CONTOUR MOVE – EDGE COATING AND EDGE STRIPPING OF WAFER FLATS

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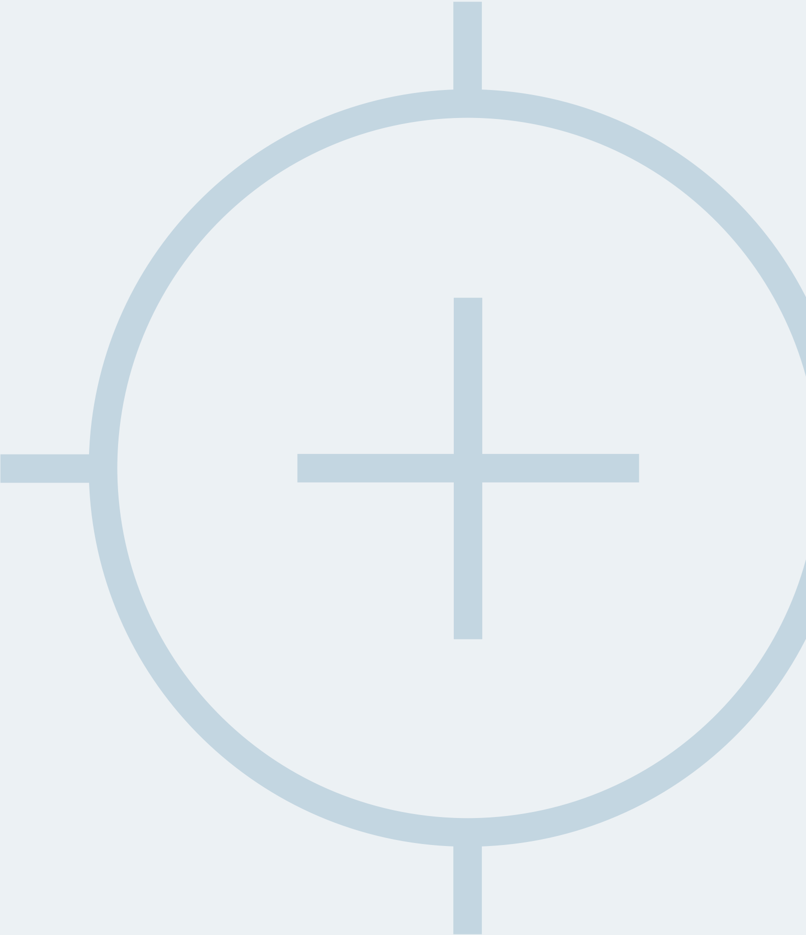

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Common issues when processing 150 mm and smaller wafer sizes for the semiconductor and especially MEMS market are arising from the wafer flat(s). Today's demand for maximizing the used area on a wafer requires a technique to perform an edge bead removal (EBR) not only at the round areas of a wafer but also on the wafer flat. In MEMS processes often a technology is required to protect the wafer edge against etching agents – this is where edge coating comes into play, that also needs to be applied not only at the round areas on the wafer, but also on the straight edge of the wafer flat. SUSS MicroTec's "Contour Move" option addresses these challenges and has gained considerable demand in the MEMS and optical components market. Its potential is growing as it offers a solution to many fabrication problems.

WAFER FLATS AND THEIR CHALLENGES

Wafers of 150 mm in diameter and below have a flat instead of a round edge. When a wafer is spin coated, the resist on the substrate builds up at the edge, at the round part as well as on the flat. This is what we call the edge bead. It has many disadvantages:

1) It can contaminate chrome masks during exposure
2) It prevents clamping of the wafer during subsequent electroplating
3) It can increase developing time,
4) It prevents good contact between mask and wafer
5) It sometimes causes wafers to break during subsequent processes

Traditionally the edge bead is removed by a stream of solvent directed at the wafer edge, while the wafer is rotating. The nozzle applying the solvent is fixed in its position, which does not change during the process. Thereby the stream can remove all the excess resist at the edge, but not at the flat. The flat still remains covered by the edge bead.

