Development of Ashing Processes for Packaging Processes

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1. Trend in Packaging Technologies

The search for semiconductor chips that are more compact, more integrated, and have higher performance has always been and will continue to be our main focus. Packaging technologies are evolving just like semiconductor process technologies (Figure 1). The previous packaging technology was peripheral terminal packaging based on insertion mount technologies (featuring wired connection of chips and leads that served as external terminals). It was followed by the area terminal packaging based on surface mount technologies. One example is the Ball Grid Array (BGA) that connects solder balls to printed circuit boards without using lead frames. This area terminal packaging method had the advantage of being able to use the entire surface of chips for connections, not just the peripheries. This further increases the packaging density. Afterward, with progress in digital household appliances, such as portable video cameras and cellular phones, the Chip Size Package (CSP) was developed, which features package dimensions nearly equal to chip dimensions and thus realize more compact and higher performance chips. In the future, products will be further advanced in terms of functions, density, miniaturization, weight and complexity, increasing the importance of semiconductor packaging technologies as well as the importance of the

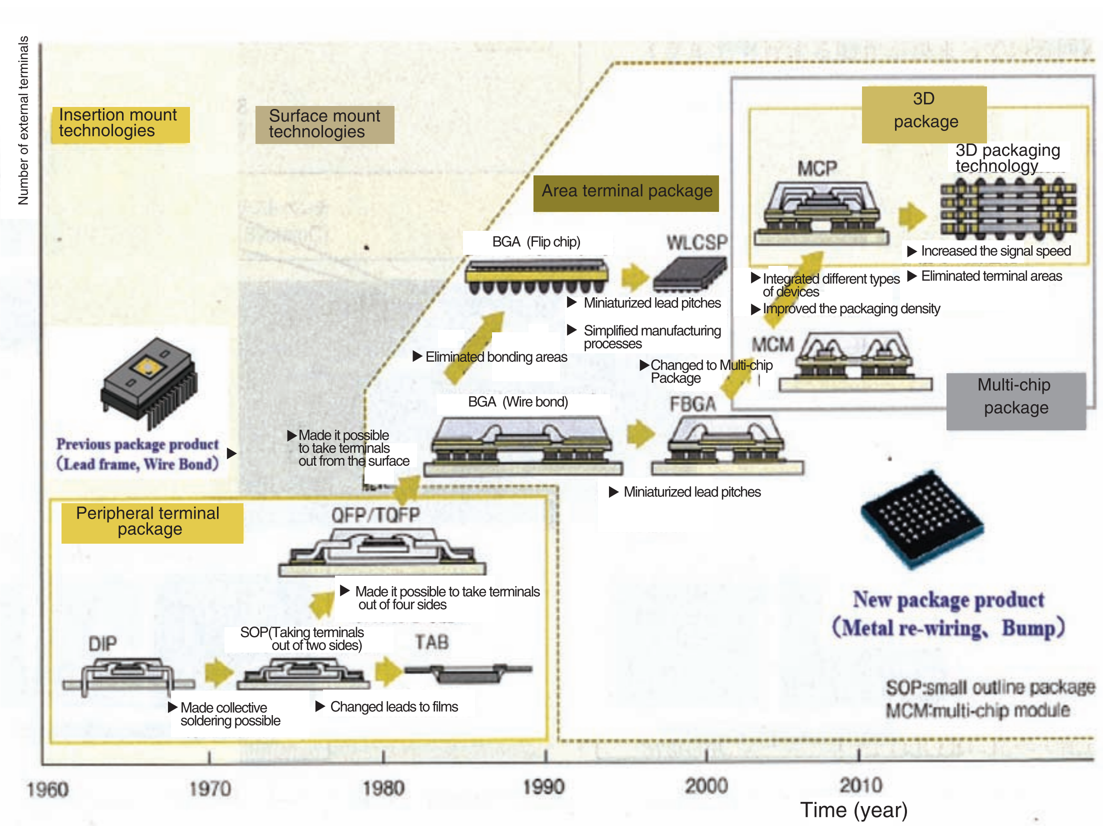

Figure 1 Semiconductor Packaging Technologies

