NICHIAS Technical Report
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〈Introduction of new products〉

Plasma resistant special fluoroelastomer
TOMBO™ No.2675-FC "BLAZER™ O-ring - FC"
TOMBO™ No.2675-FE "BLAZER™ O-ring - FE"

Elastomer Products Promoting Group, Industrial Product Division

1. Introduction

NICHIAS have been developing "BLAZER™" series high performance elastomers which have features of superior thermal resistivity and chemical resistivity. NICHIAS released TOMBO™ No.2675-FC "BLAZER™ O-ring - FC" (hereafter called "BLAZER™ FC") and TOMBO™ No.2675-FE "BLAZER™ O-ring - FE" (hereafter called "BLAZER™ FE") in December 2015, which are introduced here (**Figure 1**).

"BLAZER™ FC" and "BLAZER™ FE" are special fluoroelastomer (special FKM) products that are produced with our original blending technology to control mass reduction and cracking, which resulted in extended life and therefore decreased running costs in use.

For the application under plasma exposure environment, such as semi-conductor and liquid crystal manufacturing equipment, these O-rings contribute to decrease the maintenance cost of the equipment.

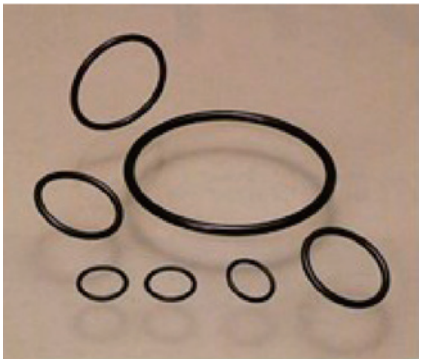


Figure 1. Appearance of "BLAZER™ FC" and "BLAZER™ FE"

2. Outline of the products

"BLAZER™ FC" and "BLAZER™ FE" are products for semi-conductor manufacturing equipment which requires plasma resistivity. Each of them has been developed for the following usage:

- "BLAZER™ FC": Plasma CVD equipment
- "BLAZER™ FE": Plasma etching equipment

Figure 2 shows the correlation between price and performance of various sealing materials for semi-conductor and positions of "BLAZER™ FC" and "BLAZER™ FE".

Although general purpose fluoroelastomer (general purpose FKM) located at the lower left of the figure costs low, the performance is slightly inferior because mass reduction, crack-

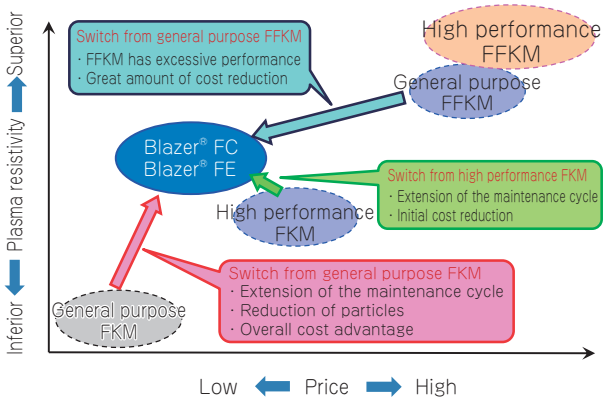


Figure 2. Product positions

ing, or product degradation occur with plasma exposure for a short duration. On the other hand, FFKM located at the upper right of the figure has superior plasma resistivity which shows only slight deterioration under severe plasma exposure environment. However, this is a high priced product solution.

There are some locations in semi-conductor manufacturing equipment where the performance and price balance in the use of FFKM is not optimum for the degree of plasma exposure there.

High performance FKM has been introduced for such medium duty applications which demand a higher performance than FKM, but not the very high performance of FFKM. "BLAZER™ FC" and "BLAZER™ FE" are the special FKM products with improved plasma resistivity but reduced cost compared to the conventional high performance FKM, so delivering performance and cost benefits.

3. Features

The features of "BLAZER™ FC" and "BLAZER™ FE", which are plasma resistivity and non-sticking tendency, are described below.

3.1 Plasma resistivity

Plasma resistivity was evaluated by mass reduction ratio and cracking occurrence time using surface wave plasma etching equipment (SWP) to expose the O-ring under plasma. Schematic of the equipment is shown on **Figure 3** and the plasma generating conditions are shown below.

