Smart Management in the Sub-fab Improves Safety, Reliability and Yield

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Significant opportunities to improve safety, reliability and yield still remain in our industry, many of them to be found in the sub-fab, where critical systems that supply vacuum and treat exhaust exist—out of sight and, too often, out of mind. Properly handling and removing noxious components in the exhaust flow clearly impacts the safety of fab personnel. As for reliability, when the sub-fab fails the process is down. And yield—the yield of many tools depends directly on steady, high-quality vacuum. “Smart” management of sub-fab systems can improve safety, reliability, yield, and energy efficiency, all of which contribute directly to the bottom line.

For example, consider high-flow CVD processes, which are finding increasing application in high-volume production of 3D-NAND, DRAM and other devices. The process precursors and their decomposition products present a flammability risk and tend to condense as hazardous materials in process exhausts. Such condensation can cause a variety of operational problems, including process shut-downs when pipes become blocked, exhaust pipe fires when fluorine reacts with condensed silicon compounds, and HF vapour releases when pipes are exposed to atmosphere during cleaning.

Several approaches may be used to address these concerns, alone or in combination. The entire exhaust assembly may be heated to maintain a thermal profile that eliminates condensation, though eliminating all cold spots can be difficult and constant monitoring is required. Exhaust gases may be diluted to mitigate flammability risks, but the cost of the diluting gas (N2) becomes prohibitive at high flows. The total cost of ownership for high dilution flows must also include increased capital investment, operating cost and sub-fab space requirements for additional abatement capacity.

A smart dilution strategy would continuously adjust the flow of dilution gas based on information from the process tool. Is flammable gas flowing? Is oxidant gas present? If the process gas is non-flammable, can dilution be eliminated entirely? When only a flammable gas is flowing, how much can dilution be relaxed while still maintaining the mixture below the lower flammability limit; or can it be allowed to exceed the LFL, since there is no concurrently flowing oxidant? When flammable gases flow concurrently with oxidizing gases, what dilution is required to keep the concentration of flammable gas below its LFL, with a sufficient safety margin to allow for fault scenarios? What is the best dilution for cleaning gases to optimize the safety and efficiency in their abatement? Answers to these questions and more can be found by analyzing information from the process tool and used in a smart dilution strategy to maximize safety, reliability and yield while minimizing cost.

Information from the process tool can also be used to control the operation of the abatement system. When only flammable gas is flowing with low or moderate dilution, the

abatement system can be operated in a “low fire” mode, minimizing consumption of fuel, city water and process cooling water. When flammable and oxidizing gases flow concurrently and high dilution flow is used, the abatement can be switched into a “high fire” mode to ensure full destruction of the process chemicals.

Coupled with smart operation, smart system design can further improve safety, reliability and cost. Consider the problem of gas leaks. Leaks from process exhaust pipes can lead to fires, equipment damage and harm to sub-fab personnel. Local gas leak detectors can protect personnel but risk process shut-down and product loss. Rigorous leak checking procedures can reduce the risk of leaks during maintenance, but cannot prevent progressive seal degradation or leaks that occur during normal operation. A smart design integrates pumps, abatement and all connecting piping in a single unit, engineered for performance and safety and thoroughly tested at all stages of manufacturing and installation. Integration also permits exhaust integrity checking, double-containment enclosure, monitored pipe temperature control, and tool-connected “smart” operation and provides single-vendor responsibility for maintenance and performance.

Opportunities for improvements abound, but taking advantage of them requires a smart approach based on broad experience and thorough understanding of semiconductor manufacturing processes.