EDGE BEAD REMOVAL (EBR) AT THE WAFER FLAT

In currently used approaches, the wafer remains static and does not rotate. The nozzle sweeps over the wafer flat using a linear motion. This linear motion arises some drawbacks. The first disadvantage of a static non-rotating wafer is the lack of centrifugal forces. Thereby the solvent creeps away from the edge, preventing a clean coating. This problem can be mitigated by applying an additional air stream, but the air stream is not applicable with all resists and it can even cause more edge bead build-up and extreme contamination of the process bowl. In addition, special hardware is often required and the process cannot be performed in a standard coater module.

FLAT EBR WITH CONTOUR MOVE

With the contour move option, the wafer is not static during the flat EBR process. It keeps rotating like during a standard EBR process. In addition, the standard EBR nozzle is used for the special procedure. At the point where the flat starts passing the EBR nozzle, the arm moves towards the wafer center while the nozzle is dispensing, as seen in Figure 1. This inwards movement is carried out until the nozzle hits the center of the flat. Consequently, the arm changes the moving direction and starts moving outwards to its starting position. Because the EBR nozzle position follows the flat, the complete edge can be stripped, while the wafer is rotating.

Timing, dispense arm acceleration and positioning as well as spin speed parameters must be under close control to achieve the presented results. The first challenge is performing a dispense arm movement at the right point in time;

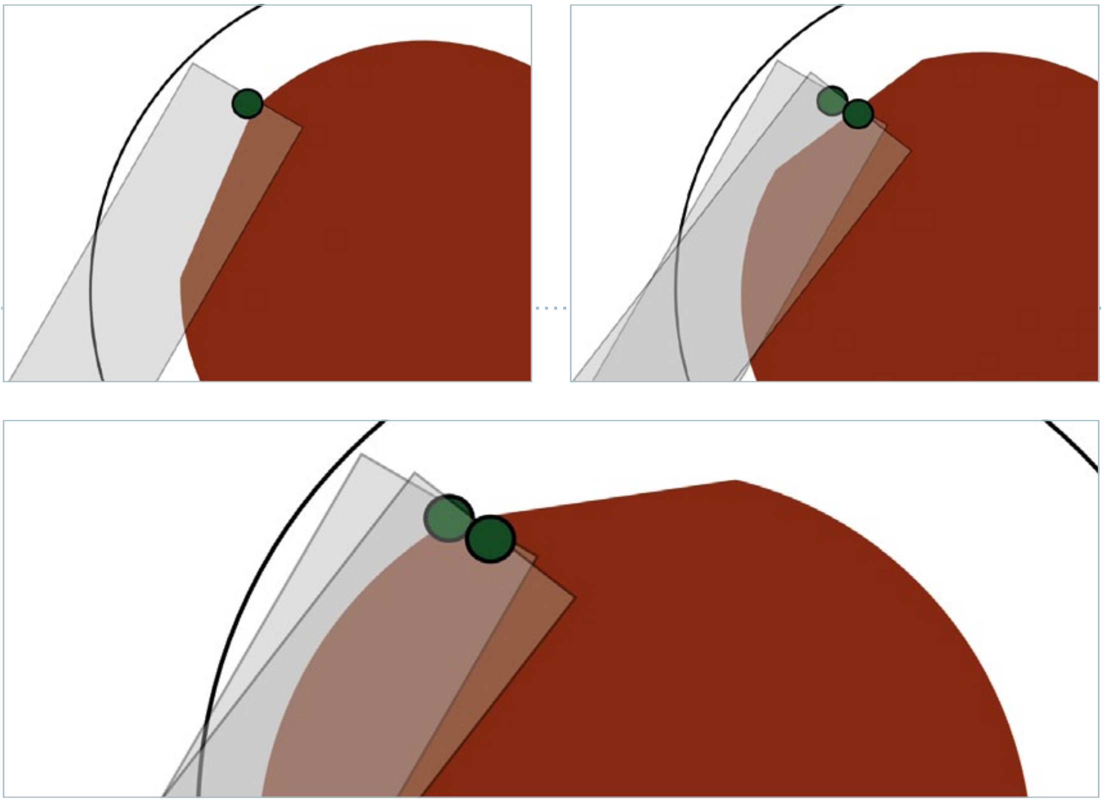

Figure 1 *Demonstration of the working method of the contour move; first the wafer is rotated until it reaches the point of impact of the solvent stream. At that moment the arm swings towards the center of the wafer. When the point of impact reaches the center of the flat, the arm swings back to the initial position*

especially when the wafer is rotating at high speed. As mentioned the high rotation speed is necessary in order to utilize the centrifugal forces and prevent solvent from creeping into the resist. This means the movement of the arm has to be quick and accurate enough to perform the desired task. However, the time the EBR nozzle is at the wafer flat is minimal as it is inverse, proportional to spin speed, as illustrated in Figure 2. Meaning, with higher rpm the timing of the arm movements becomes critical. For example: for a spin speed of 10 rpm, 100 rpm and 1000 rpm the complete inwards/outwards movement must be carried out within 0.787 s, 0.0787 s and 0.00787 s respectively. Hardware and controller software were optimized for this task.

