The Science behind the Seals: The Reality

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The newer generation sealing components are recognized as an absolute necessity in lowering contamination but the reality is that they will introduce many new issues. The paper will discuss this often overlooked misconnection of the newer generation seals introduced for their chemical resistance but never ‘defined’ for Semiconductor Industry specifications. In that regard, their cost versus their attributes (an important factor for cost of ownership) can be an inverted ratio if not truly understood. This issue stems from the fact that these new generation seals are not ‘classified’ with semiconductor performance criteria terminology - thus making them highly susceptible to early failures. The lack of proper handling or knowledge of installation nuances bring on a whole set of new failure modes and introduce problems instead of positive results. These failures take a great deal of time and money to be ‘identified’ and resolved, and will impact productivity.

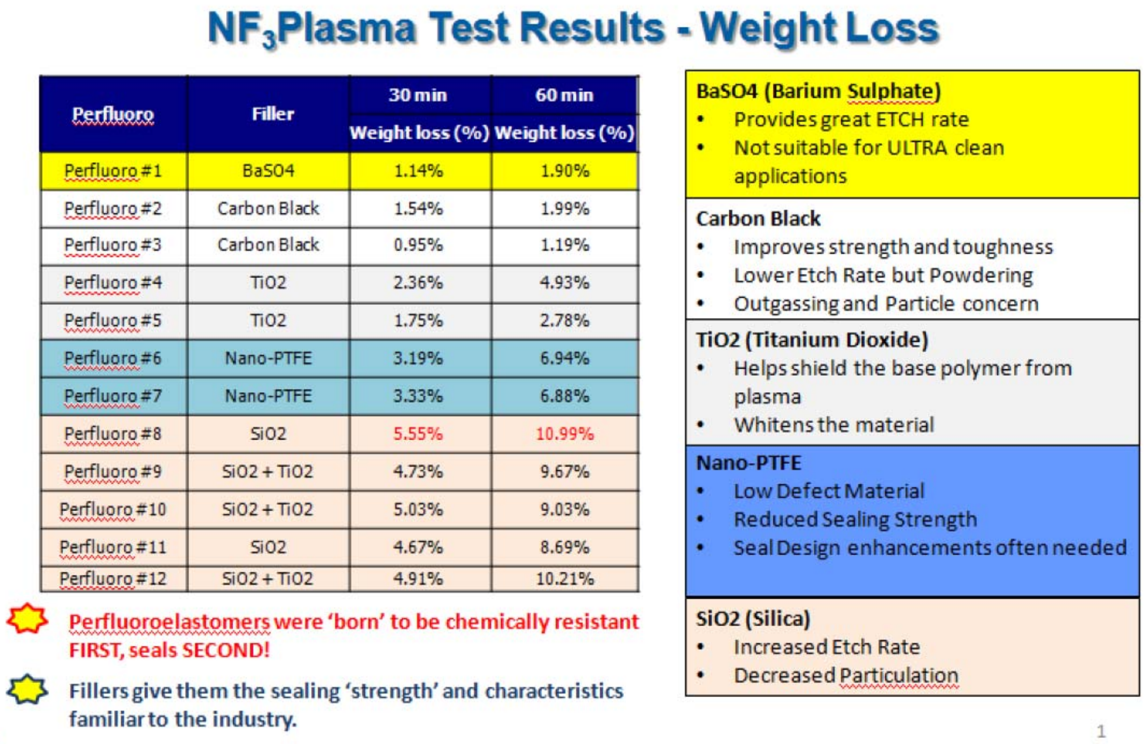
The paper will discuss the evolution of sealing elements from the early 1900’s and whose original purpose was very different than what is required for the semiconductor industry today and tomorrow. The early technical data and terminology for these elements had nothing to do with semiconductor requirements. So the performance criteria of these important components have nothing to do with our industry's standards or needs. This has created a significant gap in understanding how these parts must be installed and handled and can result in significant hours of downtime. However, with the proper training and education of this new generation product, these failures can be avoided and manufacturers can utilize "the right seal for the right application" ensuring minimal downtime and reliable production runs.