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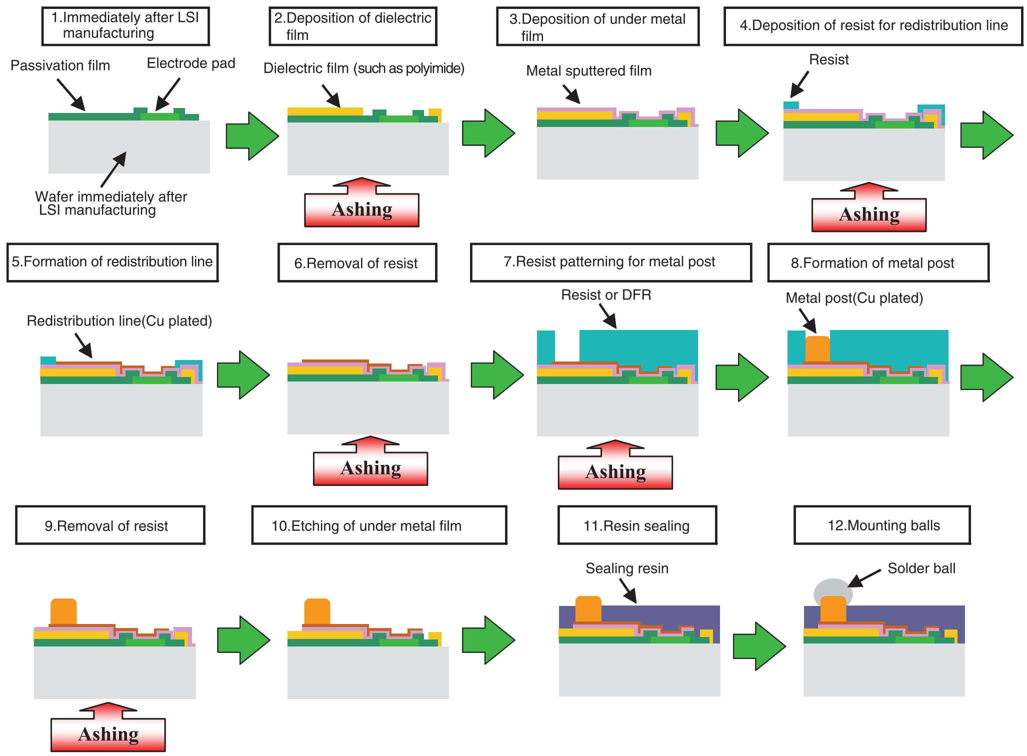

Figure 2　CSP Manufacturing Process Flow

development of Wafer-Level Chip Size Packages (WL-CSP), System on Chip (SoC), three-dimensionally stacked System in Package (SiP) and other technologies. [1)]

2.　Ashing Processes in Packaging Processes

Figure 2 shows an example of WL-CSP manufacturing processes. Ashing processes are mainly intended for removing scum at the bottom of patterns for resin masks (such as PR, PI, BCB and DFR), modifying pattern side walls to improve adhesion of plating solutions, recovering resistance of dielectric films, and modifying surfaces (to improve adhesion during packaging).

Figure 3 shows an ashing system, the NA-1300, fabricated by FPD・PV Division 3. This system has been widely delivered for the mass production lines of packaging processes in Japan, Taiwan, Korea and China. Adopting the high-efficiency microwave plasma method, this system realizes damage-free down flow. It can apply RF bias to substrate stages, supports additive fluorine gases, and enables particle-free processing. This system can be used for a wide range of processes from ashing to etching.

Figures 4 and 5 show the results of removing scum using this system. After patterning PR, PI and DFR, scum remains at the bottom of the patterns. Plating in such a state results in defective devices with growth abnormalities or shape abnormalities. Scum at the bottom of patterns for both PR and DFR samples can be completely removed through ashing using this system.

