Fab operators know the story: maximizing uptime minimizes cost. On any given tool, less frequent preventive maintenance (PM) reduces labor and part costs by increasing annualized part lifetime and reducing annualized kit cleaning, which in turn reduces wear and tear. Even better, when fab utilizations are high, more uptime means more wafers and quicker return on capital.

But before we talk tools, let’s talk sports cars. Way back in the 1990s, Ford Motor Company was rolling out a new model called the Probe. At the time, the Probe was about as forward-thinking as American rides got. It was sleek, relatively fast, could hug a tight corner and came in wild colors like aqua blue. I have a friend who owns a Probe that we affectionately named the Blue Blur. I recently had the chance to take her for a drive. I’m happy to report she can still bring out a smile spinning around a freeway on-ramp. It’s nice to know that regular maintenance, a good tune-up and a little 21st century technology applied to a few parts can keep an aging beauty in the fast lane!

Your tools, like old Blue Blur, can benefit from selective modernization. Depending on the application and financial drivers, a new engine or chamber upgrade might be the best solution. In other cases, minor improvements to a few parts might really up the ante for chamber performance without breaking the bank. Think of it as an oil change with a new set of tires.

Applied Global Services (AGS) leverages a cross-functional, close-to-fab engineering team dedicated to applying the newest materials, surface technologies and design-for-performance-or-cost principles to breathe new life into older tools. In other words, we’re working hard to take bits and pieces of our newest systems and ideas and apply them to your existing equipment. Let’s take a couple snapshots in time.

Figure 1. 200mm DPS metal.
DPS METAL

About the same time as the Probe was rolling off the line, Applied Materials was shipping 200mm DPS metal chambers (see figure 1) as fast as we could build them. Fast-forward almost two decades and there are still hundreds of these chambers in production globally, many of which are running more advanced technology nodes than originally specified.

In many ways, Applied can be thought of as an enormous continuous improvement factory. In addition to a state-of-the-art 300mm laboratory for semiconductor development at the Maydan Technology Center in Santa Clara and a 200mm engineering and development center in Xi’an China, we have thousands of field service engineers supporting thousands of tools around the globe. Our mission to keep customers’ tools running as efficiently as possible helps our engineering teams stay focused on front-of-mind customer issues, often leading to continuous improvement programs that maximize efficiency.

Take 200mm DPS metal for example. One of our customers asked Applied to address a productivity issue that had become pervasive after ramping a more advanced product line at the fab. Mean time between cleaning (MTBC) was an issue, compounded by a lengthy green-to-green recovery cycle that kept chambers offline longer. The customer engaged the AGS Engineering group to build a chamber-level solution to increase uptime.

General chamber reliability was part of the problem. Premature wet cleans were performed erratically, resulting in backside pressure faults, wafer slippage, breakage and arcing incidents. Not surprisingly, AGS targeted the electrostatic chuck (ESC) for a little modernization. The legacy polyimide ESC was upgraded to a ceramic design (see figure 2) with a lower chucking force to eliminate the premature wet cleans caused by wafer chucking issues. Current-leakage rates were optimized with a continual improvement process (CIP) design to eliminate arcing incidents. But wait, there’s more! AGS improved temperature uniformity by incorporating best known method mesa designs and helium cooling-path configurations that have been proven in leading-edge 300mm applications.

So now that we had a reliable baseline, there was still plenty of upside to extend that MTBC! Advanced ceramic coatings used in 300mm systems were applied to several of the chamber components to enhance morphology for polymer deposition. The engineering teams analyzed deposition profiles and fit, form and function of the OEM designs to determine a surface profile that would increase kit life without increasing particles.

The end results? A 4X increase in MTBC, more than 50% reduction in premature PMs, lower defect density, and a 50% increase in wafer temperature uniformity—all while eliminating ongoing de-chucking and arcing reliability issues. Suddenly the 200mm DPS metal chamber has a new set of wheels with five global implementations underway.

Figure 2. Ceramic electrostatic chuck.

Figure 3. 300mm TxZ chamber.
Let’s fast forward a decade to the 2000s. The 300mm TxZ chamber (see figure 3) was used in Endura configurations for integrated tungsten liner applications into the sub 4X-nm node. By most accounts, this is not an “old” chamber. But that doesn’t mean it can’t benefit from some new spark plugs.

Because of the nature of the Chemical Vapor Deposition process, the TxZ is relatively complex and operates at higher temperatures. As a result, PM cycles can be lengthy, with green-to-green recovery often exceeding 24 hours. As technology nodes decrease, so do particle control limits. Today, 0.12\(\mu\)m particle specs in advanced nodes can limit mean wafer between clean (MWBC) to ~2000 wafers for a 2X50 angstrom process and even lower as the threshold tightens. Couple this with another relatively long green-to-green recovery cycle for PM and chamber availability can be a challenge.

Once again, the AGS Engineering team set out to increase uptime at multiple fabs by customizing a chamber-level solution with new surface technologies. After several months of trials, testing, and a series of failure analyses from several sites, we were able to trace particle sources to just a few hot spots.

The question was how to cool them off. Conventional grit-blasting procedures can often do more harm than good by leaving embedded particles on chamber surfaces or causing micro-surface damage that leads to preferential deterioration with plasma or chemical cleaning exposure. This is especially true when blasting is used to maximize roughness on ceramics. And while it can be optimized for a micro-surface, this is only half the battle. We needed another solution to address the macro-surface to maximize effective surface area in the particle hot spots. Similarly, conventional metal and ceramic coatings were proven less than perfect in the application. Metal coatings can affect plasma profiles, while dielectric ceramic coatings have the potential to increase particles during chamber qualification.

The AGS Engineering team needed to find new ways to solve old problems. We leveraged a state-of-the-art surface technology developed by AGS for CuBS applications that maximizes macro-roughness with reliable micro-roughness. As you can see below (figure 4), LavaCoat II profiles are highly precise and repeatable, a far cry from conventional coatings. Based on the findings from extensive failure analysis, LavaCoat II was applied to the lid isolator and edge-ring to improve film adhesion, which ultimately reduced particles.

The end result? MWBC has been improved by ~1.5X on average while the particle baseline has been reduced by ~25%. Annualized chamber availability has increased by weeks per chamber, significantly improving the extensibility of TxZ into the sub-4X node.

Figure 4. LavaCoat II on lid isolator.

WHICH OF YOUR CHAMBERS NEEDS SPEED?

At the end of the day, the 200mm DPS metal and 300mm TxZ spare part enhancements are simply two snapshots in a large album of our ongoing efforts to partner with customers to maximize their productivity. AGS Engineering is hard at work on several new customer-driven programs to integrate new technology into older systems. The good news is we have plenty of bandwidth to evaluate your situation and develop chamber-level CIP to significantly improve the speed of your legacy systems. Don’t know where to start? Drop me an email and I’ll ensure we start a productive and collaborative dialogue.

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