Strength Improvement for the GaAs Thin Wafer

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Abstract

In recent years, the pursuit of improving the wafer strength after thinning step has been an on going issue for the Gallium Arsenide (GaAs) wafer manufacturing. The improvement of wafer strength will significantly decrease the wafer breakage during demounting and cleaning. It is very critical to optimize the thinning process to minimize the mechanical stress sources. One obvious way to improve the strength of thin GaAs wafers is to apply a wet etching step after wafer grinding to remove the surface damage. This paper will discuss the improvement in wafer thinning and polishing processes developed at the Skyworks facilities.

Introduction

The grinding process gives the best flatness in the wafer thinning operation [1], but also introduces a lot of micro cracks, which give rise to mechanical stress in the wafers. The purpose of wet etching or polishing is to remove the residual surface damage of the grinding process. In the past, we have learned that high percent breakage at wafer demount step had been directly related to mechanical stress and the wet etched wafer had lower yield than the polished wafer. However, this paper will show that wafer strength is directly related to the surface roughness and the polishing method had more significant impact on the wafer strength improvement than the wet etching method.

Experimental

The study was done on the four-inch<100> GaAs wafers. The wafers were measured so that the total thickness variations (TTV) before and after grinding were less than 5 microns.

All wafers were wax-mounted on the sapphire disk by the Logitech bonding machine. The wafers were divided into five groups and the final thickness target of each wafer would be 100 microns.

The G&N twin-spindle grinding machine has been optimized to produce the best surface conditions. The wet etch recipe used for this test was: 1(36.5% HCl): 4 (30% H2O2): 40 (DI), with an etch rate of about 0.3 microns per minute at room temperature.

During the polishing step, the test wafers were loaded on the 12” Lap Master polishing machine. The wafer was rotated on the polishing pad. Polishing slurry was supplied to the pad and the removal rate was 1.2 microns per minute.

Group 1. Prior to the wafer strength test, wafers were ground to 100 microns.

Group 2. Prior to the wafer strength test, wafers were ground to 105 microns then removed 5 microns by wet etching.

Group 3. Prior to the wafer strength test, wafers were ground to 110 microns then removed 10 microns by wet etching.

Group 4 Prior to the wafer strength test, wafers were ground to 115 microns then remove 15 microns by wet etching.

Group 5 Prior to the wafer strength test, wafers were ground to 110 microns then removed 10 microns by polishing.

All wafers were demounted from sapphire disks, cleaned, dried, and then rechecked for TTV by a Mitutoyo indicator; the results were plotted in Fig. 1. It is important to note that the wafers were also visually inspected to ensure that the wafer surface was free of scratches before measuring the strength.

The Wafer Strength Measurements were taken by using an AIKO material strength tester manufactured by AIKO Engineering Inc. in Japan. The accuracy of the wafer strength measurement is +/- 0.01 lbs. A special fixture was designed to hold the thinned wafer. This special fixture has an opening with the same shape as the 4” GaAs wafers with a major flat and a minor flat. There is a closed chamber with a draw to hold the cracked wafers below the opening. The stage speed was set to 10 mm/sec, as the wafer fixture stage was moving up toward the tip. The wafer stage stopped when the tip cracked the wafer and the maximum load displayed is the strength of the wafer. The results were plotted in Fig. 2 for different wafer groups.

Test wafer strips from groups 1, 3, and 5 were sent to perform surface roughness (Ra) [*] measurements by Chapman machine (model MP2100 non-contact measurement system). The results of the surface roughness were combined with the wafer strength data and plotted in the Fig.3 to make it easier to determine the correlation between the wafer strength and the surface roughness of different surface treatments.

The defect yield of wafer-demount and wafer-clean from polishing and wet etching process was collected for more than 3 months and plotted in the Fig. 4

Results and discussion

Figure 1. The TTV of Grinding, etching, and polishing.

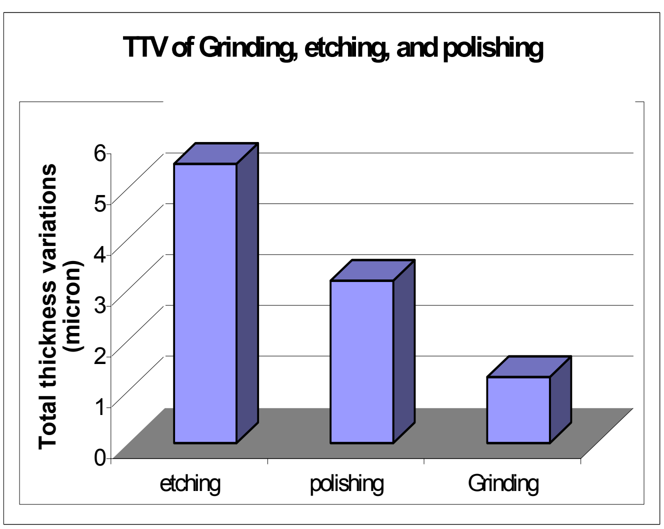

Fig. 1 shows the relationship between the total thickness variation (TTV) of the wafer finished with difference process. The polishing group has better flatness than the Wet etching. However, the grind-wafers have the best flatness in the wafer thinning operation, but its wafer strength is the lowest in the group as shown in Fig. 2.

Figure 2. The wafer strength of the different group.

