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Study of a Veil Structure and a Two-Step Corrosion Suppression Process in Al-Si-Cu Etching

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An in-depth veil structure produced during Al-Si-Cu etching is measured using μ-Auger analysis. Carbon, oxygen, aluminum, and chlorine were detected in all region of the veil structure. In addition to them, silicon is also detected in the outer region. By considering the in-depth constituents of the veil, a novel two-step etching method is proposed for corrosion suppression with CF_4 and $CF_4 + O_2$ gas plasma. This method has been found to drastically decrease the corrosion density.

1. Introduction

Corrosion in Al-Si-Cu, after etching in gas plasma containing chlorine is a serious problem in sub-micron LSI fabrication processes. The corrosion generates voids in the interconnection (Fig.1). This in turn results in unstable characteristics in the interconnection. Several corrosion suppression methods for Al-Si-Cu (during and after etching) have been reported [1]-[5]. To our knowledge, however, there have been no reports on the structure of the sidewall inhibitor film (*also known as a veil* [6]) produced during Al-Si-Cu etching. To suppress the corrosion, it is necessary to remove the chlorine in the veil. In this paper, an in-depth veil structure measured by μ-Auger is described, and a newly developed corrosion suppression method is proposed.

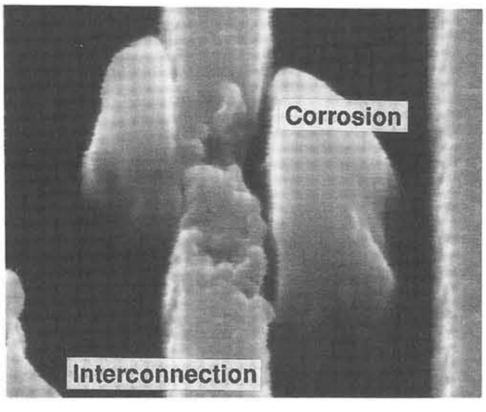

Fig.1 SEM picture of voids in an interconnection close to corrosion.

2. Experiment

The metal etcher used in this work was a hexode-type reactor capable of holding 18 six-inch diameter wafers. A multi-layer metal structure (*Ti/Al-1%Si-0.5%Cu/TiN*) was sputtered to a thickness of 600 nm on oxidized silicon and partially etched with BCl_3/Cl_2 plasma. Then, the sample was cut at a slightly slanting, in line with the point intersecting the veil and the interconnection. Next the in-depth veil construction was measured by μ-Auger (*PHI-660*) as shown in Fig.2. The corrosion was observed with an optical microscope and by SEM.

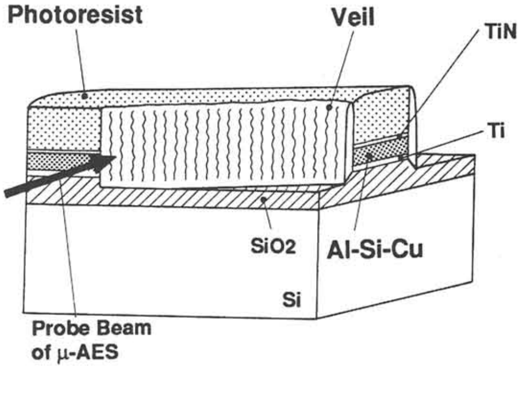

Fig.2 In-depth veil construction obtained by μ-Auger, probe beam: 10kV, 10nA.

3. *Results and Discussion*

3.1 Veil Structure

Figure 3 shows the in-depth constituents of the veil. Carbon, oxygen, aluminum and chlorine were detected in all regions, while silicon was only detected in the outer region. Figure 4 shows cross-sectional diagrams of veil formation. Figure 4(a) shows the main etching process when aluminum and photoresist are vaporized. Figure 4(b) shows the over etching process when silicon oxide is exposed. Both diagrams confirm that the veil consists of two layers: an outer layer including silicon and an inner layer with no silicon.

