

Smart Consumables Usage in Cost-Conscious Environments

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Introduction

Winning in today's fiercely competitive global environment often means operating under strict cost controls. Superior products may succeed and gain market share initially, but those products will not dominate their category unless priced appropriately; this usually translates to minimizing manufacturing costs, including use of consumables.

Nowhere is this more evident than in the semiconductor industry, which has engaged in continuous and pervasive cost-cutting measures. Wiping materials, comprising a major component of the cleanroom consumables budget, have been the focus of many cost-saving programs. The results have sometimes been mixed. End users have found that, indeed, there are ways in which wiping materials can be used more cost-effectively. But sometimes, when focusing strictly on price issues and ignoring performance and contamination control issues, some facilities have found, to their regret, that device yields can be compromised by wrong choices. This paper will address opportunities for smart consumable (wiper) usage without endangering end-product performance.

Wipers as Agents for Contamination Control

First, consider why wipers are used in semiconductor clean rooms at all. Their primary purpose is for removal of surface contaminants — primarily particles and molecular condensables. Camenzind² points out that only 10^{-5} of a monolayer of surface molecular contaminants translates to 1 million $0.1 \mu\text{m}$ particles. Routine wiping prevents re-evaporation of surface condensables, removes surface particles and minimizes contact transfer of particles from one portion of the fab to another. Occasionally, wipers are used to mop up liquid spills or to provide clean surfaces on which to place sensitive articles. But if the main objective is contamination control, then obviously, the

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cleanliness of the wiper, rather than its absorbency, is the key attribute for selection.

Paper Towels

If price were the only consideration, one could settle on something as simple and as inexpensive as paper towels for wiping activities in the cleanroom. A far-fetched idea? This possibility was explored previously³, at least hypothetically, in an examination of the impact of wiper fabrics on semiconductor yield. The observation was made that since wiper expenditures are less than 0.1% of the cost of making a chip, then choosing a wiper material that is almost free (e.g. paper towel), but lessens yield by only 0.1% is not cost-effective. Paper towels cannot be considered as appropriate contamination control tools in a semiconductor cleanroom because of the high particle, fiber and ion residues that are left behind when they are used to wipe critical surfaces. A cost/benefit approach on evaluating the cost-effectiveness of cleanroom cleaning materials has been proposed⁴.

So if price is not the only consideration, how does one decide which wiper material to use where? Some guidance can be provided by Hattori⁵ who used a bull's-eye diagram to illustrate the need to increase contamination control efforts as one progresses from the least critical area — the building — through the cleanroom, the equipment and the chamber, finally ending at the most critical area, the wafer (at the bulls-eye). In other words, the closer you are to the wafer, the cleaner the wiper needs to be. In the limit, only the very cleanest wipers should be used to clean the equipment that contacts or houses the wafer. In this regard, it becomes useful to think of the wipers used for equipment cleaning during preventative maintenance (PM) as part of the process. Entertaining use of a less expensive wiper for PM's should be evaluated, tested and decided in the same way as using a less expensive process gas or a less expensive chamber component; i.e. what effect will it have on the process and the yields?

Wiper Choices

While there are many wiper fabrics from which to choose⁶, it turns out that two types of wipers predominate in most semiconductor fabs — (i) laundered, polyester knit fabrics incorporating sealed edges or sealed borders, used in the critical areas inside the fab, and (ii) hydroentangled (also known as “spunlace”) blends of polyester and cellulose, used in less sensitive areas such as gowning rooms, sub-fabs, etc. Polyester knit wipers have the lowest levels of releasable particles, fibers and extractable ions and are used for the most critical cleaning tasks. They are more expensive than the economical

hydroentangled blended wipers which usually carry higher contamination burdens.

