Gallagher recently published its *Failure Modes of Elastomers in the Semiconductor Industry* White Paper, now available for download on our site. This white paper discusses common issues that occur with elastomer seals in the semiconductor industry. The excerpt below is the first section of our new white paper, discussing groove design and seal leakage. To download the entire white paper, visit our [Resources Page](#), or click on the image to the right.

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**Failure Modes for Elastomers in the Semiconductor Industry**

High performance elastomers are found in many applications in the semiconductor industry (see paper titled *Perfluoroelastomers in the Semiconductor Industry*). Though perfluoroelastomer (FFKM) seals are formulated to meet the highest performance requirements of integrated circuit (chip) manufacturers, even these elastomers can’t solve every sealing application nor will they last forever in service. Additionally, end users need to understand subtle performance differences between perfluoroelastomers in the same product line. For example, one product may be better at minimizing particle generation while another may be better for high temperature services.

To deal with elastomer sealing problems that occur in the semiconductor industry, root cause failure analysis is critical to solving issues and preventing them from reoccurring. This type of analysis should be carried out as a joint effort between the end user and the seal supplier/manufacturer. Although it is important to find the solution as quickly
as possible, the seal manufacturer cannot easily assist in root cause analysis without application details, including application temperatures, pressures, chemical environment and seal design. In addition, the seal manufacturer will need the failed part to properly conduct a root cause analysis.

The following sections detail common issues that occur with seals in the semiconductor industry. Examples are often given for o-rings, but are also applicable to other seal shapes.

**Groove Design**

Unfortunately a significant number of seal failures can be attributed to improper groove design. When loss of sealing force, plasma cracking, and/or extrusion occurs, anything short of redesigning the groove may not address the underlying problem. For this reason, proper groove design and elastomer selection must be considered early on during new equipment design. If a fluoroelastomer seal is selected for an application, consider future needs for a perfluoroelastomer (e.g. Kalrez®) due to temperature or the use of aggressive chemicals. Once the equipment is in the field, it is extremely difficult to replace it or re-machine the grooves to correct a sealing issue. Elastomer seal suppliers can assist equipment manufacturers with proper groove design to prevent future problems.

**Seal Leakage**

Leakage is a very general term used for a variety of problems, some of which may be related to seal design. For this section, a leak is defined as a seal (equipment and/or elastomer related) that allows fluid to pass around the elastomer and into the process from the environment, or from the process out to the environment. In the case of plasma processes, atmospheric leakage of gas into the process chamber can introduce contaminants that affect integrated circuit quality.
Some common causes of seal leakage are included below. Note that items 2-4 are often related to groove design.

1. An o-ring is cut or damaged during installation. Use care when installing an o-ring over sharp edges and/or be sure to grind off any sharp edges.

2. Improper compression is applied by the metal surfaces that compress the o-ring. For example, an installed squeeze of 18-22% is suggested for an FFKM o-ring sealing a vacuum application. O-ring tolerances as well as metal machined part tolerance stack up must be considered when calculating seal compression. Under or over compression of an elastomer seal is problematic and can lead to leakage.

3. Due to thermal expansion or chemical swell, the o-ring overfills the groove at application temperature and extrusion occurs, resulting in leakage.

4. An o-ring is overstretched, e.g. greater than 5% stretch. This overstresses the ring and can lead to premature part failure and subsequent leakage.

5. The o-ring suffers attack due to the environment and the o-ring develops splits or cracks, or general degradation, which leads to leakage.

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**About the Author**

Russell Schnell spent more than 37 years as an engineer with DuPont, the last 26 years as a Senior Application Engineer with the Kalrez® perfluoroelastomer parts business. Recognized for his expertise in elastomer applications, seal design and failure
analysis, he provided technical support for a wide range of industries including: chemical processing, aerospace, oil and gas, pharmaceutical and semi-con. He created and conducted hundreds of training seminars and workshops in this field and was solely responsible for the development of the Kalrez® Application Guide software tool.

Russ received a Bachelor of Science in Chemical Engineering from Columbia University in New York and MBA from the University of Delaware.