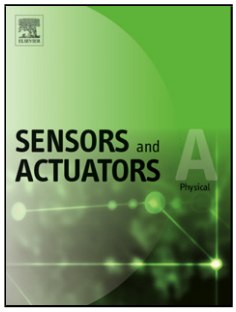

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Modified Inductively Coupled Plasma Reactive Ion Etch Process for High Aspect Ratio Etching of Fused Silica, Borosilicate and Aluminosilicate Glass Substrates

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Highlights

- Modified inductively coupled plasma etch using gas diffuser inlets
- SF_6 + NF_3 + H_2O based high etch rate and smooth glass substrate etching
- Fused silica, borosilicate glass, and aluminosilicate glass high aspect ratio etching
- Role of reactive (chemical) versus ion flux (Physical) etching components in glass etching
- Charging and loading effect on the overall glass etching metrics
- Fused silica etch rate of > 1 µm/min with smoothness of 2 Å, borosilicate etch rate of > 1 µm/min with smoothness of 67 Å, aluminosilicate etch rate of 0.45 µm/min with smoothness of 4 Å

Abstract

We report on the etching of glass substrates of various compositions in a modified inductively coupled plasma – reactive ion etch (ICP-RIE) tool using SF_6 as the plasma source gas and NF_3 and H_2O gases introduced downstream near the surface of the wafer through a diffuser gas inlet. Using this modified system, we have been able to achieve etch rates as high as 1.06 µm/min, 1.04 µm/min, and 0.45 µm/min with surface smoothness of ~2 Å, ~67 Å, ~4 Å for fused silica, borosilicate glass, and aluminosilicate glass respectively after 5 minutes etches. We examine the role of ion flux and fluorine radicals and molecules on the etch rate and the etch smoothness. We analyze the results obtained on 41 etches through multivariate statistical analysis and use the Pearson coefficient and P-value to determine the importance of these parameters for each of the glass substrate compositions. Overall for all three glass compositions, etch rate is critically influenced by ion flux. Fluorine based radicals and molecular fragments influence both the etch rate and surface smoothness of fused silica whereas they primarily influence the surface smoothness for borosilicate glass. The large fraction of impurity atoms of Ca and Al in aluminosilicate glass form non-volatile fluorides in the etched areas and therefore the etch rate and surface smoothness of aluminosilicate glass is primarily influenced ion flux and very little by the fluorine chemistry. We also examine the role of the layout of the metal mask layer on how it influences the charging of glass substrates during etching and therefore the etch rate.