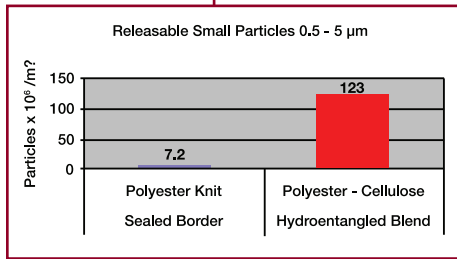


Figure 1 – Wiper comparisons for small particles

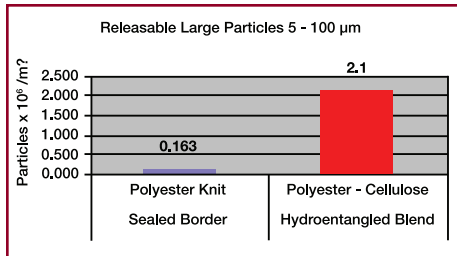


Figure 2 – Wiper comparisons for large particles

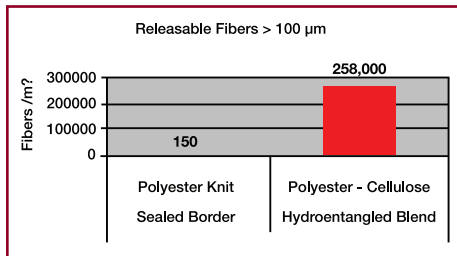


Figure 3 – Wiper comparisons for fibers

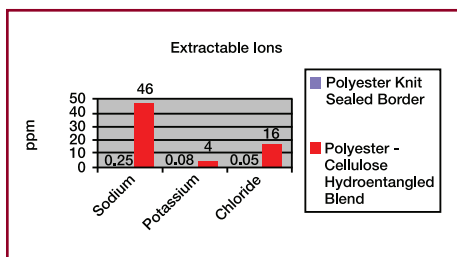


Figure 4 – Wiper comparisons for ions

Fabs using only polyester knit wipers in all locations may be sacrificing some cost savings by not considering hydroentangled blended wipers for the less critical areas. Of course, strict segregation of these blended wipers must be enforced so that they do not inadvertently “migrate” inside the fabs. This can be addressed by clear protocol enforcement, training, posters and signs. Conversely, fabs using hydroentangled blended wipers inside the cleanroom are unnecessarily endangering product yields. The possible savings in wiper cost are likely more than offset by lost product revenues (from contamination), degraded product reliability and expenditures in man power and analytical services to track down contamination sources. Hydroentangled blended wipers may be an improvement upon paper towels in terms of contamination characteristics, but they are still not clean enough to be used in very sensitive areas — wafer load ports, process chambers, etc. For these areas, only sealed edge or sealed border polyester knit wipers will do (Figures 1-4).

Alternative fabrics for wiping critical environments should always be evaluated against polyester knit as the “gold standard”. A fabric that is often proposed is microfiber polyester knit. However, when one considers the price premium for microfiber vs. traditional polyester knit, then compares the particle, fiber and extractables of the two fabrics, the value and performance of the polyester knit fabric emerge clearly. Microfiber knits may be ideal for removing surface oils from optical surfaces (e.g. flat panel displays), but they are too contaminating to be used inside a semiconductor cleanroom.

Pre-wetted wipers

For contamination control applications, wipers are used in combination with cleaning agents such as isopropyl alcohol (IPA). Although it may seem counterintuitive, pre-wetted wipers supplied by wiper manufacturers will lower overall costs of

cleaning in comparison with dry wipers and squirt bottles of IPA^{6,7} and will free up valuable personnel for more critical tasks. An analysis of costs and activities will show that the pre-wetted wiper is less costly than using a dry wiper and including all of the costs associated with purchasing, storing, blending and dispensing the alcohol.

Other benefits are associated with the use of pre-wetted wipers:

- The convenience of pre-wetted wipers means that contamination control protocols are more likely to be followed – i.e. the necessary wiping will be done. Wiping is often ignored if only empty squirt bottles of IPA are available (“I’ll get to it later”). Empty squirt bottles are often considered orphans — no one owns them, no one maintains them and no one has the clear responsibility to keep them filled.
- Wetting a wiper from a squirt bottle is unlikely to produce a dampened wiper with the proper amount of solvent on it. This is because the operator is wearing gloves and there is no tactile feedback between the wiper and the glove to indicate how damp the wiper is. Often, more IPA is dispensed onto the wiper than is desirable, leading to excessive solvent costs and inefficient cleaning (overwetted wipers do a poorer job of removing contaminants than do damp wipers). Pre-wetted wipers provide optimum and reproducible dampening.
- Excessive solvent usage described above and “fugitive emission” of solvents from the dispensing nozzles of squirt bottles leads to higher than necessary Volatile Organic Compound (VOC) levels which, in turn, carry financial penalties in some geographies.
- Pre-wetted wipers eliminate the labor associated with buying, storing and blending flammable organic solvents and eliminate the possibility of solvent spillage. Ideally, solvents should be filtered through 0.2 µm filters prior to dispensing. This is impractical when handling bulk solvents and filling squirt bottles. Pre-wetted wipers are wetted with filtered solvents during manufacture.

300 mm Fabs

The need for contamination control has not disappeared with the advent of 300 mm processing and the use of Front Opening Unified Pods (FOUP’s), automated loadports, factory interface (FI) mini-environments and robotic — or rail-guided vehicles (RGV’s) and automated material handling systems (AMHS’s). The advancements in wafer handling and transport may provide good protection for the wafer between processing steps, but they have not eliminated the

need to clean equipment exteriors, loadports, robotic wafer handling equipment (Figure 5) and process chambers during preventative maintenance (PM) activities (Figure 6). If anything, the need for specialized cleaning of these chambers is even more critical now, given the higher investment in tooling and wafers and the greater demands presented by the smaller linewidths along with the more complex processes.



Figure 5 – Maintaining cleanliness of wafer loading area is critical



Figure 6 – Wipedown of process equipment during preventive maintenance (PM)

Summary

Reducing expenditures in cleanroom consumables such as wipers can be accomplished through a clear understanding of where they are used in the cleanroom and for what applications. Cost savings can co-exist with yield improvements.

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