Figure 3　Ashing System NA-1300 (FPD・PV Division 3)

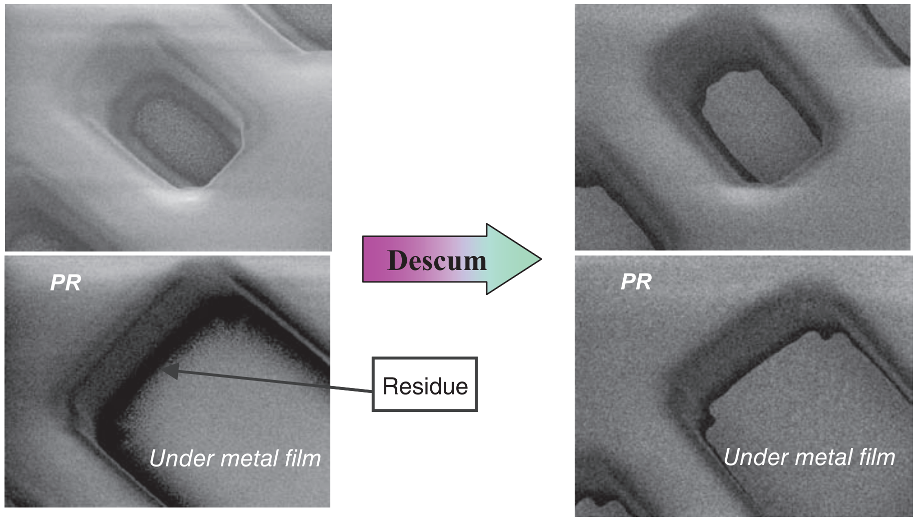

Figure 4　Scum Removal (PR Sample)

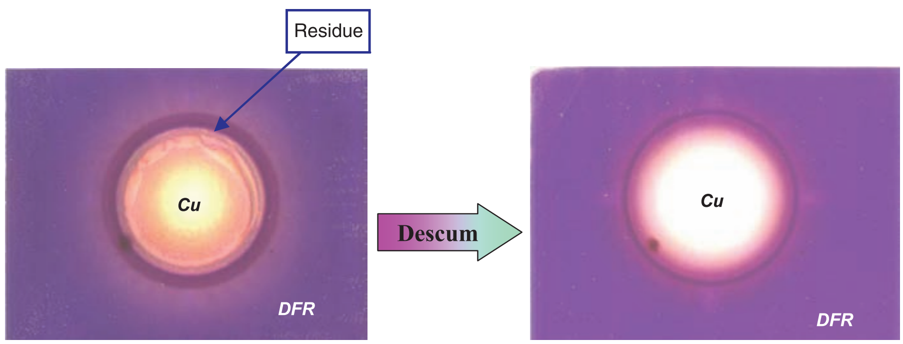

Figure 5　Scum Removal (DFR Sample)

3. Improvement of Process Stability in Packaging Processes

There are various kinds of processes involved in the ashing process of packaging processes, some of which require high RF bias power for removability improvement, resistance recovery and surface modification. In these processes, (depending on conditions) Cu or other metallic materials exposed on substrates are sputtered and thus adhere to the inner parts of an ashing chamber. If Cu or other metals adhere to the inner parts of this chamber used for a variety of processes, it deactivates radicals and thereby decreases the ashing rate or deteriorates uniformity. Most internal parts of the chamber are made of aluminum (with special alumite-treated surfaces). The STD Rate in Figure 6 indicates the ashing rate when the

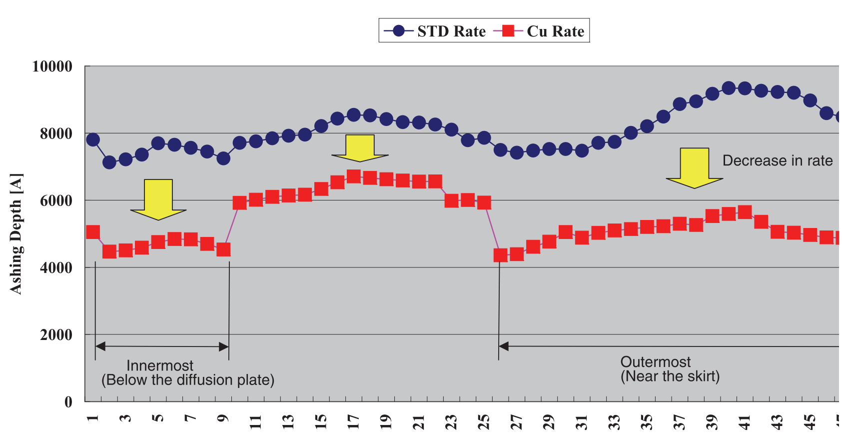

Figure 6　Ashing Rate with Cu-depositing Parts (Diffusion Plate and Skirt) in the Chamber

