DEVELOPMENT OF A DOUBLE LAYER SPRAY/SPIN COAT PROCESS FOR IMPROVING COAT UNIFORMITY OF AN 80 MICRON COAT PROCESS

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Abstract:

To achieve an 80µ coat thickness with a photo definable epoxy it has been necessary to do a double layer coat. The original process was set up to use a spin coat - post coat bake sequence followed by another spin coat - post coat bake sequence to obtain the target resist thickness. The main problem with this process is uniformity control. To improve uniformity control a process flow using a spray coat – post coat bake sequence followed by a spin coat – post coat bake sequence was developed.

INTRODUCTION

As part of a wafer level packaging process, a process by which cavities with walls of photo definable epoxy are created that are approximately 30µ wide and 80µ tall. In order to produce these walls it is first necessary to coat the wafers at the target thickness with good uniformity.

Good uniformity is necessary for several reasons. These include having consistent height so that the bonding operation has enough room to work properly and the ability to print the pattern using a proximity print method without having areas where the mask contacts the surface of the epoxy and causes defects.

The original coat process that was developed consisted of a spin coat – post coat bake sequence to coat an initial ~40µ of the epoxy followed by another spin coat – post coat bake sequence to coat an additional ~40µ of epoxy for a total final coat thickness of ~80µ. This process was performed on an EVG150 coater using IDI high viscosity pumps and in a closed bowl environment. The average uniformity achieved with this process was approximately ±7%. The major forms of non-uniformity in this process are a thick area in the center of the wafer and a thick edge bead.

The thick area in the center is a result of dispensing directly in the center of the wafer with a very viscous material (~13,000 cSt). The material dries fairly rapidly even in a closed bowl environment and requires a relatively slow spread spin speed. In addition, the material tends to build up at the edge of the wafer and even migrate toward these build ups during the post coat bake process.

Initially, it was planned to go to a spray coat process to build the entire 80µ thickness. Typically, spray coating has an almost non-existent edge bead. However because this process required a wet coat to achieve planarity, it was discovered that an edge bead would still form despite the very slow spin speed used. This is most likely due to the thickness of the coat. It was decided at that point to attempt to achieve better uniformity using a combination of spray and spin coat processes.

This paper will discuss the equipment and methodology used for developing this process and the results measured in the ability of the new process to produce better coat uniformity on a wafer.

EQUIPMENT

The equipment used for this process development was EVG150 coater/developer systems. The EVG150 utilizes an ultrasonic nozzle fed by an IDI low flow pump for spray coating and a tube nozzle fed buy an IDI high viscosity pump for spin coating.

The system has “closed bowl” capability so that during the spin out operations a lid can be lowered to seal the bowl and create a solvent rich environment. No top side dispenses can be performed with the bowl closed.

METHODOLOGY

Initial tests were performed at the EVG facility in Tempe.

Standard photo definable epoxy was hand diluted using a mixture low and medium vapor pressure solvents. The diluted mixture was dispensed using an automated dispense system to feed the ultrasonic nozzle. This was used to spray coat the first layer for the ~80µ total stack. A shortened Post Coat Bake (PCB) process using a single hotplate was utilized. The spin coat process uses a multi-stage bake and multiple hotplates.

Two wafers with the first layer spray coat were sent back to TriQuint Texas and the second spin coat was successfully applied. At this point, all testing was moved to the TriQuint Texas facility.

Further testing done at TriQuint was performed on an EVG150 system with two coat bowls. The first coat using the spray process was done in one bowl, the PCB for this was done, and then the spin coat and edge bead removal was done in the second bowl followed by its associated PCBs. Factory diluted samples of the photo definable epoxy were obtained for the spray coating. This insured consistency in dilution and more closely mimicked a production situation.

Initially the spray coat by itself was tested. Once satisfactory results (<10% uniformity) were achieved with the spray coat, the combined spray/spin coat process was tested. It is important to note that the second spin coat improved the uniformity of the overall final coat.

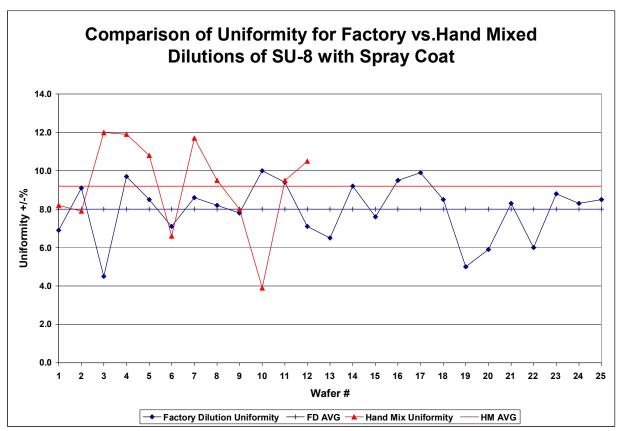
During our testing the sample of diluted material from the supplier ran out during the tests and tests were also conducted on material hand diluted at TriQuint. The process was split into two to enable the ability to test the spray coat by itself and then test the combined process of spray and spin together.

