Process Technology for Device

Cleaning to the edge — Post-CMP Cleaning —

Post-CMP Cleaning Technique by SEZ Cleaning of Backside by Wet Etching

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Now that the time for the 0.35μm processing has come, the introduction of the CMP technique into DRAM has been actively promoted. However, few of a variety of problems on introducing CMP have still remained to be solved. Among them, one of the important issues needed to be solved for its introduction into the mass production lines, which places emphasis on cleanness, is contamination with particles and heavy metals generated by slurry. Although various cleaning methods have been put to practical use 1)-3), the major concern of many of those cleaning techniques currently in debate is regarding how to clean the device surface, which directly affects the defect rate. To date, few discussions have been made on the cleaning of the wafer backside, which is expected to be a focal topic in the 256 M DRAM process requiring a microstructuring at 0.25 μm level.

This article describes the influence of the contamination with particles and heavy metals left on the backside after CMP on the device surface during the 0.25 mm processing with 300 mm wafer, and introduces a cleaning method for them.

Influences of particles left on device backside.

The advantages of applying CMP technique to DRAM processing include microstructuring, a low defect density and a low wiring capacity 4). Especially, the primary reason for introducing CMP into 256 M which employs 0.25 μm processing is to have an adequate depth of focus in lithography. To compare the change in depth of focus (DOF) of i-line stepper between CMP and an etchback by conventional SOG, the planarization of interlayer insulating films was performed on metallic three-layer wiring.

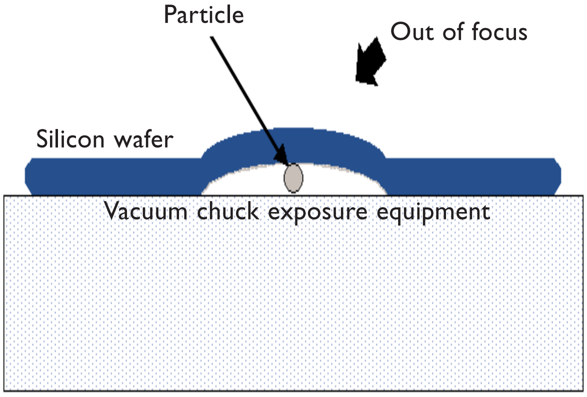
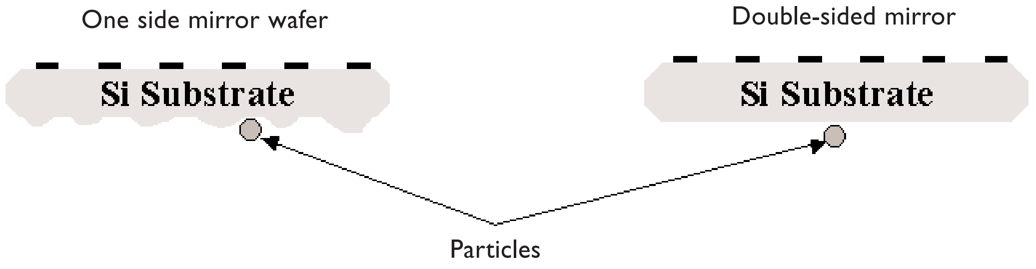


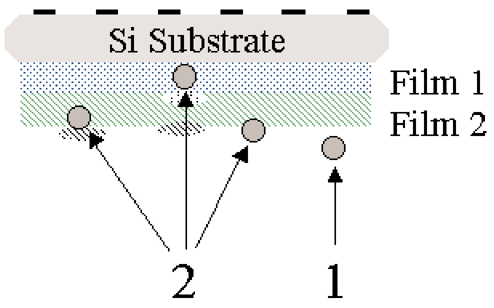
Fig. 1. Inadequate resolution by particles left on wafer backside.

The samples obtained by CMP showed DOF of 1 μm in each pattern of all three layers, whereas the samples by the conventional SOG process showed DOF reduction toward upper layer, as small as 0.3 μm in the third layer 4). In most cases, the margin of depth of focus is determined by the precision of an exposure device. This result, as well as the requirement of planarity on the exposure surface for the 0.25 μm processing, demonstrates the importance of introducing CMP. However, even if the counter-measures for focus errors on the device surface were established by the introduction of CMP, the advantages of CMP introduction would be reduced by half if other factors associated with CMP caused focus errors.