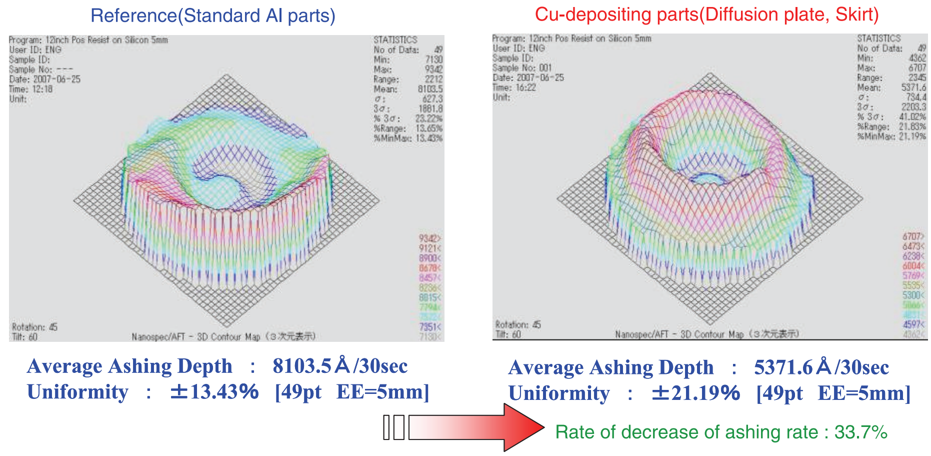

Figure 7 Ashing Rate with Cu-depositing Parts (Diffusion Plate and Skirt) in the Chamber (3D Maps)

chamber is equipped with aluminum parts. The ashing rate measuring points on a wafer begin from the center and move to the outer edge. Cu Rate in the graph indicates the ashing rate when the chamber is equipped with a diffusion plate and a skirt on which Cu deposites. The ashing rate significantly deteriorates in the areas immediately below the diffusion plate and near the skirt. The ashing rate for the entire wafer and the uniformity of wafer are also deteriorated. Figure 7 shows 3D maps for these results. Figure 8 shows the results of examining the influences of microwaves (MW) and RF on the ashing rate for the Al parts and the Cu-depositing parts. The reduced ashing rate and the deteriorated maps are greatly affected by MW, but only slightly affected by RF. This means that Cu-depositing parts in the chamber deactivate radicals and result in the reduced ashing rate and the deteriorated uniformity.

To solve this problem, we tried to stabilize the ashing rate by equipping the chamber with internal parts made of a metal on the assumption that the metal would adhere to the inside of the chamber. In Figure 9, plots of Cu parts (conventional conditions) indicate the rate of ashing in the chamber equipped with internal parts made of Cu and under conventional processing conditions. By optimizing the processing conditions, we observed performance at a level equal to or higher than that of conventional Al parts, as shown by the plots of Cu parts (optimum conditions) in the graph. Deterioration of the rate was observed after only a few samples fully covered with Cu were processed in the chamber with the conventional Al parts. However,

