

New technology elastomer raises seal performance benchmark for semiconductor manufacture (K13X)

Exceptionally low plasma etch rates, minimal particulation, improved seal performance and life-time, plus lower cost of ownership, are just some of the benefits that customers are discovering with the new Kimura K13X high performance elastomer from Perlast Limited.

Kimura K13X is a unique material specifically developed by PPE to offer a step-change in sealing performance, designed to support the continued drive towards lower feature sizes. Unlike previous elastomer polymer technologies which have been adapted to meet the rigours of semiconductor processing conditions, Kimura K13X has been developed specifically for this market. It is a new type of polymer that addresses the particulation and thermal expansion issues that can arise with inorganically-filled materials currently used in semiconductor processing. There is also evidence that in some instances even nano-filled materials suffer from particulation issues. With Kimura K13X, the absence of any filler, even an organic one, means no differential etching between polymer and fillers, hence Kimura shows very low levels of particulation in both hot and cold processes.

Representing the latest advance in elastomer technology, Kimura K13X has a number of intertwined phases, with a morphology known as an 'interpenetrating network'. The phases are intimately mixed on a molecular level, producing material that is different to any elastomer on the market today. An example of the morphology is shown in Figure 1.

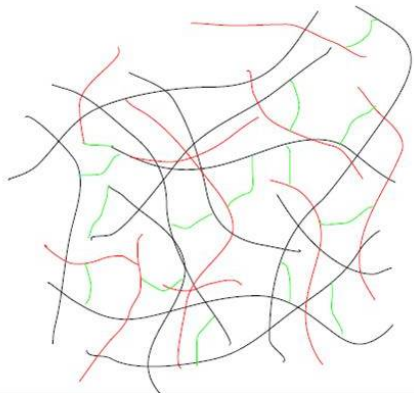


Figure 1: Diagram of how molecular dispersion would look in Kimura K13X

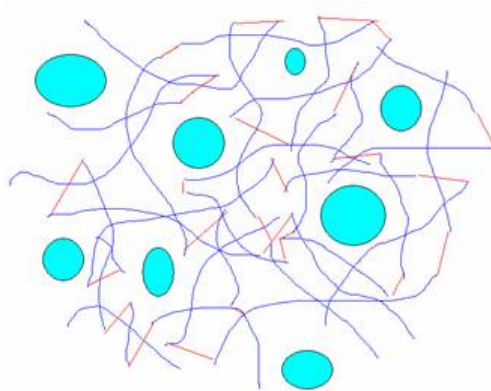


Figure 2: Diagram of how an organic filled elastomer would look on a molecular level.

This breakthrough in elastomer technology has been possible through the application of carefully controlled chemistries developed in-house by PPE's Material Technology department.

The different phases of the Kimura K13X polymer are chemically joined together as well as being intimately mixed, resulting in a material that provides excellent mechanical properties. This controlled molecular architecture means that the material is self-reinforcing and has no need for fillers of any kind. This is demonstrated in Figure 3, where a scanning electron micrograph shows the structure of Kimura K13X.

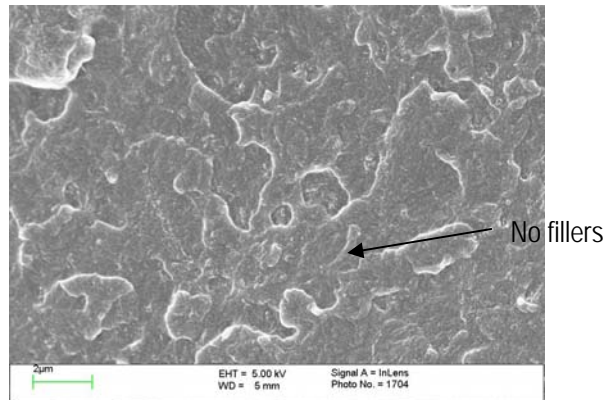


Figure 3: SEM micrograph of a section through Kimura K13X

Results from customer evaluation have confirmed the exceptional performance of Kimura K13X in a series of demanding environments.

Case Study 1

Independent testing of Kimura K13X showed that the material had the lowest etch rate of all the materials tested; the graph in Figure 4 shows the comparative erosion rate in $\mu\text{m/hr}$ of six different elastomers when exposed to $\text{HBr/NF}_3/\text{O}_2/\text{SiF}_4$ plasma.