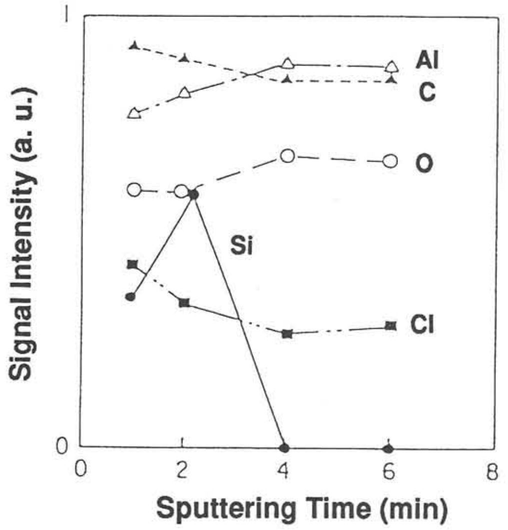

Fig.3 In-depth constituents of the veil.

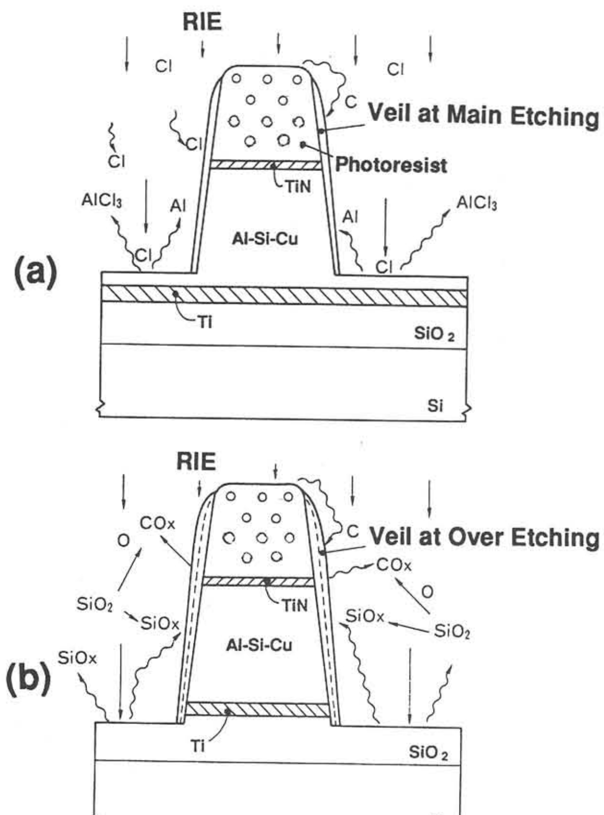

Fig.4 Cross-sectional diagrams of veil formation: (a) during main etching and (b) during over etching process.

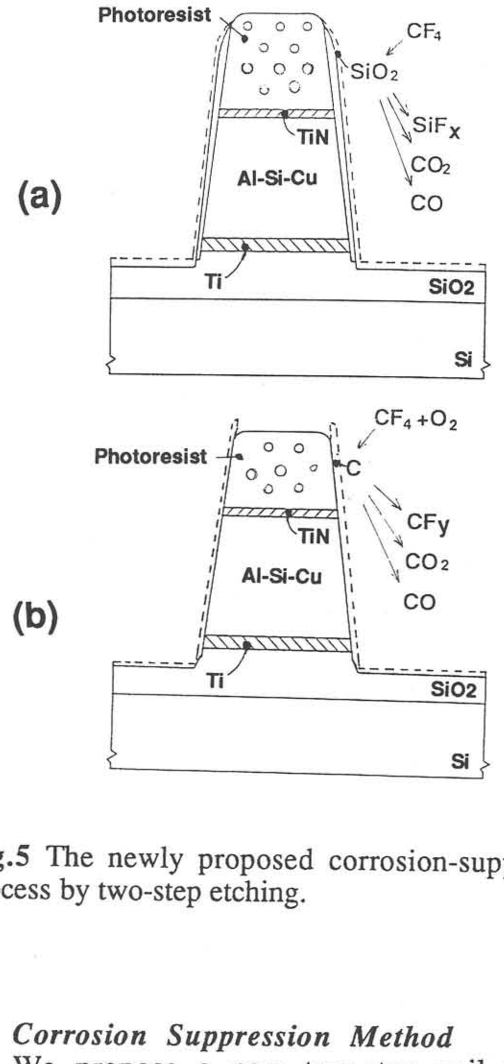

Fig.5 The newly proposed corrosion-suppression process by two-step etching.

3.2 Corrosion Suppression Method

We propose a new two-step veil etching process for after metal etching (Fig.5). In the first step, the outer layer including silicon is treated with CF_4 gas plasma at 550 W. In the second step, the inner layer is treated with $CF_4 + O_2$ gas plasma at 430 W. This two-step treatment can be done in the same etching system.