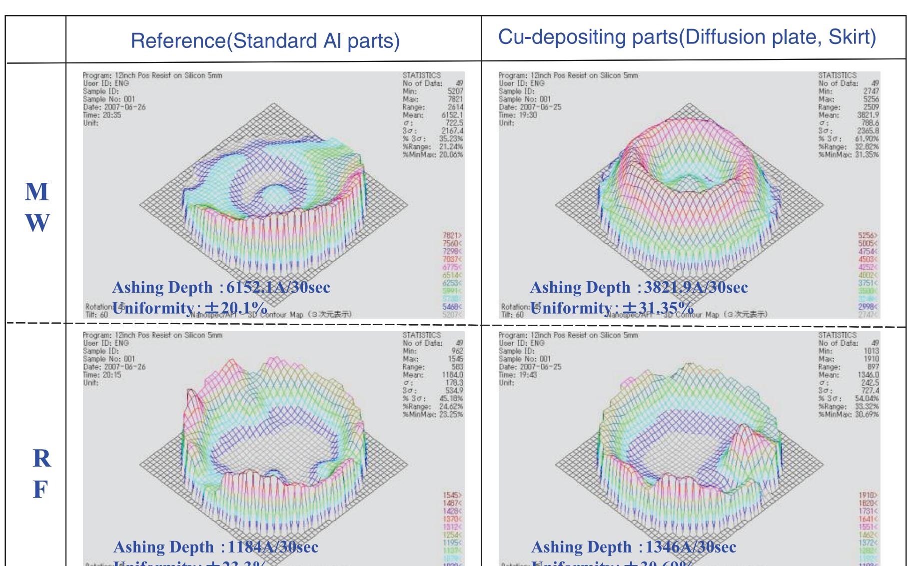

Figure 8 Influences of MW and RF on Ashing Rate with Al Parts and Cu-depositing Parts (3D Maps)

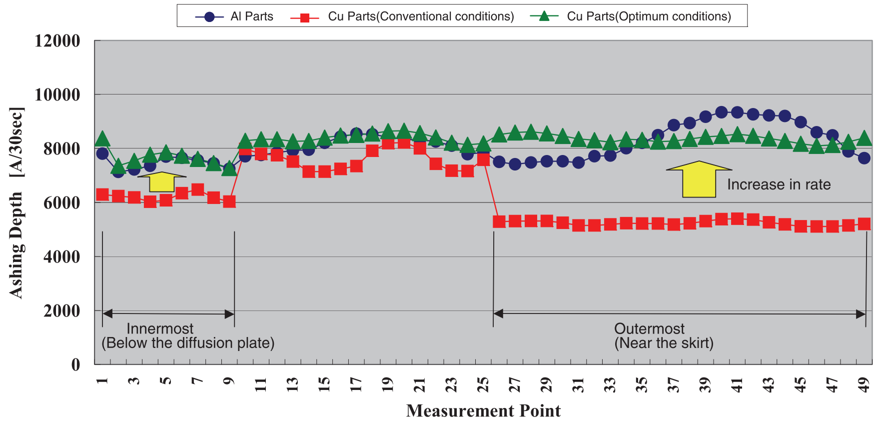

Figure 9 Optimization of Conditions with Cu Parts

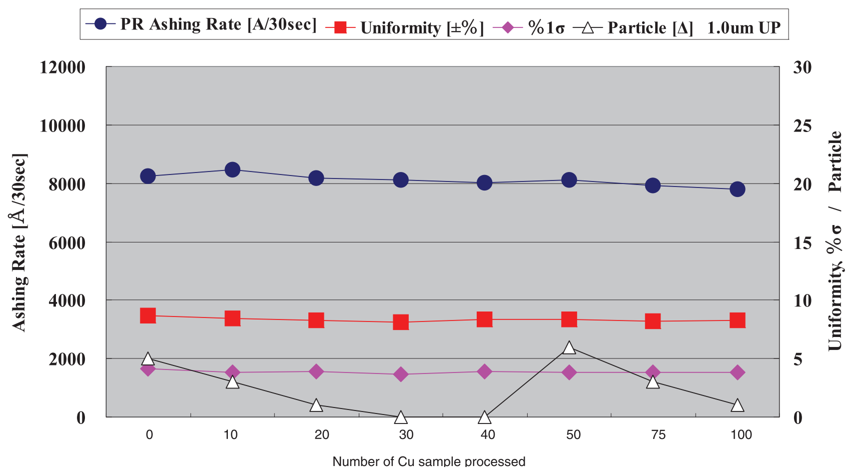

Figure 10 Stability of Ashing Rate with Cu Parts

by equipping the chamber with internal parts made of Cu and optimizing the processing conditions, in Figure 10, the ashing rate showed almost no deterioration even after processing 100 samples fully covered with Cu. This demonstrated the stability of the process.

4. Conclusion

We developed a technology to steadily process products with exposed metals on substrates in ashing processes in packaging processes without degrading the ashing rate. We will continue to develop ashing technologies for packaging processes from the aspects of hardware and processing in order to further improve process stability.

References

1) September 2008 NIKKEI MICRODEVICES, P71-76.