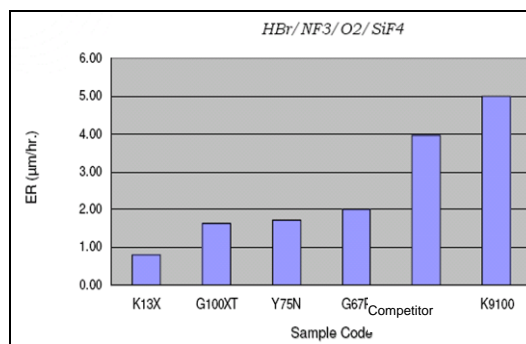


Figure 4: Accelerated Plasma Testing Results

Case Study 2

In trials to determine the suitability of Kimura K13X for use on Producer equipment, the samples were exposed to a high concentration of NF_3 and O_2 process gases at $80^\circ C$ and ambient pressure. The customer assessed the plasma etch resistance of Kimura K13X compared with other compounds. Results showed Kimura had excellent performance. Figure 5 shows micrographs of the surface of the material before and after exposure to the process chemistry.

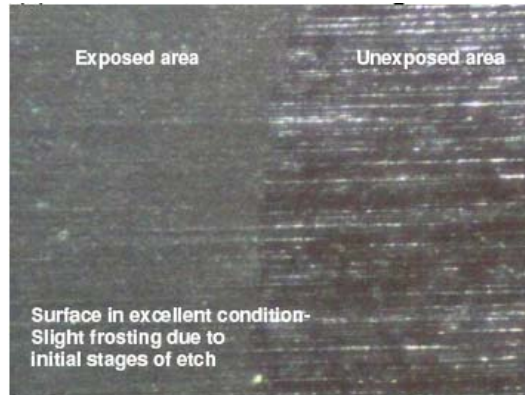


Figure 5: NF_3 / O_2 Exposure of K13X

Case Study 3

Table 1 shows the results of independent benchmark testing comparing the erosion rate of the leading elastomer materials used in etch processes. Kimura K13X was the best performing material in this test. This testing was carried out by a major US OEM.

Material	Weight (gm)			
	Pre-Etch	Post-Etch	Total Weight Loss	Weight Loss/RF-hr
Competitor 1	0.8007	0.6194	0.1813 (highest)	0.0166 (highest)
Competitor 2	0.7445	0.5975	0.1470	0.0135
Competitor 3	0.7613	0.6518	0.1096	0.0101
Competitor 4	0.7544	0.6236	0.1307	0.0120
Kimura™ K13X	0.6611	0.5694	0.0917 (lowest)	0.0084 (lowest)

Table 1: Weight loss in Cleaning Process

Case Study 4

For a major fab in Singapore, Kimura K13X parts in 13 different locations have been evaluated on LAM9600 conductor etch equipment, with chemical exposure CHF_3 , CF_4 and oxide gases at temperatures up to $\sim 300^\circ C$. The O-rings performed well and were removed after 30 days for a preventative maintenance cycle, without failure. This is equivalent to 300 RF hours. Using Kimura K13X allowed the customer to extend their PM cycles significantly.

Case Study 5

Table 2 shows the comparative erosion rate of Perlast elastomer materials in chlorine plasma. Kimura K13X was the best performing material in this test. This testing was carried out by a major US OEM.

Cl₂ Etch 5 RF hours

Material	Etch Step	Etch Rate
Perlast® G67P	429.0	85.8
Perlast® G74P	426.0	85.2
Perlast® G75H	13.6	2.7
Kimura™ K13X	13.0 (lowest)	2.6 (lowest)

Table 2: Chlorine Etch Results

Kimura K13X has exceptional permeation resistance, with helium leak data showing that the material outperforms all other competitor grades. The table below compares helium leak rates of Kimura K13X and other competitor materials.

Material	Time (s) to 1E-10 mbar/s	Time (s) to 1E-9 mbar/s	Leak rate E-12 at 120 seconds
Kimura™ K13X	246	299	2
Competitor 1	208	259	31
Competitor 2	128	150	40
Competitor 3	134	159	50
Competitor 4	124	155	75
Competitor 5	111	129	467
Competitor 6	74	121	843
Competitor 7	103	123	900
Competitor 8	105	127	1,250
Competitor 9	79	104	4,180
Competitor 10	38	63	10,350

Table 3: Helium Leak Data

The results clearly demonstrate how well Kimura K13X performs when compared to competitor materials. Having such a low permeation rate ensures that faster vacuum pump-down times are possible, as well as reduced metal oxidization due to low oxygen permeation.

In summary, Kimura K13X is an entirely new breed of high performance elastomers specifically developed to meet the future challenges facing the semiconductor industry when moving towards lower feature sizes. Proven in numerous applications to provide exceptionally low plasma etch rates, minimal particulation, improved seal performance and life-time, plus lower cost of ownership, Kimura K13X from PPE, projects sealing technology beyond the limitations of today and provides real sealing solutions for the future.