研究論文

シール用ふっ素ゴムにおけるラジカル消耗速度のひずみ依存性（第二報）

－有限要素法によるOリングの消耗量予測－

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Relationship between Radical Thinning Rate and Tensile Strain of Fluoroelastomer for Sealing Parts, Part II: Finite Element Prediction of O-ring Thinning Volume

by

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Abstract

Fluoroelastomer sealing parts used in semiconductor dry etching equipment are degraded by reactions with radicals, and accurate lifetime prediction is required. O-rings are compressed during installation, which produces a non-uniform strain distribution on their surfaces. This strain distribution can affect radical thinning behavior. In this study, a previously formulated strain-dependent radical thinning rate model of fluoroelastomer was applied to O-rings using finite element analysis. The surface strain distribution of compressed O-rings was calculated, and local radical thinning rates were evaluated based on the local strain. The total volume reduction of the O-rings was estimated by integrating the local thinning rates over the radical-exposed surface. Radical exposure experiments were conducted using actual O-rings under the same compression conditions. The calculated results showed trends that were generally consistent with the experimental results. Although some discrepancies remained due to modeling conditions, the proposed method demonstrated the feasibility of predicting radical degradation behavior of O-rings with realistic geometry.

Keywords: Radical thinning, Fluoroelastomer, Semiconductor manufacturing equipment, Finite element method

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1. 緒言

ドライエッチングプロセスでは，エッチングチャンバー内を高真空状態に維持する必要があり，装置には多数のシール部品が使用されている．しかし，プラズマ生成の副産物として発生するラジカル化したガス[1),2)]の反応性，拡散性が高く，高分子材料と化学反応を起こして消耗させる．よって，これまで使用されてきたゴムなどのシール用素材では，長期間にわたるシール性を維持することが困難になっており，シールの耐ラジカル性向上による長寿命化に加え，エッチング装置のメンテナンス周期を最適化するために，