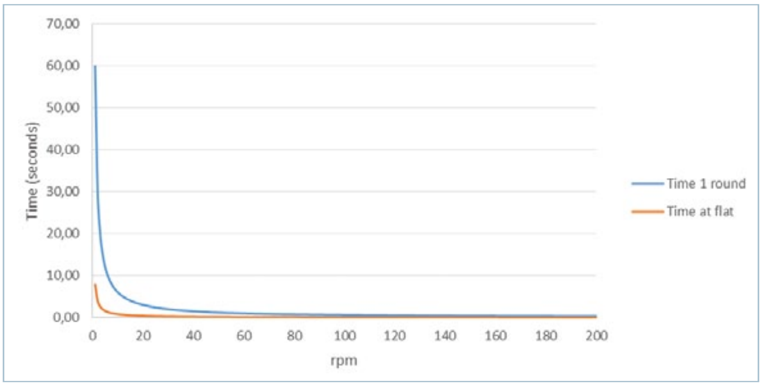

Figure 2 *Time required for one round of the wafer (blue line) and time required for the flat (orange line) over the spin speed. The diagram illustrates the short times available to perform the edge bead removal at the wafer flat*

Another challenge that arises with high spin speed is the timing. With increasing the spin speed, it is critical to start the arm movement at the right point in time. Meeting the exact time to start the inward/outward movement becomes critical. A millisecond lag in time can result in (or lead into) a huge difference in the performance of the system.

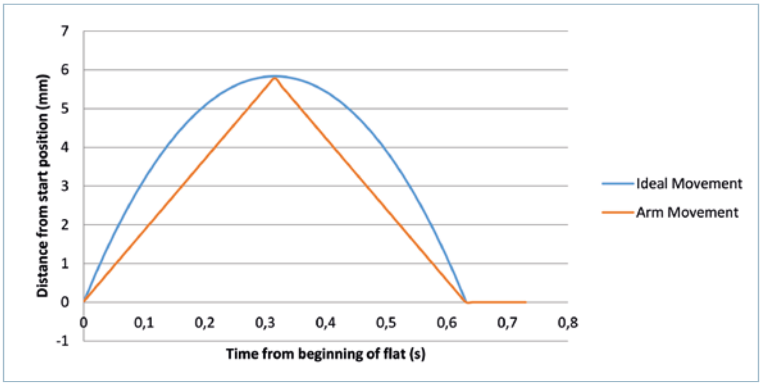

Figure 3 *Typical arm movement (orange line) and ideal movement to ensure parallelism (blue line)*

The main challenge is getting a parallel movement of the EBR nozzle relatively to the wafer flat. The arm is mounted to a stepper motor, which commonly performs the motion profile linearly: it accelerates to the desired speed, keeps the speed, brakes and accelerates into the opposite direction, as illustrated in Figure 3 (orange line). In order to be parallel to the flat the arm needs to do a circular motion as also shown in Figure 3 (blue line). The linear motion of the motor is far different than the ideal movement, which the arm has to take. Thereby the arms speed profile is tweaked in order to ensure the parallel movement to the wafer flat.

RESULTS

The contour move feature ensures good repeatability and accuracy at high speed. The EBR profile can be adjusted to several flat sizes, from 3 inch to 150 mm wafers. Within a wafer, the deviation of the values can reach down to 400 µm. As for process capability and repeatability, Figure 4 shows results of 240 measurement points. All data values are within 1 mm. These results meet and exceed the requirements of several applications in the field and have proven good performance. Figure 5 shows adge bead removal at the flat with a width below 2 mm.

