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A study on the removal method of Si residue during Si Wet Etch

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ABSTRACT

In this paper, problems that can occur during the poly-Si wet etch in the semiconductor process are used and methods to solve these problems are introduced. In order to prevent the substrate from being damaged, we generally use a wet etching process that uses alkali solutions rather than dry etching process. If poly si residues remain after etch process in this critical step, it bring about a huge impact on the wafer yield.

The reason there are Si residues is largely divided into two categories. One is low wettability by hydrophobic Si surface and the other one is local residues due to insoluble H2 Bubbles that are generated during a wet etching.

At First, as shown in Figure 1, The shape of the defect inspection map appears like a tornado that is generated by a poor wetting, the cause of this occurrence is as follows. Before Si etching, a pre-treatment of Fluorine series is needed to remove native oxide. As a result, Poly-si is significantly changed to more hydrophobic. In this state, Alkali solutions cannot be used fully when wetting on the wafer's surface, and it makes tornado shaped defects in the single type equipment. This problem can be solved using a hydrophilic surface treatment(SC1) between fluorine pretreatment and poly-si wet etching. This can be demonstrated via the contact angle measurement, surface tension of the solution is dramatically reduced by SC1 treatment. Additionally, we have learned that the solutions having longer carbon chains have better wettability than ammonia and small amounts of IPA with a low surface tension added for improving wettability.

Secondly, even if defects due to low wettability disappeared, residue does not disappear completely. The reason is a generation of H2 Bubble during the reaction of Si and hydroxide, it can be written as

$$\mathrm{Si} + 2\mathrm{OH}^- + 2\mathrm{H_2O} \longrightarrow \mathrm{SiO_2(OH)_2^{2-}} + 2\mathrm{H_2}$$

As shown in figure3. H2 bubbles make hillock and increase of roughness by wet etch masking, if it is captured between a narrow space pattern, bubble removal on the surface is more difficult.

As shown in figure 4. H2 Bubbles remained for a long period on the Si surface in specific adhesion force and assembled with each other if there was no additional surfactant or physical force.

A simple solution is a multi-step process that continues wet etching and rinsing because bubbles are removed by a high RPM Rinse after wet etching but the Process's time will be longer.

This paper describes the experimental results of the IPA added for lowering surface tension chemically and using ultrasonic waves for physical removal.

References

[1] Solid State Phenomena Vol. 187 (2012) pp 53~56
[2] Chii-Rong Yang, Science Direct 2005 263-270p

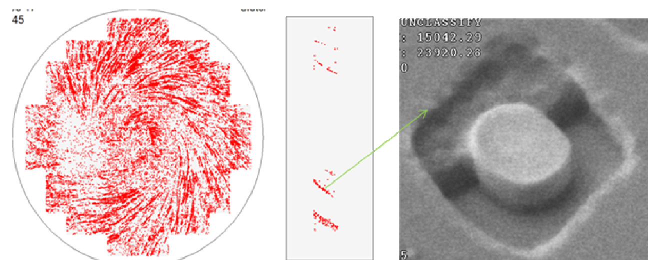

Figure 1. Defect inspection map of tornado shape after poly-si wet etching & SEM image of poly residue

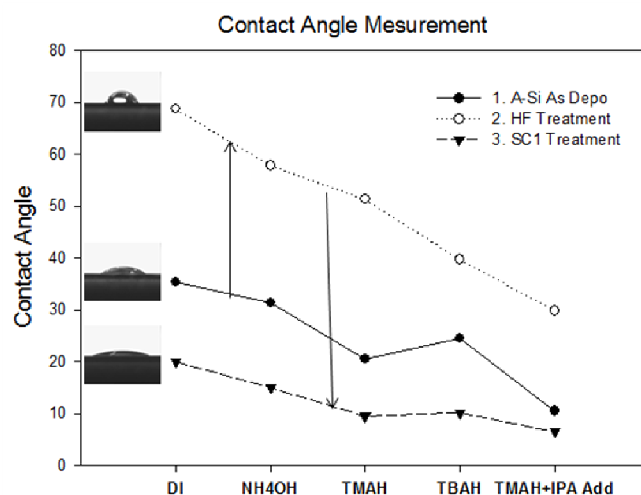

Figure 2. Contact angle measurement of alkali solutions after HF & SC1 treatment

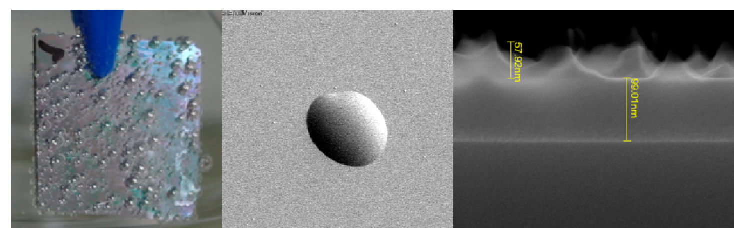

Figure 3. Generation image of H2 Bubble / Hillock & Roughness SEM Image by bubble Masking

	TMAH (Ref.) 6wt%	With Stir (400rpm)	With Sonic (300MHz)	IPA Add in TMAH 5wt% IPA Add
Experiment Image				
Bubble Formation Per Unit Area (1 x 1cm)			Bubble Free	
Etchrate (A/min)	1440	1309	1610	1267

Figure 4. Results of bubble removal experiment according to adding IPA & using ultrasonic waves