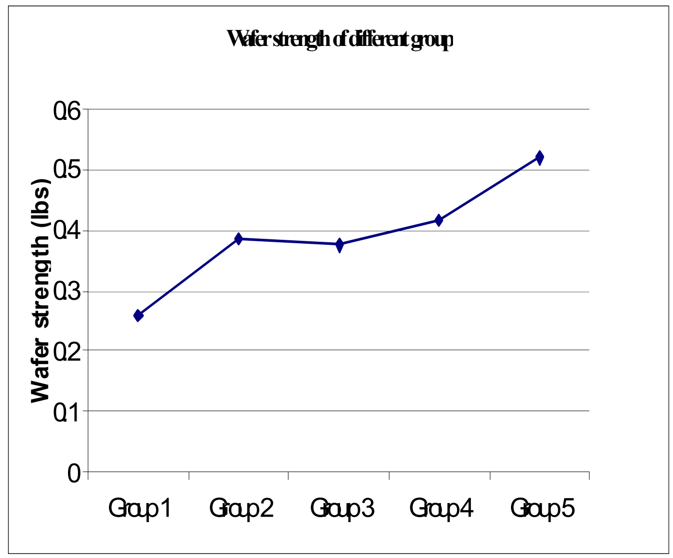

Fig. 2 shows the wafer strength of the different groups. The wafer strength of group 1 is 0.26 lbs, group 2-4 is between 0.376-0.418 lbs, and group 5 is 0.52 lbs. This indicates that after grinding the wafer has a lot of mechanical stress on the surface originating from the grinding wheel. The wafer strength was improved by wet etching method because it releases the mechanical stress by removing the damaged layer. It was thought that the more the surface damage layer etched away, the higher the wafer strength would be, but the wafer strength levels off and the wafers with 5, 10, and 15 microns removed by wet etching were equivalent, and there was no significant improvement by longer etching. The Fig.2 also indicates that the polishing (chemical-mechanical) process gives higher wafer strength than one treated by wet etching process.

[*] Ra= Roughness Average. The roughness average is the most typically used “one number” description to specify the roughness of a surface.

Figure 3. The relationship between surface roughness and wafer strength.

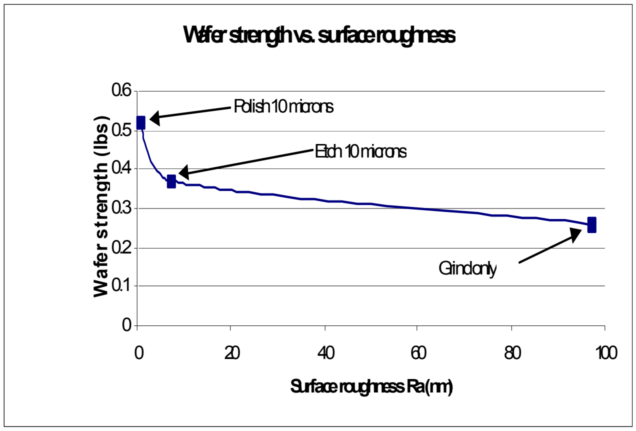

Fig. 3 shows the relationship between the surface roughness and the wafer strength. The wafer strength was increased from 0.26 to 0.52 lbs. as the surface roughness value decreased from 97.3 to 0.5 nm. Fig. 3 also shows that the polishing process had lower surface roughness than the wet etching process, therefore it has higher wafer strength. Furthermore, wet etching can remove surface damage layer but the surface is not mirror finish because the micro cracks may exist on the surface. On the other hand, polishing can remove the entire surface damage layer and produces a mirror finish surface thus increases the wafer strength. This increase wafer's strength will overcome the stress and help preventing the breakage during the wafer demount and wafer cleaning processes as shown in Fig.4.

Figure 4. The effect of surface roughness to the wafer yield.

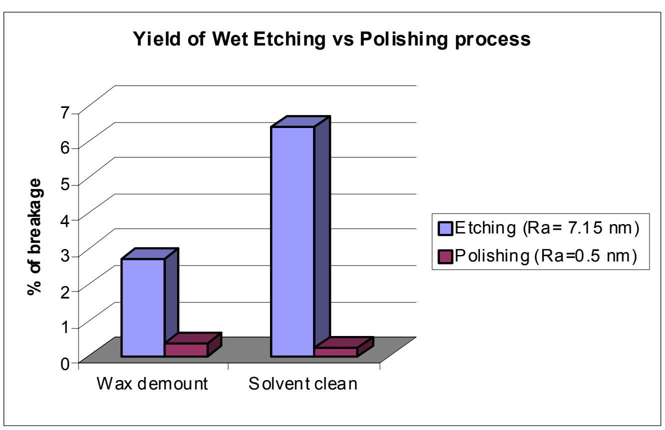

Fig. 4 shows the effect of the surface roughness and wafer yield. As the surface roughness value decreases from Ra=7.15 to Ra= 0.5 nm, the total wafer breakage rate decreased from 9.13% to 0.59%. Results from Fig.4 clearly confirm the importance of surface roughness in the yield. The polishing process can remove surface defects and reduce the surface roughness more effectively than the wet etching method.

Conclusion

The lowering of surface roughness is a major factor for wafer strength improvement, the smoother is the surface, the stronger is the wafer. The smooth surface will help preventing breakage during the wafer demounting and solvent cleaning. It is very important to do polishing instead of wet etching process in the wafer thinning operation to minimize the thickness variation, and reduce the surface roughness to improve the wafer strength.

By implementing the polishing process in our high volume production line the wafer breakage rate was reduced from 9.13% to 0.59%.

Reference

[1] Ralph Williams, Modern GaAs Processing Methods, 2nd Ed., Artech House, Boston, 1990, p. 322.