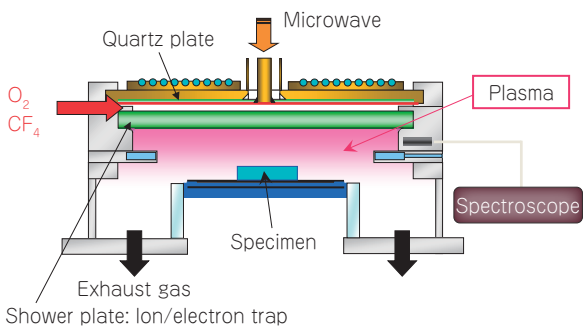


Figure 3. Schematic of SWP

<Plasma generating condition>

- Type of gas: O_2 (2000 sccm*) + CF_4 (40 sccm)
- Pressure: 133 Pa
- Output: 2 kW
- Set temperature for stage cooling water: 30℃

*sccm: Standard Cubic Centimeterper Minute
Gas flow rate (cc) per minute at the standard state (normal temperature and normal pressure)

3.1.1 Mass reduction due to plasma exposure

String shape specimen (ϕ3.53 mm × 30 mm) of "BLAZER™ FC", "BLAZER™ FE", general purpose FKM TOMBO™ No.2670-FA rubber O-ring fluoroelastomer FA made by NICHIAS (hereafter called "FA"), plasma resistant high performance FKM made by other company (hereafter called "Competitor A high performance FKM product"), and plasma resistant FFKM made by other company (Hereafter called "Competitor B FFKM product") are exposed under plasma with SWP for 120 min., and after then, each mass reduction ratio was compared. The result of the test is shown in **Figure 4**.

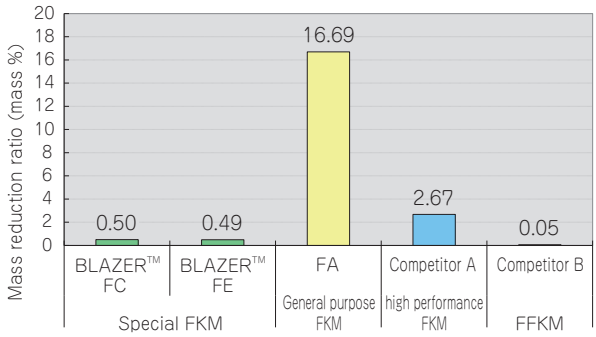


Figure 4. Mass reduction ratio of each specimen (After 120 min. plasma exposure)

The mass reduction ratio of "BLAZER™ FC" and "BLAZER™ FE" are approximately 1/30 of that of FA (general purpose FKM) and approximately 1/5 of that of Competitor A high performance FKM product, which shows that the above two products have superior plasma resistivity in the FKM group. Although Competitors Product B is FFKM and has higher plasma resistance, it is too high priced for the duty re-

quired by the application.

From the above, "BLAZER™ FC" and "BLAZER™ FE" cost lower than the conventional high performance FKM, and they are expected to extend the maintenance cycle.

3.1.2 Cracking due to plasma exposure

While tensile force is applied to the specimen of "BLAZER™ FC", "BLAZER™ FE", FA (general purpose FKM) and Competitor B FFKM product, they were exposed under plasma and the time till crack occurs was measured. The appearance was observed at 5 minute intervals up to 20 minutes, and at 10 minute intervals from 20 minutes until 120 minutes. The test results are summarised in **Figure 6**.

FA, the general purpose FKM shows low plasma resistivity with cracking occurring after 20 minutes plasma exposure.

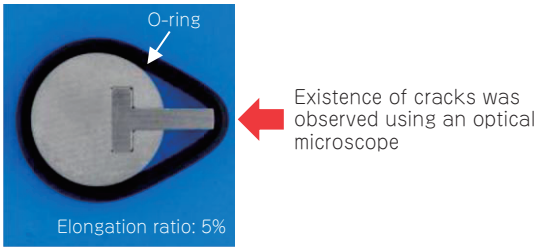


Figure 5. Shape of specimen and portion to be observed

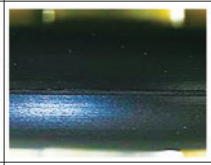
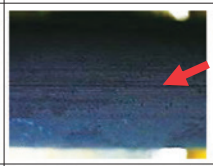
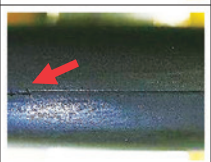
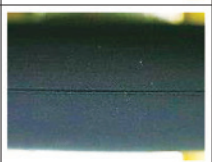
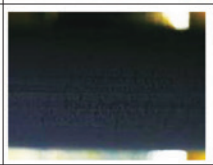
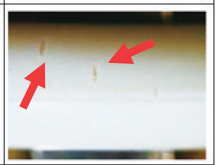
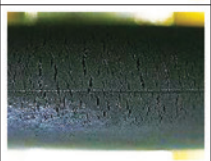
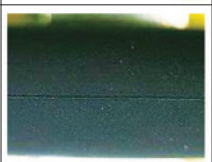
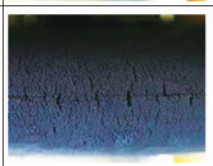
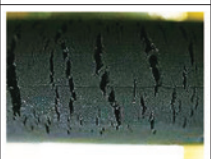
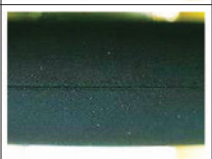
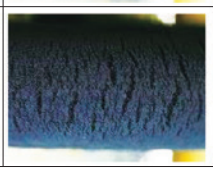
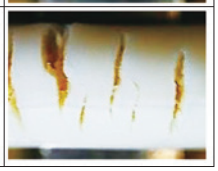
Specimen	Special FKM		General purpose FKM	FFKM
	BLAZER™ FC	BLAZER™ FE	FA	Product B of other company
Time till cracking (min.)	40	No crack	20	40
Before exposure				
After 20 min.				
After 40 min.				
After 60 min.				
After 120 min.				