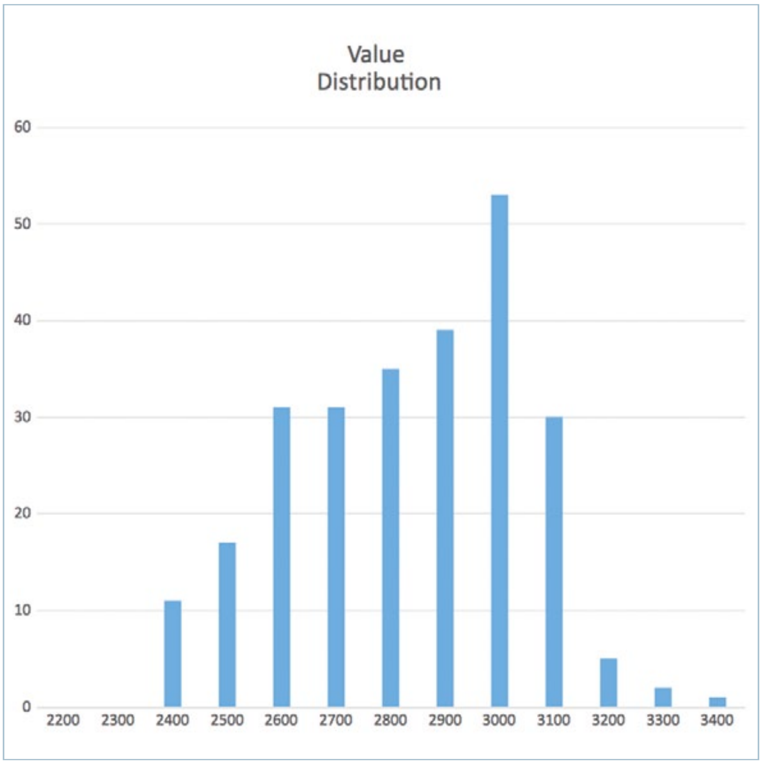

Figure 4 *Histogram showing the repeatability of the system over 240 measurement points*

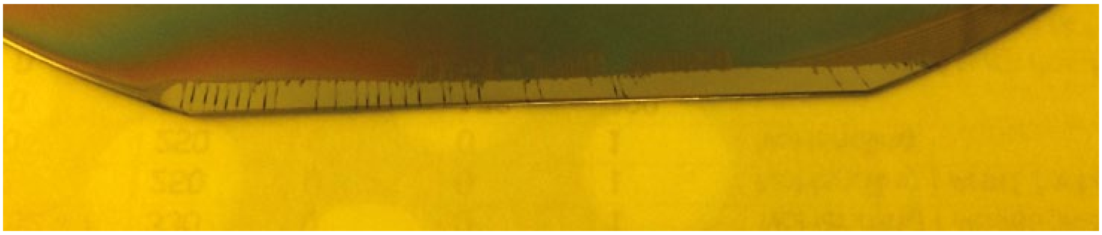

Figure 5 Edge bead removal at the wafer flat for a resist with 5 µm thickness

EDGE COATING WITH CONTOUR MOVE

The contour move system is designed to follow the wafer flat. It is not only capable to remove resist from the flat, it can also cover the flat of the wafer with a protection layer. This is desired when deep etching is performed to the wafer. The deep etching could attack the edges, which in turn has consequences to subsequent processes. The two modes, edge removal and coating, can be integrated easily in one module and can be used consequently without any mechanical change over. The edge coating is slightly different from edge stripping. The thickness of the resist is determined by the flow of the resist and the spin speed. For edge coating, the dispense method is crucial in achieving the same coating width throughout the wafer flat, as seen in Figure 6. A standard deviation of only 0.16 mm over a lot of 25 wafers was achieved. The results are shown in Figure 7.

