Setting Standards for Sealing

By Dalia Vernikovsky, President and General Manager, Applied Seals North America Inc., Newark, Calif., www.appliedsealsna.com -- Semiconductor International, November 1, 2009

In chip production, every facet of the process is created and designed with the most sophisticated tools, the most amazing technology and the most advanced controls. Super-stringent requirements are applied to each of the fabrication steps, which are guarded with process definitions, controls and documentation that forbid any variation or anomaly. As semiconductor technologies continue to evolve to higher and higher levels, the bar is raised at every step.

With so much emphasis on precision and tight tolerances, why has there not been any measure of "control" — any standardization, any requirement applied in the realm of specialized seals and O-rings used throughout every wafer fab? Why have sealing standards not been addressed when virtually all deposition and etching equipment's critical process performance depends on them?

As demonstrated by the tragic fate of the Challenger Space Shuttle in 1986, too often O-rings and seals are not factored into process control considerations. Yet all of these seals are vital to the challenges that surround ultra-sensitive environments and advanced process states. As our industry expands its applications of the periodic table, O-rings and seals must not be overlooked. The infinite number of variations that now exist in the development of specialized, next-generation materials have got to be considered in the design and selection of the optimal sealing solution for each intended use.

Today's sealing components are far from commodities. They — and the materials used to create them — have got to be recognized as specialized products with the unique makeup to meet a variety of increasingly demanding process parameters. Whereas the original — and only — purpose of O-rings was simply to create an airtight seal, today these pervasive components also must protect against molecular contaminants and process failures while guaranteeing optimal performance conditions. As the expression goes, "The devil is in the details." Care must be taken in designing and engineering sealing solutions that can reliably shoulder all of these burdens.

Perfluoroelastomers have become the material of choice for many harsh environments. They are well suited to withstand very aggressive chemistries, temperatures and pressures. But the lack of semiconductor-grade standards for the various formulations of perfluoroelastomers exposes our industry to two glaring pitfalls.

The first of these is usage. O-rings and seals were originally developed for the aerospace and industrial markets. Early product specifications were created by the Society of Automotive Engineers (SAE), followed by Mil-Spec standards, to assure that the same size and shape would be repeated regardless of the manufacturer. But size isn't everything. Today's semiconductor-grade perfluoroelastomer components have unique material properties that can be degraded if an O-ring is stretched, for example. So usage guidelines are needed to ensure that a seal's integrity is not compromised during installation.

Then there is composition. This is the least understood aspect of the newest family of perfluoroelastomers, and it can make all the difference in optimal sealing. There are many types of polymers, curing agents and fillers used in making seals. Each must be properly matched to the intended application to get the most from a user's processing equipment and to enable repeatable, reliable technological advances. A perfluoroelastomer type used in a previous process node will not necessarily be the right choice for a newer version, just as industry advances have challenged so many other aspects of product compatibility.

Most seals and O-rings used in the semiconductor industry aren't even required to meet a current SAE standard, opening up the field to all of the industrial base variations in existence today. As an industry, we are exposing our end products and our businesses to huge potential problems if we blindly assume that O-rings do not need to be considered in contamination challenges and will remain sufficient in the face of new process chemistries.

Without education and standardization, sealing components are sure to be misused. In addition to costing preventable downtime and parts replacement, there is the greater inefficiency of wasting the time and talents of technicians, maintenance engineers, process engineers and contamination experts to analyze and hunt for damaging particle generators, the culprits in distressing leak back rates. In my experience, the investigation often overlooks O-rings among the potential suspects. So whatever seals may be in a fab's

stockroom continue to be used as replacements — with the problems associated with overstretching, unmatched sizes and incorrect perfluoroelastomer types never fully understood. This scenario could be efficiently averted by industry-wide education as to why all seals are not the same.

A standardization effort is needed for sealing products to provide guidance on everything from material composition to the proper sizing and installation of these pivotal components. This information can benefit everyone from fab operators to all major developers of process technology and hardware. At stake are not only the process integrity of current and next-generation semiconductor products, but also the yields and profitability of multibillion-dollar wafer fabs.

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