Figure 6. Plasma exposure - time untill cracking and appearance (the arrows in the figures show cracking point)

On the other hand, cracking did not occur on BLAZER FE even after 120 minutes plasma exposure. For BLAZER FC, cracking occurred after 40 minutes exposure, which is equivalent to Competitor FFKM product B (that shows superior plasma resistivity).

From this, both "BLAZER™ FE" and "BLAZER™ FC" show superior cracking resistivity against plasma exposure.

3.2 Non sticking tendency

Not sticking to the material the O-ring is fitted on is also an important factor for sealing material choice when it is used for the movable part of the gate portion of semi-conductor manufacturing equipment or when it is to be replaced during maintenance. Hence, the sticking force of "BLAZER™ FC" and "BLAZER™ FE" was measured using the jig shown in **Figure 7**, and the non-sticking tendency was evaluated. The test condition is shown below and the result in **Figure 8**.

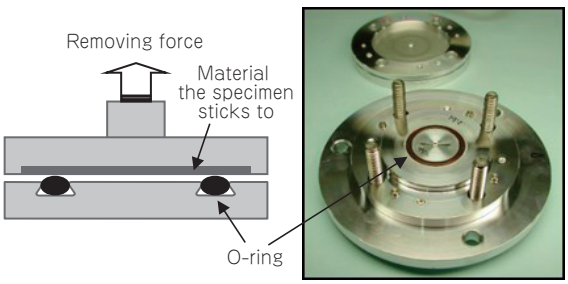


Figure 7. Jig for sticking test

Test conditions

- Temperature: 100℃, 200℃
- Time: 22 hours
  (After the prescribed time has passed, take the jig out, cool to room temperature, then measure the removing force.)
- Material on which the specimen is fit: A5052 anodized aluminum, SUS316L (Ry 1.6)
- Tension speed: 10 mm/min
- Shape of specimen: AS568-214 (ϕ3.53 mm × ID 25.0 mm)
- Compression ratio: 25%

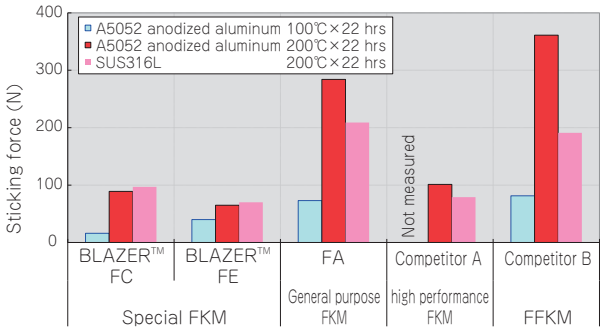


Figure 8. Result of sticking test of each specimen

The sticking force of BLAZER™ FC and BLAZER™ FE is less than 100N, irrespective of the type of material they are fitted on, or the test temperature, which is equivalent to Competitor A high performance FKM product. In addition, it was found that under some conditions, "BLAZER™ FC" and "BLAZER™ FE" were found to show the sticking force of 1/3 that of Competitor B FFKM product that shows superior plasma resistivity.

Since non sticking tendency of "BLAZER™ FC" and "BLAZER™ FE" is not realized with coating material, it will not be degraded by abrasion due to long use.

3.3 General physical property

General physical property of "BLAZER™ FC" and "BLAZER™ FE" is shown in **Table 1**.

Table 1. General physical property

			BLAZER™ FC	BLAZER™ FE
Color			Black	Black
General physical property		Hardness (DuroA)	60	60
	Tensile property	Tensile strength [MPa]	18.8	11.4
		Elongation [%]	210	230
		100%tensile stress [MPa]	3.9	3.5
Compressive permanent strain (100℃×72 hrs) [%]			9	9

4. Product dimension

Dimensions of BLAZER™ FC and BLAZER™ FE conform to standard dimensions of JIS B2401, AS568. NICHIAS can also produce the products in other shapes and dimensions. Please contact us for such requirements.

5. Conclusion

Our new products, TOMBO™ No.2675-FC "BLAZER™ O-ring - FC" and TOMBO™ No.2675-FE "BLAZER™ O-ring - FE" introduced in this document are special FKM sealing materials in which both plasma resistivity and low cost are realized by our original blending technology.

We hope these products will be widely used as the sealing material for the semi-conductor/liquid crystal manufacturing equipment used under plasma exposure, to improve life cycle and reduce cost.

We will further continue to develop and improve the products to meet customers' needs.

We appreciate your comments and suggestions.

If you have any questions or inquiries about this report, please contact Elastomer Products Promoting Group, Industrial Product Division.

* The measurements presented in this report should be used only as a guide and not as guaranteed values.