Particles left on the wafer backside during the transport in a fabricating equipment have also been the problem in the lithography process of conventional devices. As shown in Fig. 1, planarity cannot be achieved if a particle is sandwiched between chuck and wafer, when the wafer is mounted on the vacuum chuck of a stepper. This causes a pattern defect due to focus defect 3).



a) Influence on double-sided mirror wafer



Particles	Brush scrubber	Chemical Spin Etcher
1	O	O
2	X	O

O: removable, X: unremovable

b) Particles absorbed in deposited films

Fig. 2. Particles adhered to wafer backside.

It is almost impossible for CMP to reduce the generation of particles in terms of the nature of the process, and the amount of particles attached is incomparably larger than that in a conventional fabricating equipment. Therefore, it is likely that the adoption of CMP will bring about higher probability of focus errors.

Additionally, the double side-mirror treated wafer is expected to become the prime choice of 300 mm wafer. As shown in Fig. 2, small particles on the rough surface of the backside were inconspicuous due to its uneven surface, whereas those on the mirror surface are likely to have a notable influence on the smooth exposure surface.

Influences of backside-heavy metal contamination on devices

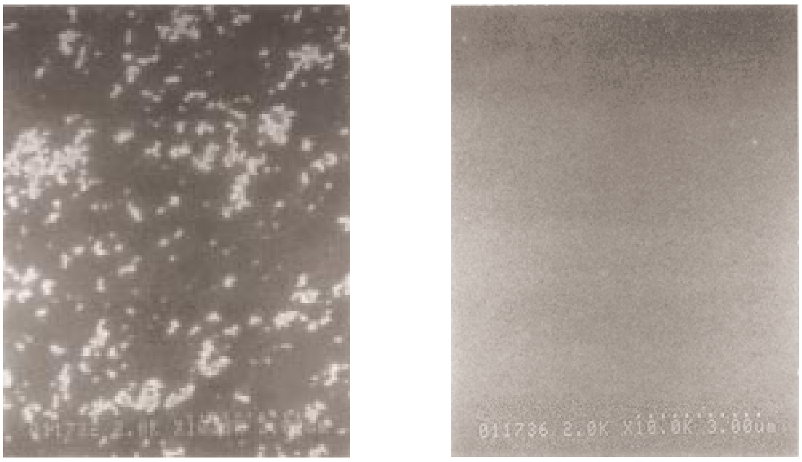
Currently, the interlayer insulating oxide film CMP is the most commonly used CMP. In the coming 256 M age, CMP is expected to be introduced into damascene architecture. Damascene processing brings about a contamination problem with heavy metals rather than with particles because of its use of CMP polishing after embedding and depositing the metallic films. It has been under discussion regarding which of Al or Cu to use for the wiring material of the damascene processing. Either case raises an important issue on post-metallic CMP cleaning, how to remove Al or Cu films after CMP. In addition, the importance of the backside cleaning has to be emphasized because the wafer backside also becomes contaminated in the same manner at the same time.

During the Al or Cu damascene process in CMP, stripped metals form chemical compounds by reacting with interlayer insulating films (such as TEOS) deposited on the wafer backside. These compounds are difficult to remove with an ordinal brush scrubber. It is easily predicted that proceeding to the subsequent process without proper removal of these compounds can lead to cross-contamination to other processes.

Post-CMP cleaning of the wafer backside

As mentioned above, the removal of particles and heavy metals left on the backside in 0.25 µm processing has become critical. It is expected that CMP will be adopted in many processes including applications to a multilayered wiring or metallization. In those cases, the particles would be embedded among a variety of films which are deposited on the backside if the particles were not completely removed from the backside, as shown in Fig. 2. The influence would be greater on increased mutilayering or on the mirror surface.

The post-CMP cleaning techniques commonly practiced for removing particles left on the wafer backside include a brush scrubber cleaning and a megasonic cleaning.



(a) Slurry-contaminated wafer

(b) After 60 seconds processing.

Chemical solution: ELM-C-30 (fluorine-type semiconductor cleaner: Mitsubishi Gas Chemical Company, Inc.)

Fig. 3. Effect of particle removal by single wafer chemical spin etcher.

