Perfecting Chucks: Wafer Backside Particle Reduction

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Abstract

Yield enhancement is the most important success factor in IC manufacturing. Backside contamination (BSC) of wafers is a big problem, because it may impact the wafer flatness which may lead to yield loss. The importance of unwanted impurities even increases with continued device miniaturization.

Almost all processes in a wafer fab can cause backside contamination. One source for backside contamination of the wafer is the wafer chuck. Its purpose is to fix the wafer, to straighten it, to keep it at a certain temperature, and to release it quickly without damaging the substrate or causing contamination.

Therefore, it was the aim to create a wafer chuck that reduces wafer backside particle contamination. The chucks developed and manufactured by Berliner Glas already have been made as resistant as possible to particle contamination by using a special pin or mesa design. The contact area between the wafer and the chuck has been reduced down to 0.1%. Now, we identified ways to further reduce the backside contamination by altering the properties of the pins. Tests were designed to measure the impact of different pin designs.

Introduction: Backside contamination and the wafer chuck

The wafer chuck has a very difficult and important task to accomplish. It has to hold a wafer flat to extremely tight tolerances. Chucks – electrostatic or vacuum chucks – are used in various areas of the semiconductor industry: in lithographic processes, inspection steps, coating, 3D integration, wafer handling, and during etch processes.

Particles that will attach to the backside of a wafer will result in an unacceptable wafer surface flatness. This will even worsen from processing step to processing step resulting in wafer defects and yield loss.

The International Technology Roadmap for Semiconductors (ITRS) provides guidelines for upper limits of the size and amount of allowable backside wafer particles in lithography and measurement tools. For the years 2013 to 2028 as one criterion backside particles should not exceed 200 particles per wafer with a maximum size of 0.1 µm.

Recently Berliner Glas Group improved the flatness of chucks using a special pin pattern. This time trying to reduce backside contamination, the pins on a SiSiC vacuum chuck have been manufactured with different methods. Three test chucks with different production plans were made. Several tests were performed to investigate the behavior of the different pin properties in terms of added particle. Measurements were taken before and after the different manufacturing methods of the pins. The results are published in this paper.

Test Parts

Three 300 mm vacuum chucks made of SiSiC with different production plans have been used. All pins had a diameter of 400 µm. The pin pitch was 5 mm each. After every processing step of the chuck the backside contamination (BSC) of the wafer has been measured. Therefore Berliner Glas has developed different pin features. The three different methods presented below can be combined.

The pins can have two different qualities in SiSiC: Standard and Advanced (see figure 1). The standard pins were manufactured traditionally using CNC machining.

The advanced pins were produced by using a new innovative proprietary technology (patent pending).

Figure 1: Different pin qualities: left standard pin, right advanced pin. In both cases, the pin diameter is 400 µm.

Berliner Glas also has the ability to round the pin edge (figure 2). Additionally the pins can be coated to with a non-conductive coating.

Figure 2: Left standard pins, right rounded pins. In both cases, the pin diameter is 400 µm.

Test Setup

For testing the chucks and avoiding the influence of manual handling a pneumatic system with three lift pins were used. To get stable results the chuck had to run through a comprehensive cleaning program consisting of the following sequence: ultrasonic cleaning – fine cleaning – acetone, fine cleaning. All cleaning steps were realized in clean room condition class 5.

The completely cleaned chuck was installed on the test setup where a second cleaning procedure was performed: Two wafers were chucked ten times with a rotation. The cleaning wafer was rotated in between the chucking steps.

Test Sequence

The three above described test parts were used for experiments. For each experiment ten wafers were chucked with 230 mbar by test part 1, test part 2 and test part 3.
The measurements of the backside contamination of the wafers were performed using a KLA Tencor Surfscan SP1 system (figure 3). The results were determined as the average of at least six wafers.