In the chart that follows (Figure 1), a disassociation can be created between the ‘clean’ o-rings that are thought to be the ‘answer’ to resolve advanced processes and their ability to ‘do their job’-that is to seal. The ‘cleaner’ the o-rings, the more they will be etched away and as a result the less they will ‘mechanically’ fit. This issue can be avoided if the O-ring is designed properly and handled appropriately from the outset so advanced processing will be successful. Without addressing this important issue, failure of seals will continue to impact productivity and their misapplication will continue to cost the industry millions. The choices of sealing devices will bring harsh realities to the industry as particle sizes of the very materials formulated for ALL sealing elements will impact all areas of Semiconductor manufacturing as they reach down below 45nm. This has already been seen in the new EUV world, which has encountered issues of failure because standard fillers used in sealing elements are much larger (50-80 microns) than the nanometer requirements measuring down to below 22nm particles, as well as the harsher requirements of PVD, Etch and CVD to come.

These components will continue to be factors in hardware of all types through advancing technologies and the issues of chemical breakdown or mechanical failure will continue to be misunderstood.

If they are not addressed, the effects of their misapplications and mishandling will impact the advances of these technologies for years. This is especially true as the cleaning gases (now generally NF3) continue to evolve and impact these seals even more.

Figure #1



NF_3 Plasma Test Results - Weight Loss

Perfluoro	Filler	30 min	60 min
		Weight loss (%)	Weight loss (%)
Perfluoro #1	BaSO4	1.14%	1.90%
Perfluoro #2	Carbon Black	1.54%	1.99%
Perfluoro #3	Carbon Black	0.95%	1.19%
Perfluoro #4	TiO2	2.36%	4.93%
Perfluoro #5	TiO2	1.75%	2.78%
Perfluoro #6	Nano-PTFE	3.19%	6.94%
Perfluoro #7	Nano-PTFE	3.33%	6.88%
Perfluoro #8	SiO2	5.55%	10.99%
Perfluoro #9	SiO2 + TiO2	4.73%	9.67%
Perfluoro #10	SiO2 + TiO2	5.03%	9.03%
Perfluoro #11	SiO2	4.67%	8.69%
Perfluoro #12	SiO2 + TiO2	4.91%	10.21%

Perfluoroelastomers were 'born' to be chemically resistant FIRST, seals SECOND!

Fillers give them the sealing 'strength' and characteristics familiar to the industry.

BaSO4 (Barium Sulphate)
- Provides great ETCH rate
- Not suitable for ULTRA clean applications

Carbon Black
- Improves strength and toughness
- Lower Etch Rate but Powdering
- Outgassing and Particle concern

TiO2 (Titanium Dioxide)
- Helps shield the base polymer from plasma
- Whitens the material

Nano-PTFE
- Low Defect Material
- Reduced Sealing Strength
- Seal Design enhancements often needed

SiO2 (Silica)
- Increased Etch Rate
- Decreased Particulation

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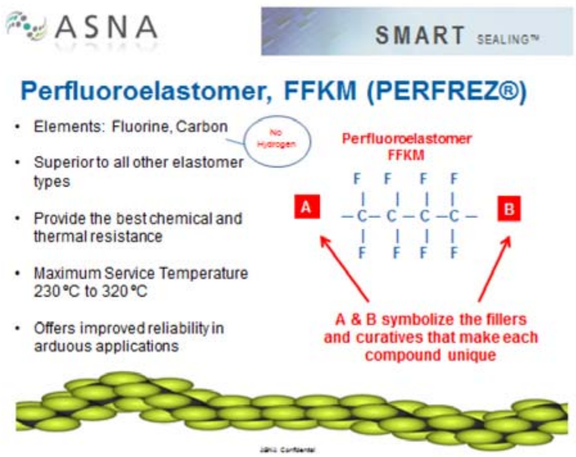
The last element of this paper will also address the similarities as well as differences of the many 'families' of sealing elements that are considered the 'same.'- They are in fact, very different one from the other and are not interchangeable. A basic knowledge of what they are made of, how they are made, the various parts including cross-linking agents, curative variations, and fillers will also be addressed...



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Perfluoroelastomer, FFKM (PERFREZ®)

- Elements: Fluorine, Carbon
- Superior to all other elastomer types
- Provide the best chemical and thermal resistance
- Maximum Service Temperature 230°C to 320°C
- Offers improved reliability in arduous applications

No Hydrogen

Perfluoroelastomer FFKM

$$A \quad -\overset{F}{\underset{F}{C}}-\overset{F}{\underset{F}{C}}-\overset{F}{\underset{F}{C}}-\overset{F}{\underset{F}{C}}- \quad B$$

A & B symbolize the fillers and curatives that make each compound unique

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Figure #2

A summary indicating the science versus practical applications will finally bring the paper to its full content capabilities.