As a general practice, 12 to 25 wafers were coated for each test and the mean thickness and average uniformity were calculated for comparative purposes. It was discovered that with the hand diluted material issues in the wafer to wafer uniformity would be seen on the 5th or 6th wafers in a lot. Larger lots of 12 to 15 wafers per test insured true consistency was being tested.

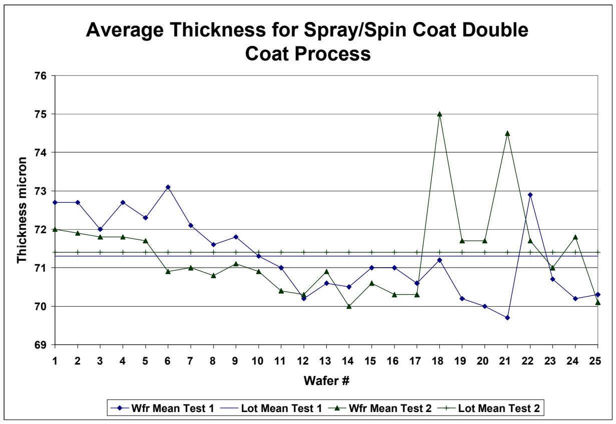
RESULTS

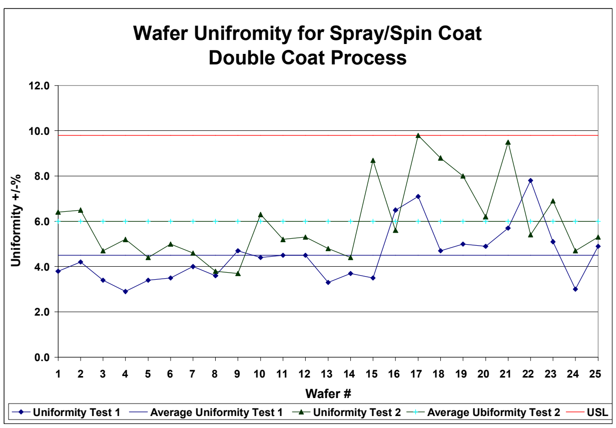
For the initial spray coat tests performed at EVG, final thickness for the spray coat was 30 to 35µ with an average uniformity of ±10%. Due to the issues with the nozzles, only two wafers with acceptable first coats were produced These two wafers were shipped to TriQuint and had the spin coat applied at the TriQuint Texas facility, a total stack thickness of 70µ was achieved with an average uniformity of ±7.8%. A baseline test processed at the same time using the double spin coat process produced a thickness of 79µ with an average uniformity of 6.3%. A characteristic double hump center defect which was observed on the double spin coat processes was eliminated on the spray/spin coat wafers but the edge bead was worse. It was decided to continue testing. Eventually it was decided that in order to improve the edge bead, an edge bead removal would be performed before the second, spin coat.

When the factory diluted sample of the material for spray coating was used, an improvement in coat uniformity of the first coat was obtained. The average uniformity went from the ±10.0% seen at EVG with hand mixed material to ±8.0%. The mean thickness was ~35µ with the center at 33µ. When hand mixed material was tested at TriQuint, the average uniformity went to ±9.2%. The mean thickness with the hand mixed material dropped to ~32µ and the center was now ~35µ.



The current process for double spin coating is specified at 77.4 ± 4.8µ for the average wafer thickness and uniformity less than or equal to ± 9.8%. The average thickness is averaging 76.7µ and the uniformity is averaging ± 5.4% with the current process. The following charts show the average resist thickness per wafer and the uniformity per wafer for two tests processed using the spin coat/spray coat double coat process.





For the two tests, the overall average resist thickness was 71.4 µ and the overall average uniformity was ±5.3 %. The average uniformity for Test 1 was ±4.5 % and Test 2 was ±6.0 %.

At this point testing was halted due to other priorities in the fab.

CONCLUSIONS

Uniformity for the double layer spray/spin coat process is as good as and perhaps better than that achieved with the double layer spin/spin process. It is believed with some minor adjustments the uniformity will be consistently better.

Average resist thickness achieved with the spray/spin process was below the lower limit for the spin/spin process; however, it is believed that this value can be increased to meet the specification requirements with some minor process tweaks.

There is a large potential for cost savings by using resist diluted in house; however, a more robust mixing process is needed to insure consistency of the material. The ability of the hand mixed resist to meet the uniformity requirements will likely depend on this.

A noted problem is with how the spray process contaminates the coater system. The aerosol mist settles below the coater cup in the bottom of the system. This is an issue that will have to be addressed if this process is to be put into production.

The potential benefits of the double layer spray/spin coat process warrant further investigation as time and priorities permit.

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