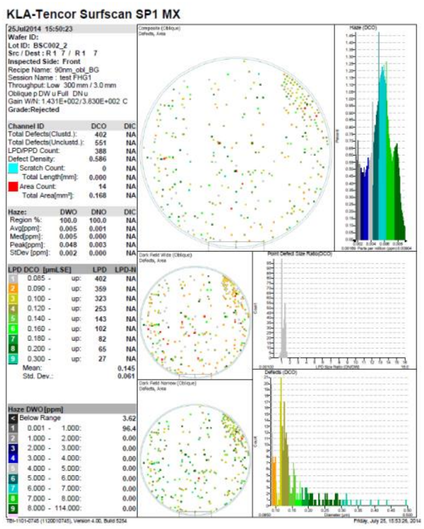

Figure 3: Test report example

Results

The results of the first experiment are shown in figure 4. The target specification – 200 particles per wafer, particle size 0.1 µm – could not be met by the vacuum chucks, neither with the standard pins nor with the standard rounded pins. The standard rounded and coated pins achieved outstanding results: less than 100 particles with a diameter of 0.1 µm.

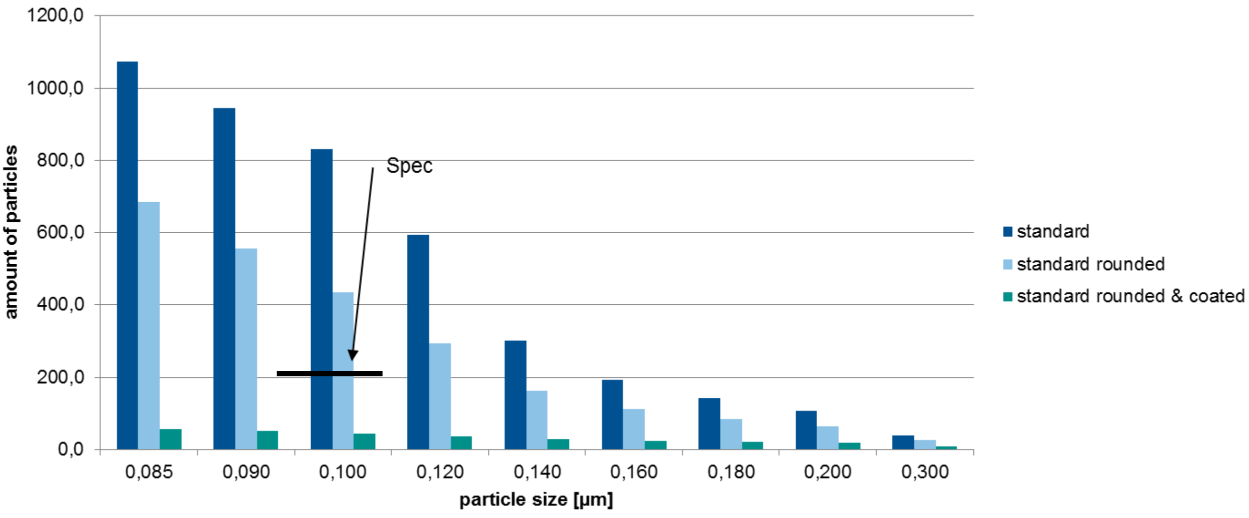

Figure 4: Test results of test part 1: standard, standard rounded, standard rounded & coated pins

The test with test part 2, which had advanced pins, advanced rounded and coated advanced rounded pins, showed similar results: Even though the backside contamination was reduced at large, only the coated advanced pins met the success criteria (see figure 5).

