Debris Reduction in GaAs Wafer Dicing Process

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Abstract
Lots of debris is usually generated during the GaAs wafer dicing process leading to chip defects and scum on the chip and ultimately, low wafer yield. In this study we combine the cutting fluid with an appropriate water pressure to make the GaAs debris easy to be carried away from the chip surface. Furthermore, we increase the DI water cleaning time after a sawing process to ensure the chip cleanness. An oxygen plasma process after DI water cleaning is also implemented to further clean any remaining amount of debris from GaAs chips. The wafer re-work rates are significantly reduced from 60–70% to 1–3%, resulting in high wafer yield and shortened backend processing time.

Introduction
Wafer dicing is a very important step in the backend wafer process because at this stage the wafer is almost completed and is ready for delivery. The stability of a dicing process not only directly impacts the line yields, also affects the wafer turnaround time.

Experiments
In this study, we analyzed the debris remaining on the wafer with EDX technique and concluded that the debris consists of GaAs particles coming from the sawing process. The EDX analytical data are shown in figure 1.

Most sawing debris can be carried away by DI water during the dicing process but a small amount of GaAs particles still adhere to the dicing street or on the chip. Therefore, in our initial experimental plan in order to avoid the GaAs debris remaining on the chips we tried to coat a thin film on the wafer which later can easily be removed by warm DI water after dicing. Typical wafer cross-section with a coating thin film is shown in figure 2.

Water solvable wax was the first material we chose for the experiments since its powder can be dissolved in 80°C DI water and the wax can be coated on the wafer and then is washed away with warm DI water. During the experiments we found out that the wax was solidified too quickly during the film coating, causing the thickness uniformity of wax to become an issue as shown in figure 3. This will make aligning the chip with a sawing tool unfeasible. During the sawing process due to the high pressure of DI water applied, the coating wax can be washed away within 10 minutes.
thereby removing the film protection for the wafers we originally expected.

Figure 3. Wax coated on wafer surface

From the first experiment we concluded that in order to fulfill what we expected, the coating film needs to (1) have enough thickness uniformity after coating, (2) have sufficient water resistance during the dicing, and (3) be easily removed with warm DI water afterwards. Therefore, we identified a different kind of PVA that can meet the above-mentioned characteristics. This new material can be dissolved in 80°C water and uniformly coat on the wafer at room temperature. But after dicing we found out that this new PVA cannot 100% be removed even at 70°C warm water as shown in figure 4.

Figure 4. A new PVA material cannot be removed by DI water.

We also tried to use a specific photoresist as the coating film and the results are shown in figure 5 and figure 6. Figure 5 shows that GaAs debris adhered to the coating film and with a proper developer we are able to remove it with debris completely as shown in figure 6.

Figure 5. The debris was adhered to the protect film.

So far the photoresist is the best candidate for achieving our purpose. But we also found out that the resist would spread to the cutting tape during the coating and lead to glue erosion of the sawing tape, making it still not a perfect choice.

After evaluating many different kinds of materials we concluded that it was difficult to find a proper material to meet our requirements at this moment and we tried to concentrate on what we could do with the sawing tool itself. According to our experience the water flow conditions during the sawing process affect the debris adherence to
chips significantly. Mixing a proper cutting fluid with DI water may become a feasible solution.

The right mixture of a cutting fluid with DI water becomes our next important theme because the cutting fluid has (1) to reduce the surface tension of water, (2) to decrease ESD values during dicing, and (3) to lower the thermal effects of a sawing blade and allow the GaAs debris to be easily carried away from the chip surface as shown in figure 7.

Figure 7. The function of a cutting fluid.

Results and discussions

With a controllable diaphragm pump the right mixture of a cutting fluid and DI water is injected into the dicing tool and the equation is set as follows:

\[
\text{(counts}/360 \text{)} \times 38 \text{ cc/min} \times 1 \text{ (100%)} = \text{flow rate per minute}
\]

In terms of the proper pump operation the mixture can uniformly spread to every GaAs chip during the dicing process to avoid the debris adherence to the chips. The excellent results are shown in figure 8.

We also found out that increasing the water pressure during the sawing process and extending the DI water clean time after sawing would give better wafer cleanness. Generally, the DI clean time after sawing is 1 to 2 minutes and 90 to 95% of debris or foreign materials can be removed from the wafer surface. If we increase the clean time to 3 to 5 minutes, then the yield can improve 2 to 3% more as shown in figure 9.

Figure 9. Comparing with different DI cleaning time after sawing.
Utilizing the cutting fluid, increasing the DI water pressure during the sawing, and augmenting the water clean time after sawing as reported previously, the wafer rework rates are dropped from 60 to 70% to 10 to 15%. Furthermore, we also figured out that oxygen plasma can effectively remove the remained debris on chips as shown in figure 10.

![Figure 10. Wafer was cleaned by oxygen plasma.](image)

After we implemented all the necessary clean techniques we have developed at Win, the wafer rework rates in the existing manufacturing line have now dropped to 1 to 3% in comparison with the original 60 to 70% rework rate as shown in figure 11.

![Figure 11.](image)

**Conclusions**

Debris or foreign materials remaining on GaAs chips after the dicing process is always a very critical issue in a GaAs manufacturing line, since the chip cleanliness directly impacts the final line yield. By implementing (1) the cutting fluid, (2) increasing the water pressure during the dicing, (3) augmenting the DI water clean time after dicing, and (4) an oxygen plasma process in the existing manufacturing line, the GaAs debris removal issue is solved in Win’s dicing process. We will continue to monitor and improve our dicing process for reaching a higher yield.