Real Time Monitor of Cu Pollution in Clean Room Ambient near Cu CMP Equipment

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Abstract

QCM was applied to measure Cu pollution in the vicinity of the Cu CMP equipment. QCM can detect the cupriferous mist seeping out from the CMP chamber to the environment successfully. The mist spreads throughout the tool, but not diffusely from the tool into the clean room ambient, except when performing maintenance by opening the equipment panel. Based on the experimental results, the Cu wiring area has been directly connected to other areas by opening the door isolating them.

1. Introduction

Cu contamination should be strictly restrained in a clean room ambient in order to avoid a fatal yield loss in LSI manufacturing. However, the isolations of area, entrance /exit and clean room wear from other area results in productivity degradation as well as inconvenience. It is of great worth to investigate whether the stringent isolation is inevitable or not.

Ito[1] and Okamura[2] have proposed the real time detection of chemical contaminants in a clean room ambient using QCM (Quartz Crystal Microbalance). The frequency shift of QCM is represented by the following equation (1).

$$\Delta M = -k \cdot \Delta f / f0 \qquad (1)$$

$$k = Vs \cdot Se \cdot \rho \qquad (2)$$

where f0, Δf and ΔM are the base frequency of the quartz, frequency shift and the amount of adsorbant, respectively. And Vs, Se and ρ in equation (2) are the sound velocity in quartz, area of the electrode formed on the quartz crystal and density of quartz, respectively. The frequency shift is inversely proportional to the amount of adsorbing species.

We applied this technique to measure Cu containing species floating in the environment. This paper reports the successful detection of Cu seeping from Cu CMP tool to the ambient and discusses the adequate contamination control.

2. Experimental

Fig. 1 shows a schematic illustration of the QCM system, which is the same as that reported by Okamura [2]. This system, which consists of five QCM probes, a main control circuit and a PC, can measure at 5 points concurrently.

Fig. 2 shows the illustration of the CMP tool used in this work. The polishing of electroplated Cu film was carried out using a silica slurry and chemicals containing organic acid and H_2O_2.

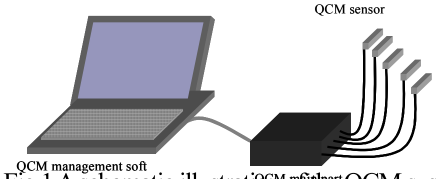


Fig.1 A schematic illustration of the QCM system

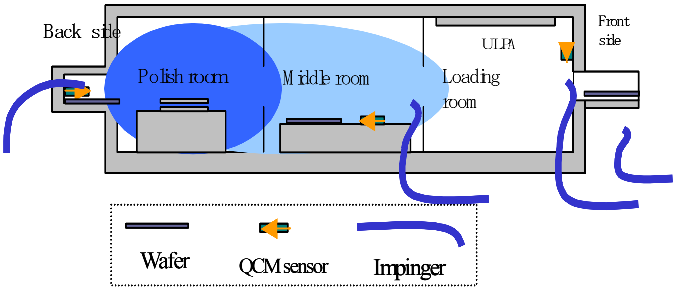


Fig. 2 A schematic illustration of Cu CMP equipment

3. Results and Discussion

3-1. Detection of species containing Cu

Fig. 3 shows the frequency change for 4 days. The ordinate indicates the frequency change in 3 min, since the frequency was measured every 3 min. A drastic increase and decrease are observed 4 times in the polished room. Periods, indicated by arrows, in which Cu polishing was carried out coincide well with the frequency shift of QCM. It is evident that the frequency shift detects something seeping out from the polish chamber into the ambient.

The increase and decrease in the frequency shift demonstrate the adsorption and desorption of species on the quartz vibrator, respectively. It is interesting that the frequency does not return to the initial level, suggesting the adsorbed species do not evaporate into the environment completely.

Fig. 4 indicates the detail around the second peak in Fig. 3. The four figures (a), (b), (c) and (d) show the frequency shift in the polish room, in the middle room, in the loading room and outside of the tool, respectively. The frequency shift is observed not only in the polish room, but also in the middle room as shown in Fig. 4 (b). The species seeping from the CMP chamber spread within the equipment.

In order to investigate what kind of species adsorb on the QCM, the species adsorbed on a Si wafer near to QCM was analyzed by SEM-EDX. The material adsorbed on the Si wafer seemed to be damp and was parched during air exposure. The photograph shown in Fig. 5 (a) indicates residue after drying. EDX spectra (Fig. 5 (b)) analyzing the marked point demonstrate the existence of Cu in the residue.