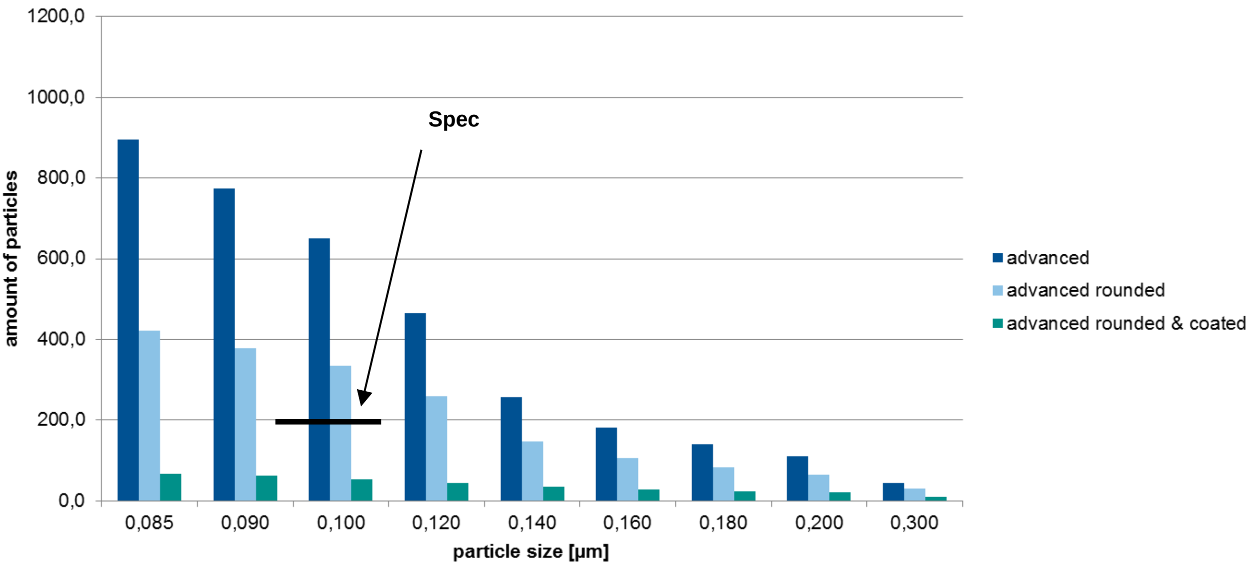

Figure 5: Test results of test part 2: advanced, advanced rounded, advanced rounded & coated pins

In the last test advanced pins were used. The second processing step was removed and the pins were coated without being rounded before. Test results were the same as of the proceeding tests: The advanced pins did not reach the target specification; the coated pins did (figure 6).

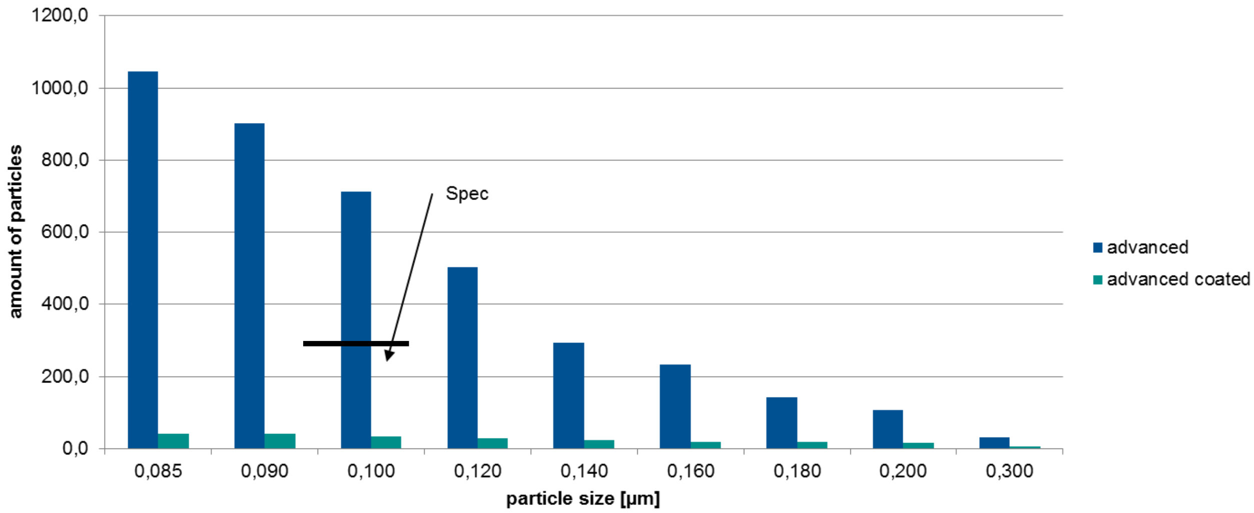

Figure 6: Test results of test part 3: advanced pins and advanced pins that were coated

Conclusion

Different pin features were employed to investigate the impact of these properties on backside contamination of wafers.

Tests showed that advanced pins produce fewer particles than standard pins. Round edges decrease the amount of particles independent from the production type of the pins. Coating decreases the amount of particles significantly independent from the preprocessing.

In summary, the trend is evident. The presented new pin designs reduce the wafer backside particles. Berliner Glas is able to design and produce wafer chucks that meet and exceed the guidelines of the International Technology Roadmap for Semiconductors (ITRS).

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