New short cycle wet cleaning concept for a 300 mm fabrication line

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Abstract

A new concept for short cycle time wet cleaning is investigated. It was found that using this concept, a typical 64 min HF-SC1-SC2 process can be reduced down to 2 min. The chemistry of this concept consists of a single step modified SC1 which replaces the dual step SC1-SC2.

Introduction

Shorter cycle times are necessary for a variety of reasons, such as rapid prototyping, smaller WIP and faster ramp of new technologies, tool qualifications and fab upstarts.
Wet cleaning is the most recurring process step in a VLSI manufacturing process. This process step suffers from very long cycle times. The example used is a traditional HF-SC1-SC2-dry cycle used in pre-thermal clean applications. This step currently has typically a 64 min cycle. This step by itself is usually repeated roughly 12-15 times in an entire VLSI process flow. The same applies to other similar wet cleaning steps such as SPM-SC1-SC2-dry. There are about 60-120 wet cleaning steps depending on the process flow.
In this paper, we will use the HF-SC1-SC2-dry cycle as a case study, but the results apply to most wet cleaning steps. We present here a new concept for short cycle wet cleaning that reduces the cycle time for this process down to 2 min, instead of 64 min. Surprisingly, the CoO of this new concept is similar or lower than the current conventional wet bench HF-SC1-SC2 processing, which allows it to be used not only for rapid prototyping, but for volume manufacturing as well.

Chemical concept

The chemical concept is shown in fig. 1.

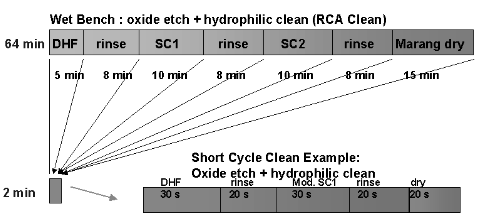

Fig. 1. Chemical concept to reduce the cycle time of HF-SC1-SC2 from 64 to 2 min.

The cycle time can be reduced as follows. The DHF etch can be reduced from 5 min to 30 s by using a horizontal spin and dispense/spray concept. Horizontal spin and dispense/spray allows very short etch times with very good uniformity. High concentration HF with very short exposure times can be used. The rinse can be reduced from 8 min to 20 s, by using the same concept and using centrifugal forces to reduce the boundary layer. In immersion wet benches, boundary layers of the order of 150 μm lead to rinse times of 8 min. In a horizontal spin system, the boundary layers are of the order of 10 μm, resulting in rinse times of the order of 20 s. The traditional SC1-SC2 cycle, where each step takes about 10 min, can be reduced into a single step of 30 s, by using the following concepts: the metal removal function of the SC2 can be combined into the SC1, by using a modified SC1, that includes chelating agents. The chelating agents take over the traditional metallic impurity removal function of the HCl, but work at high pH [1]. The SC1 itself can be reduced from 10 min down to 30 s, by using a much more efficient megasonics unit. Additionally, we have added surfactants to the SC1 to avoid any redeposition of particles and to achieve a total process time of 30 s. Finally, the drying relies mainly on the centrifugal forces to dry a wafer in 20 s.
This concept makes rapid prototyping possible.

Particle Removal efficiency

We evaluated the particle removal efficiency, using a modified SC1 for only 30 s with this single wafer system. We added chelating agents and surfactants to … cessful.

No damage on 0.1 μm poly lines

We evaluated the Si_3N_4 particle removal at 0.12 μm and above both on the front side and the backside. We deposited Si_3N_4 particles in a random mode and in a spot. Starting Si_3N_4 particle counts were of the order of 2300 particles. A typical result on the

front side before and after a 30 s clean is shown in fig. 2 and 3 (front and backside) measured >0.12 μm.

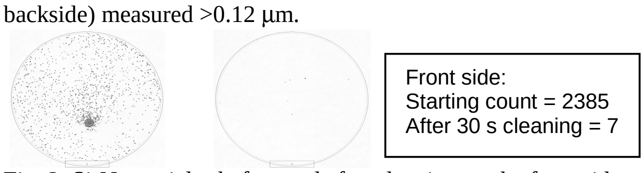

Fig. 2. Si_3N_4 particles before and after cleaning on the front side.

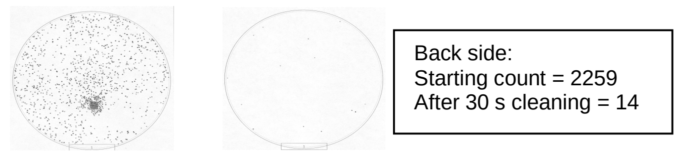

Fig. 3. Si_3N_4 particles before and after cleaning on the backside.

We also measured the thermal oxide loss. Due to the short process times, the thermal oxide loss is extremely small. In all cases, the thermal oxide loss for the modified SC1 in a single wafer mode is less than 0.1 nm.

Metallic impurities

We measured the metallic impurities after this clean to validate the combination of SC1-SC2 into a single step. The metallic impurities after this clean are shown in fig. 4.

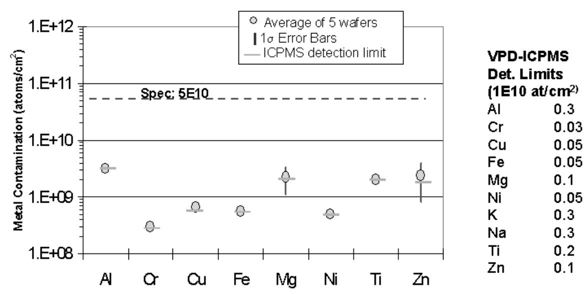

Fig. 4. Metallic impurities after the modified SC1 process

As can be seen from fig. 4, all common metallic impurities are below the VPD-ICPMS detection limit, which is of the order of 1e8 at/cm^2 to 1e9 at/cm^2.

Organic Residues

We have selected chelating agents and surfactants, which can be completely rinsed. First, we measured the characteristic peaks in a TOFSIMS spectrum of the chelating agent and the surfactant, by depositing a concentrated solution on the wafer and letting it dry to the air. This is shown in fig. 5. Then we looked for these peaks after the short cycle clean (modified SC1) followed with a rinse. No organic residues were found with TOFSIMS as shown in fig. 6.

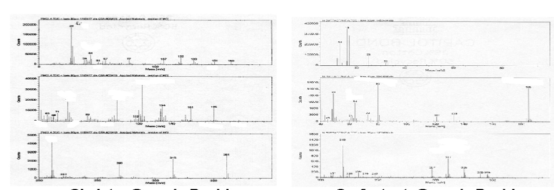

Fig. 5. TOFSIMS spectra from the chelate and the surfactant residue on the wafer.

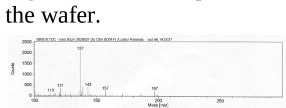

Fig. 6. TOFSIMS spectra after modified SC1+rinse.

Summary

In this paper we have presented a new concept and the feasibility data of a short cycle wet cleaning process that is equivalent or better than a conventional batch wet cleaning. We have shown that the particle removal efficiency is better or equivalent to a 10 min conventional wet bench process. At the same time, no damage to 0.1 μm poly-lines was observed and less than 0.1 nm of thermal oxide loss was measured. Metallic impurities are below the detection limits and no organic residues were found with TOFSIMS.

References

1. S. Verhaverbeke et al., in Tech. Dig. IEDM (1991), p.71.