3.3 Effect of Corrosion Suppression

Figure 6 compares the after-corrosion density of the conventional and this newly proposed method. The conventional method refers to corrosion suppression with substituent fluorine in CHF_3 gas plasma. The new method has a

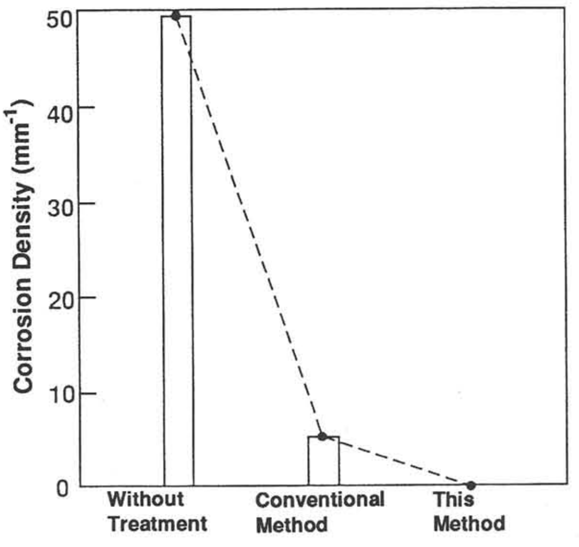

Fig.6 Comparison of the after-corrosion density.

significantly lower corrosion density. Figure 7 shows the conductance of the metal interconnection vs. interconnection width for with and without the proposed treatment. The conductance of the sample is proportional to the line width of the interconnection for the treated sample. The conductance of the sample without treatment is lower that of the treated one because corrosion has narrowed the interconnection. Figure 8 compares two samples treated with the conventional and this method by SEM photographs. Corrosion is not observed with this method. Therefore, this proposed method is effective for corrosion suppression.

4. Conclusion

We investigated a veil structure and proposed a corrosion suppression process. The experimental results showed that (1) the surface region of the veil includes silicon, and that (2) the proposed two-step etching is effective for suppressing corrosion.

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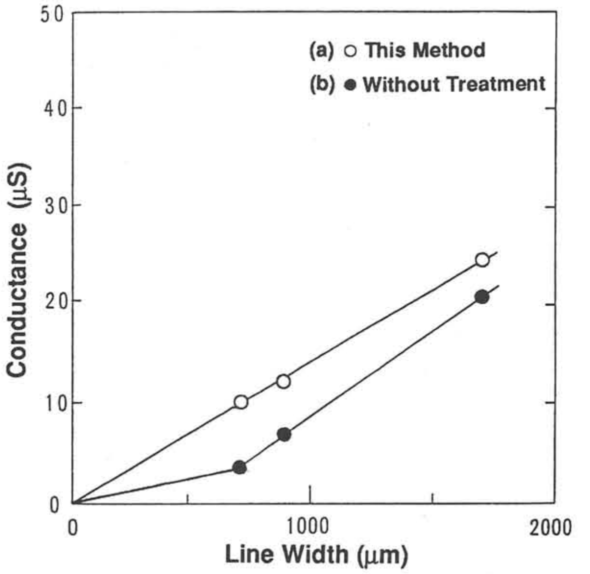
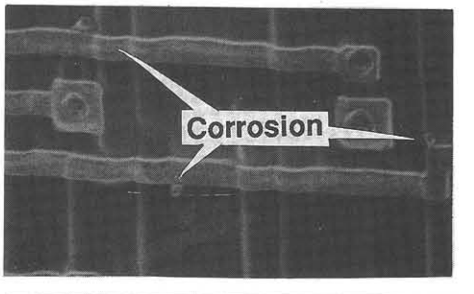


Fig.7 Conductance of the metal interconnection vs. interconnection width: (a) with the proposed treatment and (b) without treatment.

(a)



(b)

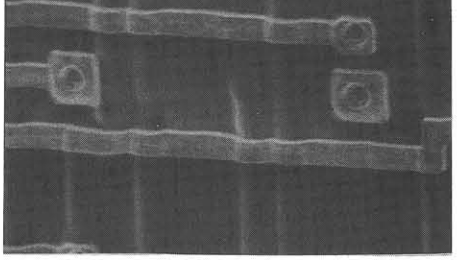


Fig.8 Comparison of samples by SEM photographs: (a) the conventional method and (b) the proposed method.