Is 10 nm Production Feasible? Is Predictive Maintenance Possible?

By Dalia Vernikovsky

In previous articles, ASNA and its many collaborators have written about the lack of awareness and the often misunderstood nature of sub-components in relationship to the ongoing and major effort to reach 10nm manufacturing goals. It continues to be an on-going concern for major fabrication houses and OEMs, that the supply chain is "self-aware", and that SEMI standards that dictate the cleanliness, consistency and optimal designs are chosen. Therefore, the processes (chemistry, plasma, etc.), which are the most difficult of all possible characterizations and take years of genius and experimentation, will magically reach those goals. And yet, here we are, attempting to transcend the barriers of 22nm, marching forward towards 14 nm, and finding the difficulties compounded by the inability to predict what will fail and when. The pluses that advanced process nodes are to offer are hence nullified by the expense and unattainability of that proverbial pot of gold, repeatability.

In this article, I will present a review of a possible format that could be required for sub-components, and has been developed for seals and closely related components, that could identify various processes, as well as areas of production, which may be vulnerable to defects or contaminants. This in itself still does not have direct correlation to that elusive end goal: predictive maintenance. Currently, it is much harder to predict what is generating defects, or how to prevent downtime and even worse, how to work towards reliable manufacturing and efficiency that will achieve the economical stability coveted by those adopting these advanced technologies. It is still fascinating to watch the day-to-day activities surrounding the hyper-pace of the advanced world of semiconductor manufacturing. Every day, millions of dollars are spent in tracking down, understanding the source, analyzing the defects, and evaluating how this data will make manufacturing more proficient. Establishing the known vulnerability of each part of the tool in each process area may be a step forward.

As the template in Figure 1 shows, we should at this point be able to disseminate the requirements of certain sectors of the process as a basic methodology of doing business. This will make it extremely easy to begin going down the path of deciding what should be, and what should not be, acceptable to meeting the ever increasingly stringent requirements leading to the advanced process nodes. An evolving format like the one seen in Figure 1 could help establish badly needed specifications if not certifications, or guidelines that can help establish which parts can be prequalified for specific processes. This would ensure that the hardware used in the individual tool-set and in processes will have passed important criteria set out for these advanced processing steps.

This is not to say that other areas of sub-components, be they pumps or filters or others must use the same template; but this first established guideline or standard or certification process can certainly begin to go down the very important road of evaluating and predicting what should or should not be or a part of the sub-component that is being specified.

Table 1 Required Seal Performance Criteria by functional areas
Rate 1–5, 1: most important; 5: least important

Functional area / Properties specifications	Wet Etch	Etch	CVD/PVD	Diffusion	Sub-fab
Etch rate	5	1	3	5	2
Scaling force retention	1	1	1	1	1
Impurities					
Leachable 6.2.13	1	5	5	5	3
Ash	5	1	1	1	2
Outgassing 6.2.15	5	2	1	3	5
Permeation 6.2.19	5	1	1	2	3
TOC * 6.1.14	1	5	5	3	5
Refer to document F75 1102 section 8.2					

Measuring Methodology/Sample Preparation

- Total Organic Carbon (TOC testing)
- Surface Extractable Metallic Contamination
- Ash Metal Analysis
- Outgas Test

Figure 1. SEMI F51-0200 Guide for Elastomeric Sealing Technology

The idea that what is known is better than the unknown is progress and may lead to the elusive goal of predictive maintenance. As we now begin to understand that there are NO standards for the predominant amount of sub-components in this industry and that measurements of

these parts are only as so-called standard as each individual manufacturer determines, it should become more and more important to set certain criteria, templates, and guidelines that express the same data from the same samplings and the same recorded results. That in itself would be a huge step forward in working towards some predictability and in understanding which manufacturing processes may be unknowingly introducing into the process defects and contaminants.

However, the larger question to be explored and that will be discussed in the next article will be the question of how this will indeed solve, or attempt to solve the predictability of these defects and/or contaminants. The ultimate way to improve manufacturing efficiency, increase yields, and improve reliability is to be able to predict the advent of down-time so that valuable product is not lost. Predictive maintenance ideas have been a subject of deep discussion and debate and of course, economics as well. Considering what is already known may not always solve the production problems incurred since identifying the defect in itself will not always resolve problems. Just like the debate on "how clean is clean" or the old concept that clean rooms must be Class 1 or below, the same type of discussion will occur with sub-components or any part of the manufacturing process. Seals are an example: the cleanest of seals will not always be the ones that are the best seals since robust and clean are presently, at the opposite ends of the spectrum, and their application (slit valves, fittings, etc.) may be problematic, instead of their composition.

In Figure 2, we exemplify what would be optimal: seals that are certified or have been chosen based on the specific criteria required in different processes. The question of that in itself resolving the problems if there are mechanical issues as well, then must be asked.

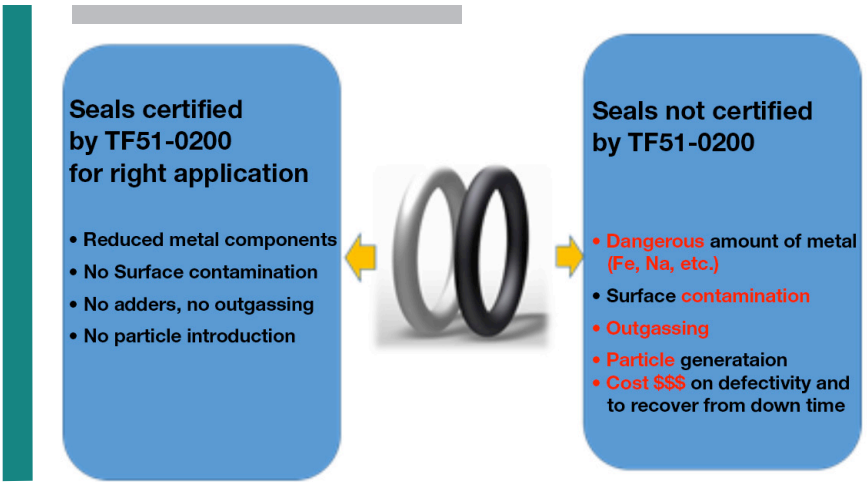

Figure 2. Subcomponent example: perfluoroelastomer seals

The most important questions to answer must always be application-specific. As an industry that deals in complex manufacturing, understanding all the areas of concern, like chemical compatibility, dynamic forces, extremely tight controls and yes, adherence to newly developed standards and guidelines never before considered for hardware parts such as valves and seals, is paramount. The answers must be understood, accepted and applied throughout the entire supply chain to match the sophistication of the process, if we are to meet the reliability and efficiency required.

So indeed, the ability to manufacture in a way that makes economical sense will be an important aspect of the realm of advancing technology. Whoever learns the right so-called balance will indeed be the one that moves into the future with the type of advantage that will win valuable market-share and be ahead of the pack.

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