Best Practices for Protecting & Extending the Life of Electrostatic Chucks in Plasma Applications

EO: Equipment Optimization

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Introduction

Production of silicon wafers relies on electrostatic chucks (ESC) to hold the wafer in place during plasma etch and deposition operations. Without proper sealing design, plasma will attack the copper and polyimide layers that produce the electrostatic force, leading to costly and dangerous failures. By following best practices, ESC manufacturers and users can eliminate problems with yield loss, arcing, and unchucking. This paper will explore advances in seal materials and geometries and will provide insights into selecting the best sealing material for protecting and extending the life of electrostatic chucks in plasma applications.

Electrostatic Chuck Challenges and Seal Applications

There is a gap between the top edge ring and the ESC that provides a path for plasma attack. The primary seal that is typically used to protect the ESC from plasma ingress is silicone epoxy, but this can become etched away from plasma attack. If the silicone epoxy primary seal becomes etched, then the ESC becomes open to plasma exposure, leading to particles, arcing, yield loss, and damage to the chuck. Loss of a chuck in a 300mm wafer fab is likely to result in $25K to $80K for repair and replacement, and results in costly downtime.

ESC Seals as a Proven Solution for Extending Chuck Life

1. **How Elastomer Solutions Can Solve Common ESC Maintenance and Performance Challenges**

A proven solution to close the gap and prevent plasma ingress is to machine a groove and install a supplemental ESC seal, often called an “E-Seal”, made from a high-performance perfluoroelastomer (FFKM) like Chemraz® XPE. First generation E-Seals were a rectangular cross section, but advancements in designs have led to new geometries that improve performance and simplify installation.

The FFKM seals are molded elastomers and are therefore flexible and Greene Tweed’s unique manufacturing process allows us to produce small cross sections that will fit inside the extremely thin groove of the ESC. Chemraz® XPE has excellent plasma resistance and extremely low metal ions content, making it an ideal solution to replace silicone epoxy as the primary seal for the ESC.

The thin flexible profile of the elastomer seal may be prone to twisting on installation. An installation kit is often beneficial to ensure the seal is properly fitted to the groove without twisting or misalignment, and/or to improve installation efficiency. Visual and physical indicators can be added to the seal design to help the operator validate that the seal was installed in the correct orientation. Greene Tweed's engineers have deep experience in helping customers along every step of design, installation support and maintenance using proven solutions such as Chemraz® XPE.

2. How Thermoplastic Solutions Can Solve Common ESC Maintenance and Performance Challenges

An alternative E-Seal to the perfluoroelastomer material is to use the latest generation modified PTFE, such as Avalon® 56HP, which offers excellent chemical resistance and very low extractable levels. Avalon® 56HP is designed for wafer processing semiconductor applications and is a high purity clean material. Depending on the application, an engineered E-Seal manufactured from Avalon® 56HP that offers exceptional NF3 and O2 plasma resistance can be a great fit. Engineers with the right expertise and experience can leverage these characteristics to make it a strong contender to supplement the silicone epoxy that is the primary seal for the ESC. The PTFE E-Seals are molded and then machined from rigid plastics and therefore maintain their circular shape. Since Avalon 56HP is a rigid material, it holds its intended shape and this minimizes installation issues. Operators may be able to effectively install the PTFE E-Seal freehand with less tooling. Installation tooling is still considered beneficial however, as it can lead to a more consistent and efficient installation process.

Conclusions And Material Selection Recommendations

ESCs in plasma applications must be sealed appropriately to avoid problems with yield loss, arcing, and unchucking. "E-Seals" made from FFKM or PTFE offer significantly upgraded protection compared to silicone epoxy. It is possible to choose the optimal sealing material by considering the features and benefits of these two solutions that are most important to the users of the ESC in each application. The FFKM material is a more established solution, while the PTFE materials are emerging as possibly the next generation solution for some applications.

A Greene Tweed customer was replacing their electrostatic chucks (ESCs) after approximately 4,500 radio frequency (RF) hours of use. The ESC would begin to fail due to damage caused by aggressive process and cleaning chemistries. The use of Greene Tweed's Chemraz® E-Seal solution offered 10 times greater RF life (up to 45,000 hours). The Chemraz® E-Seal solution eliminated nine out of ten downtime cycles. The number of ESC replacements was significantly reduced with the Chemraz® E-Seal solution.

Depending on the application, latest generation modified PTFE solutions like Avalon® 56HP may offer excellent plasma resistance and should be considered for new E-Seal applications.

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