON NEW HARSH PROCESSES

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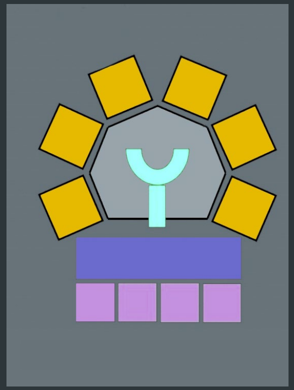
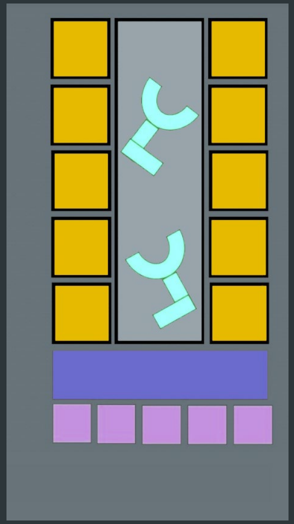
The 2019 article, “Harsh New Processes and Materials Pose Challenges for Vacuum Systems,” focused on the need to simultaneously manage process by-product condensation and corrosion issues. These conditions have only become more challenging with time.

Furthermore, what were previously considered secondary product parameters, have now become more critically significant.

New cluster tool architectures are dramatically changing SubFab equipment selection requirements. Fab strategies to manage process output are dependent upon sophisticated *“Tool to Tool”* matching with vacuum equipment sets that can service a broad range of harsh process applications.



Traditional radial cluster tool



New linear cluster tool

NEW ETCH APPLICATIONS CHALLENGES

Emerging process requirements are pushing the limits of vacuum equipment and creating *new etch applications challenges*. Process environments can be highly corrosive with in-situ chamber clean and waferless auto clean steps.

Precursor by-products are both condensable and corrosive. Combined, in-situ atomic layer deposition within etch applications is but one example.

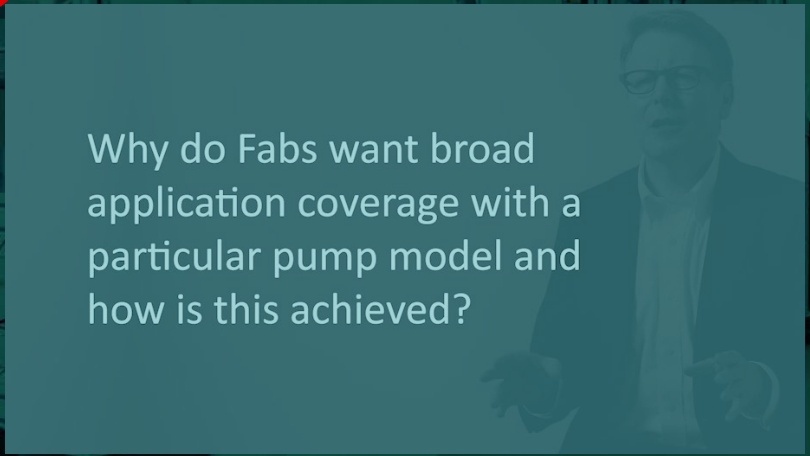
Future technologies, such as selective etch for gate-all-around, very high aspect ratio / buried power rail architectures, and e-DRAM capacitor devices, are expected to further complicate matters.

New process applications have pushed the limits of legacy pumping products. Technology challenges have led to the development of enhanced pump solutions. Performance headroom is desirable to meet future requirements and provide long product life cycles. Furthermore, it is becoming more critically important that pumping solutions are suitable for an increasing range of semiconductor applications.

BROAD APPLICATION COVERAGE

Fabs want to use the same pump model across a wide range of applications for several reasons which include:

- Tool-to-Tool (TTT) matching
- Reduced spares inventory
- Standard facilities interface points
- Uniform maintenance procedures.



Alan Brightman

To achieve this, pumping equipment must have:

- A widely settable and controllable temperature range profile
- An effective corrosion mitigation strategy
- Precision delivered and adjustable purge gas
- Tuneable vacuum performance
- Optimised size and mass with standardized installation template.

Ultimately, the vacuum environment must be designed to protect and enable the Fab’s wafer throughput and overall productivity.