Fig. 6 shows humidity in the polishing room in the period of the second peak shown in Fig. 3. This figure clearly indicates that the humidity increased with the beginning of the polishing and decreased after the end of the polishing, suggesting the chemical species seeping out from the CMP chamber is a kind of a hydrate.

Furthermore, the ambient in the CMP tool was analyzed by using ICP-MS. ICP-MS analysis revealed the presence of Cu in the ambient. Fig. 7 shows variation in Cu concentration in each room of the CMP tool. Cu concentration is highest in the polish room, and in addition, it increases during polishing. These results coincide well with the frequency change of the QCM.

According to these experimental results, the following model is plausible. A hydrate containing Cu seeps out from the CMP chamber during polishing, causing the humidity increase. The adsorption of the hydrate on the QCM results in the frequency shift, and evaporation of water from the hydrate recovers the frequency shift. The difference between before and after polishing (as shown in Fig. 3) corresponds to the net weight of the Cu compounds.

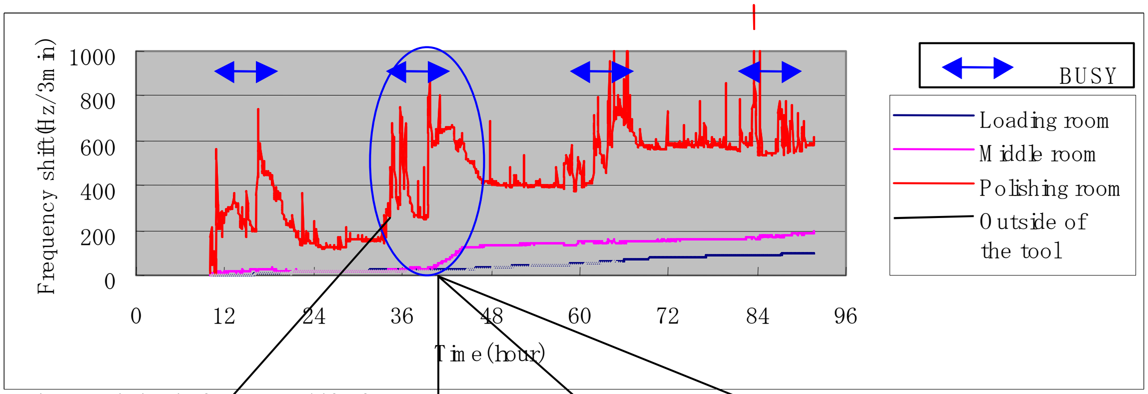
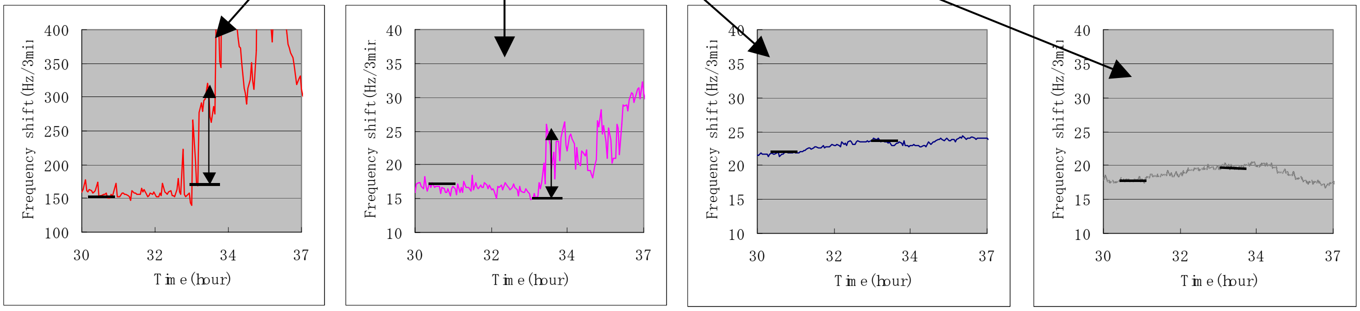


Fig. 3 Variation in frequency shift of QCM



(a) Polishing room

(b) Middle room

(c) Loading room

(d) Outside of the tool

Fig.4 Detail of frequency change in the second CMP (circled part in Fig.3)

