OPTIMIZATION OF ELECTROPLATING PROCESSES FOR COPPER BUMPS

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Abstract

Ramping up a given semi-conductor process is always a challenge. Lessons learned from pilot lots help in lowering potential risks that may occur during high volume production process, but some fine tuning is still needed to make the production process robust. This paper aims to describe the optimization performed to achieve a robust semiconductor manufacturing process for electroplating Copper Bumps on gallium arsenide and silicon wafers.

INTRODUCTION

In 2011, the TriQuint Oregon and Texas facilities started making Cu Bumps using a laminated resist based photolithography process. Copper is first electroplated on a negative resist followed by tin. Cu Bumps are placed on a variety of mask sets. Open areas of these mask sets range from 3 to 20 %. As the developed process was ramped up, variability in the process was exposed, resulting in non-uniformity of the plated bumps. Certain areas of wafers were found to have taller bumps than target bump heights while other areas had shorter or missing bumps. Other issues found while ramping volume included: Copper and tin dendrites, Oxidized tin on Cu Bumps, and Tin voids after reflow during packaging.

Resolving these challenges and locking down the electroplating processes for Cu Bumps using the new laminated photoresist based process required an integrated approach of controlling three process inputs. These inputs were Plating bath solution stability, Hardware configuration, and Operations procedures (Figure 1). Finally, a new metrology tool was put in place to provide 100% die level inspection in order to provide capability for investigating further process improvements.

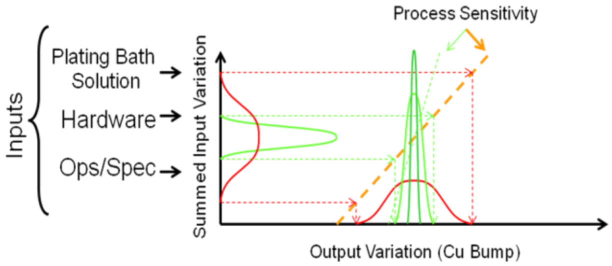

Figure 1. Controlling Input to Electroplating Processes

PLATING BATH SOLUTIONS

Initially, the electroplating sink used for depositing copper and tin was configured such that a tin plating tank was beside copper plating tanks (Figure 2). In this way, a direct copper-tin process could be carried out. However, it was found that by having a configuration like in Figure 2 cross contamination of chemistry between tanks could lead to poor quality of bumps. Thus, the two plating chemistries were segregated.

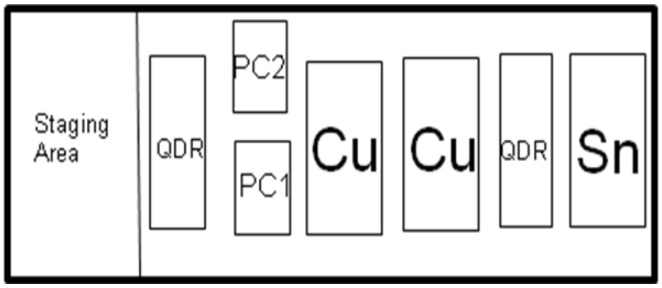

Figure 2. Plating Sink Configuration.

Once cross contamination had been prevented, the concentrations of components in the plating bath solution were optimized and tightly controlled. This was achieved by:

- establishing a reliable chemical monitoring system;

- re-targeting concentrations of components in tin plating chemistry based on DOE's that analyzed all of the failure modes mentioned previously as outputs;
- tightening control limits for concentrations of components in plating bath solution;
- proper conditioning of plating chemistry (Figure 3).

(**Figure 3:** YIELD FIGURE TO BE ADDED HERE – WILL SHOW SPECIFIC IMPROVEMENTS TO TIN VOIDS, BUMP UNIFORMITY, AND DENDRITE REDUCTION)

HARDWARE

The plating bath sinks were modified to help control the plating chemistries (Figure 4). Preventive Maintenance was revised to reduce intervention to the plating bath solutions to help further control chemistry consistency.

(**Figure 4:** AN IMAGE WILL BE ADDED HERE SHOWING MODS TO PLATING BENCH)

OPERATIONS

Specifications were revised to reflect changes and Operators were re-trained to explain the importance of the changes made to the process. Critical procedures were put on video so that operators can review the procedure in action. The videos are now included in the specification and are revision controlled.

METROLOGY.

A 3-D Automated Optical Inspection was introduced to perform 100% inspection of die on the wafer. This provides rapid feedback for any new issues or changes to tools/processes as well as helping to make additional improvements.

CONCLUSION

Through a tight chemical monitoring of the plating bath solution and sufficient conditioning of chemistry, variability in the electroplating processes of copper and tin on Cu Bumps is reduced. Quality on Cu Bumps has been achieved and maintained at high production volumes.