FOOTPRINT AND FACILITY INTERFACE

To maximise Fab productivity, SubFab equipment should fit within the footprint of the cluster tool. Failure to achieve this condition leads to the so-called ***"iceberg effect,"*** limiting fab efficiency.

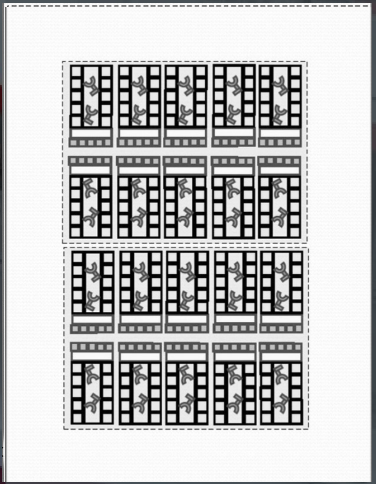
Traditional semiconductor cluster tools employ a radial architecture with typically four process chambers. New linear cluster tool designs can accommodate ten, or more, process chambers.

For a given process chamber count, vacuum and atmospheric automation equipment is reduced. However, the same number of vacuum pumps are required. In this instance, equipment manufacturers are under greater pressure to reduce the size of vacuum pumps. Non-optimally sized equipment has a cumulative negative effect as a typical Fab uses thousands of vacuum pumps.

Highly engineered forelines serve as the physical connection between SubFab vacuum pumps and process chambers. These forelines must be routed through a complex architectural network. Multi-level SubFabs add further complexity. Exact matching of tool parameters requires uniform foreline geometries with pumps efficiently located within the cluster tool footprint. Therefore, vacuum pumps need to be optimally sized with accommodating form factors.

The iceberg effect

Compare radial and linear clusters in the Fab



ENERGY COST

5-30%

of fab operating expenses depending on local electricity rates

ENERGY REDUCTION THROUGH EQUIPMENT OPTIMISATION WHILE MAINTAINING RELIABILITY

The cost of energy is a significant portion of a fab operating budget. Energy cost can be ***up to 30 percent of fab operating expenses***, depending on local electricity rates. Wafer processing tools and support equipment account for nearly 50% of the total energy consumed.

Larger fabs can consume more energy than other comparable industrial complexes, such as auto plants.

Minimizing energy consumption becomes even more critical during times of reduced production, which periodically occur during the semiconductor industry business cycles.

Additionally, power reduction is often a government mandate, or corporate goal to meet “Green Initiatives.” Therefore, the pressure to reduce energy consumption is not only measured in economic terms, but in political terms, as well.

PUMP SIZES AND SPECIFICATIONS ARE OUTMODED

Much of the wafer processing support equipment is oversized and operates above the actual, required specification in order to provide headroom and support chamber matching. It is essential to develop cost effective solutions while maintaining critical process parameters and avoiding costly downtime.

Pumping system power consumption can be reduced with the application of “right-sized” equipment. For example, the incorporation of a proximity booster at the semiconductor tool reduces the peak pumping speed requirement of the subfab backing pump. Power consumption of this optimised pumping system can be significantly less than the power consumed by a single, oversized SubFab pump.

Additionally, the reduced equipment footprint saves valuable SubFab space and avoids the costly “iceberg effect.”

COST SAVINGS BY MANAGING THE WATER USED

Pumping systems are generally water cooled. Cooling water system pressure, flow, and temperature are significant cost contributors. A best-in-class pumping system can be designed for efficiency, whereby the cooling water is nearer ambient temperature and provided at lower pressure. Cost savings are cumulative as there are thousands of pumps in a typical fab.

MINIMISING INSTALLATION COSTS

Cost of installation is receiving more attention. For example, equipment full load current ratings drive breaker and power cable sizes. Through the incorporation of sophisticated motor drive control schemes, pumps can achieve an optimized full load current rating while maintaining high reliability. This is particularly important during harsh duty restart events, after an unexpected power outage.

CONCLUSION

With a thorough knowledge of critical semiconductor operating parameters and Fab facility cost drivers, equipment suppliers can optimise pumping systems. Reliability can be maintained, or even enhanced, without the need to over specify equipment performance.

Contact Alan Brightman directly for information.

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