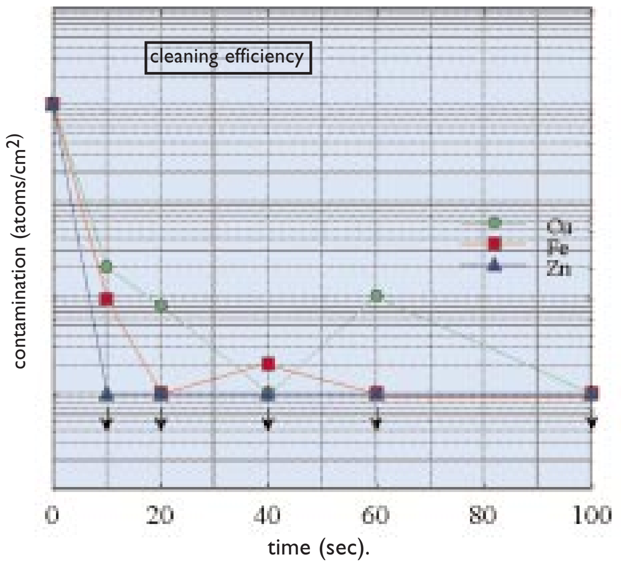


Fig. 4. Effect of heavy metal removal by single wafer chemical spin etcher.

Yet most of them employ a cleaning technique for the purpose of removing particles left on the surface of the deposited films of the backside. This technique has a limit to a complete removal of particles left on the surface of the deposited films, and is impossible to remove particles absorbed between layers. Additionally, in the post-CMP cleaning of the wafer backside, chemical compounds resulting from the reaction between the wafer backside-films and metals are difficult to remove by either the brush scrubber cleaning or the megasonic cleaning.

On the other hand, wet etching is an effective cleaning method by removing particles and reactive compounds together with deposited films of the backside. The device which is capable of this treatment include a single wafer chemical spin etcher. The chemical spin etcher is able to maintain a high degree of etching uniformity on the wafer surface without causing cross-contamination which is seen with a batch processing. Furthermore, the chemical spin etcher requires no protection for the device surface and is capable of removing multilayer films including oxide films, poly-Si and nitride films through one process, because it is equipped with wafer maintaining function using gas as well as a multistep processing bath. These facts explain fewer processes and a lower running cost of the chemical spin etcher compared to other etching devices.

The basic cleaning ability in the spin processing is mentioned below. Fig. 3 shows pictures of SEM cleaned with a single wafer chemical spin etcher after intentionally contaminated with slurry used in CMP. The processing was carried out using a chemical solution, ELM-C-30 (fluorine-type semiconductor cleaner: Mitsubishi Gas Chemical Company, Inc.). As shown in Fig. 3, the slurry on the backside was completely removed after 60 seconds processing.

The backside cleaning method with a single wafer chemical spin etcher is also effective on the removal of heavy metal contamination. Fig. 4 shows the changes in contamination levels of Fe, Cu and Zn ions upon processing. The experiment

ment was conducted on wafer with the intentionally contaminated surface of Si substrate using a chemical solution of 1% HF. The contamination level of each ion decreased as the processing time increased. In about 60 seconds, the contamination levels of Fe and Zn ions were under detection limit of 10^{10} atoms/cm^2. Furthermore, Cu ion, which is considered to be difficult to remove, decreased to the level under 10^{10} atoms/cm^2 after about 100 seconds processing. The results demonstrate that a single wafer chemical spin etcher is highly capable of removing heavy metals. 5) Thus, chemical spin processing is considerably effective on the cleaning of particles and heavy metals.

Summary

CMP is expected to be introduced in many processes for the 0.25 µm processing. Therefore, the particle and heavy metal contamination which is unavoidable in CMP is likely to become a more critical issue. It is undoubtedly believed that not only the evaluation of the device surface cleaning but also the wafer backside cleaning, to which not much importance has been attached, will become still more important in post-CMP cleaning.

Conventional techniques for removing particles and heavy metals left on the surface have a limit to their application to post-CMP cleaning of the wafer backside.

The new cleaning technique proposed here to remove particles and heavy metals by etching the deposited films on backside is considered to be effective. For the introduction of this cleaning technique, a single wafer chemical spin etcher is useful because it requires no protection of the device surface and is capable of etching multilayer films deposited on the backside (such as nitride film) during one process without causing cross-contamination.

It was reported 7) in the past that the defect rate was improved by 1.5% after introducing a backside film removal technique using a single wafer chemical spin etcher into the backside cleaning process of 16 M DRAM. The introduction of this cleaning technique into post-CMP as well as other processes is expected to bring about tremendous effects in the 0.25 µm processing.

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