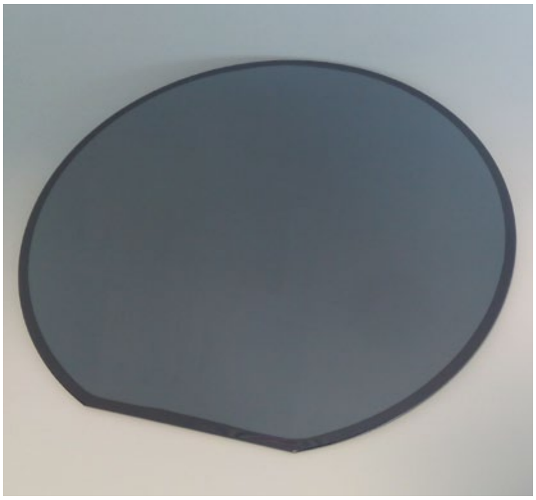

Figure 6 Wafer coated with a protection layer using contour move

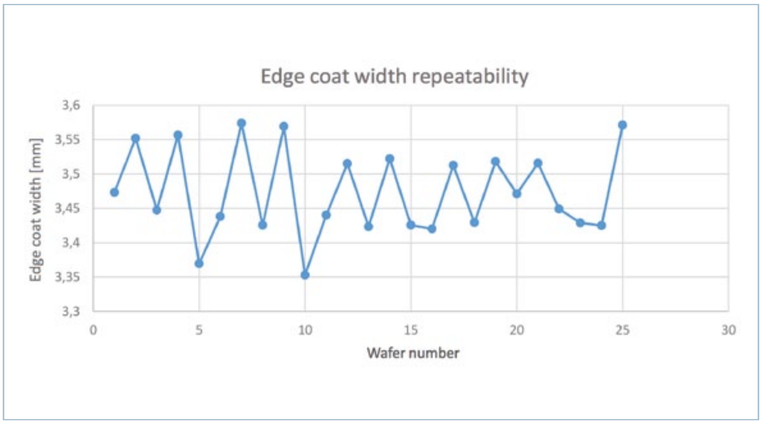

Figure 7 Edge coat width repeatability over a lot of 25 wafers. The standard deviation is 0.16 mm

BACK SIDE COATING WITH CONTOUR MOVE

Coating the edge with conventional methods is often not enough as a protection against e.g. etching agents. The edge is rounded and the coating only covers the top part. The backside of the edge remains uncovered and unprotected. Therefore a method was developed that can perform an edge coat at the backside of the wafer, including the flat, without the need of flipping the wafer. Results can be seen in Figure 8 and Figure 9.

CONCLUSION

Contour move is a versatile method that can perform edge stripping, as well as top- and backside edge coating. The reproducibility of the system lies within a 3 sigma of 1.5 mm for edge stripping and 1 mm for edge coating. Further improvements are expected over time as the technology is continuously optimizing for higher accuracy and repeatability.

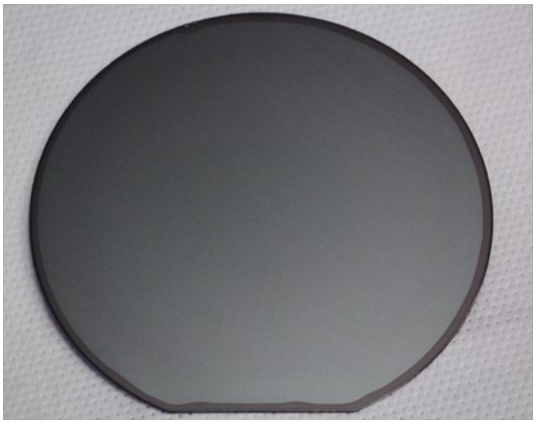

Figure 8 *Backside of a wafer with edge coated without flipping the wafer*

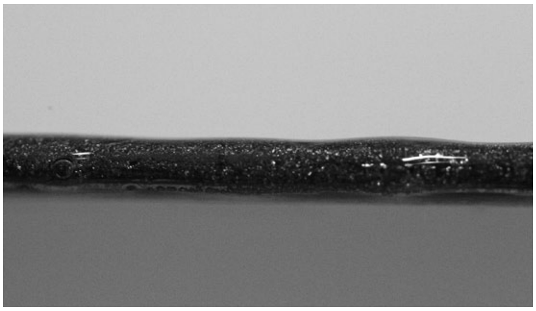

Figure 9 *Side view of a wafer edge coated on top and backside to ensure complete coverage of the edge curve*

Dr. Omar Fakhr graduated in 2006 from the Technische Universität München in Electrical Engineering with focus on semiconductor device fabrication and nanotechnology. At the age of 28 he earned his PhD degree, where he designed and tested new methods for the fabrication of nanometer sized structures. He joined SUSS MicroTec in 2011 as an application engineer for spin coating systems. During that time he has installed numerous machines at customers worldwide and conducted joined research with renowned institutes. Since 2014 he is an application scientist responsible for spin coating, nanoimprinting and laser imaging systems.