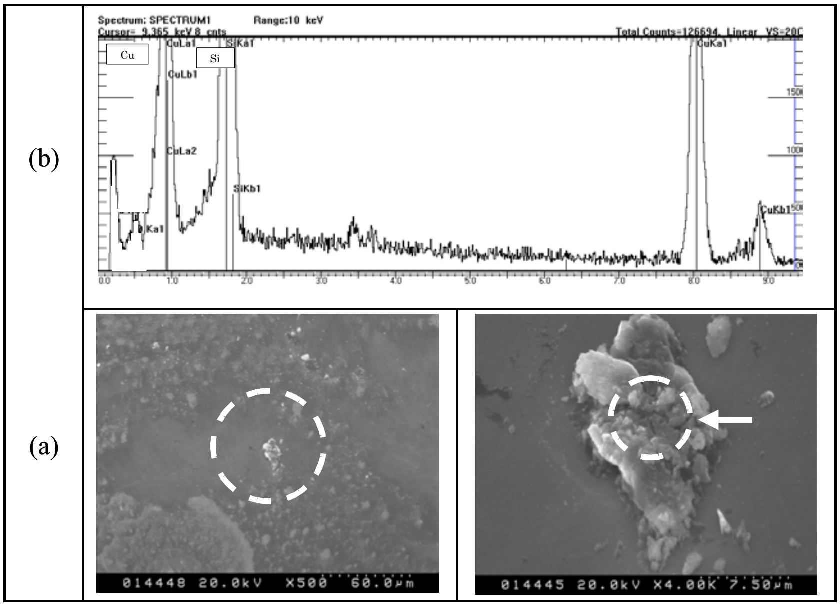


Fig.5 SEM/EDX image on wafer

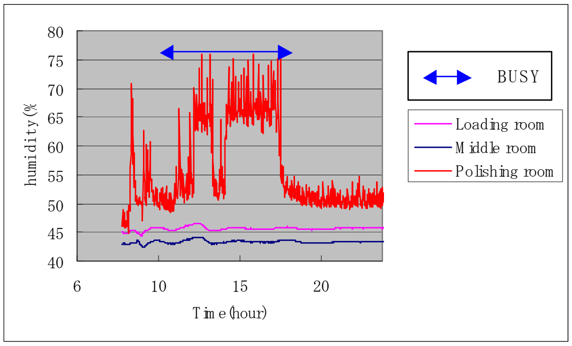


Fig. 6 Humidity measured

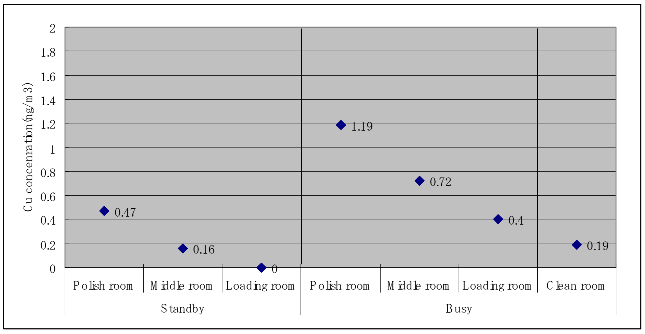


Fig. 7 Cu concentration measured by ICP-MS

3-2. Improvement of QCM probe

Based on the findings described above, the QCM sensor head was improved, as shown in Fig. 8 (a) and (b). In the improvement type (b), the air is forced through slits by a fan in order to dry the mist adsorbed on the QCM. Fig. 9 shows the frequency shift measured for 4 days, indicating the stable frequency shift during polishing.

3-3. Management of Cu wiring area

The frequency shift is observed only within a tool, but not observed outside of the tool, demonstrating that Cu hydrate spreads throughout only within the CMP tool. Actually, the analysis of the clean room wear revealed that species containing Cu do not attach on the wear except during the maintenance accompanying the opening of the panels. Fig. 10 shows the plane view of Selete's super clean room in Tsukuba. The Cu wiring area was isolated by closing the door (shown by an arrow). In addition, the exclusive entrance and exit connected to the Cu wiring area were used. Based on these experimental findings, however, the locker room and Cu wiring area are directly connected by opening the door between the Cu wiring area and front end area. Not only was there no fatal yield loss, but also no degradation of device performance was observed at all.

4. Summary

Real time monitoring of Cu pollution was carried out by using QCM. The Cu hydrate diffuses out from the CMP chamber into the environment in the tool. This species spreads widely in the tool, but does not exude into the clean room ambient. Direct connection of the Cu wiring area to other areas does not result in the serious spread of Cu.

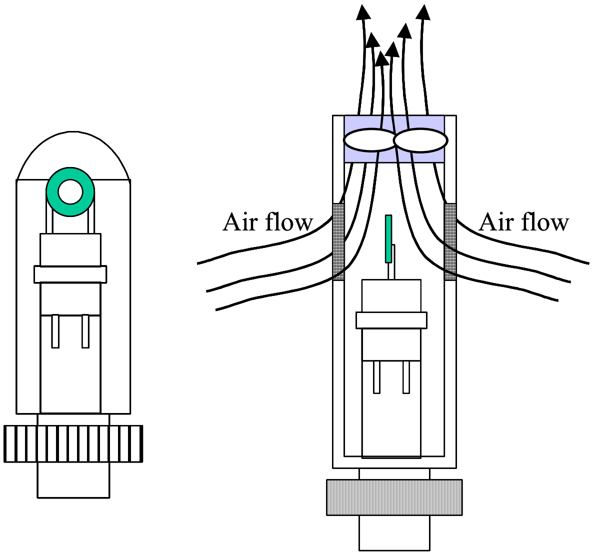
5. References

1) S. Ito et. al., Proc. of ISSM 2002, pp. 49-52, Tokyo (2002)

2) S. Okamura et. al., Proc. of ISSM 2002, pp. 157-160, Tokyo (2002)

6. Author Biography

Masaji Sasaki joined Fujitsu Co. Ltd. in 1968, where he was engaged in production and production engineering of the semiconductor division. In 2002, he moved to Semiconductor Leading Edge Technologies, Inc. (Selete) to join the ASUKA project. His responsible area is the management of the ASUKA Research Line.



(a) Normal type (b) Fan type (Improved)

Fig. 8 Improvement of QCM sensor

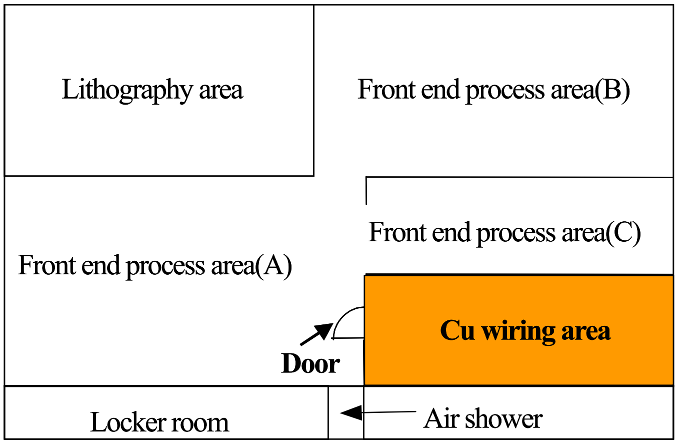


Fig. 10 Plane view of Selete's super clean room

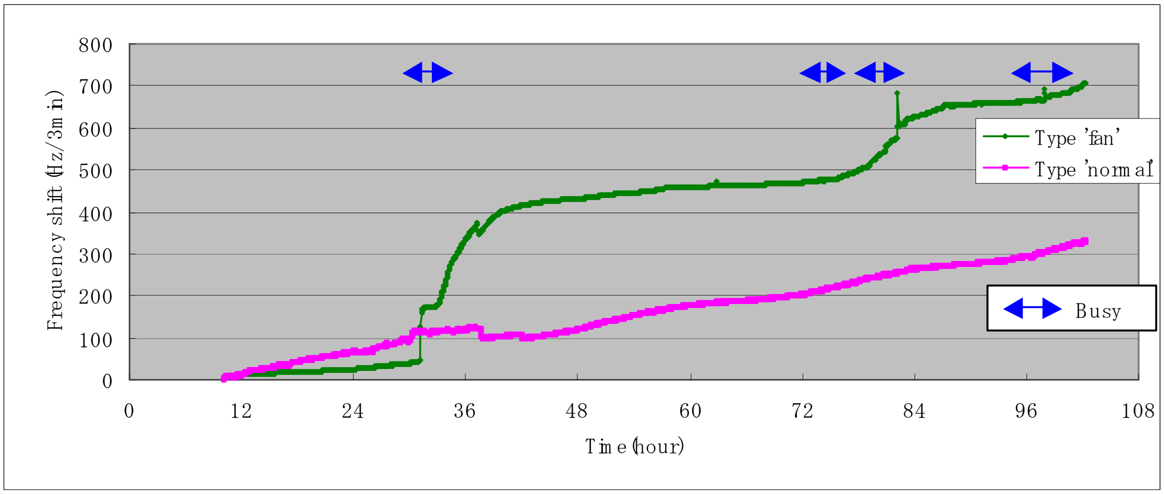


Fig.9 QCM sensor type frequency shift