Wax Mounting, Backlapping and Chemo-Mechanical Polishing of 150mm (6 Inch) GaAs Wafers.

Keith W Torrance[1], Jim McAneny[2] and Maxwell Robertson[2]

1. Struers Inc. 810 Sharon Dr., Westlake, OH 44145
2. Logitech Ltd. Erskine Ferry Road, Old Kilpatrick, Glasgow, Scotland, G60 5EU

ABSTRACT

Lapping continues to offer some advantages over wafer grinding for backside thinning of GaAs substrates. Lapping systems are widely used to successfully thin 3" and 4" GaAs wafers, but until now, no studies have been published on larger wafers. The feasibility of lapping 150mm (6") GaAs wafers is investigated using a new precision lapping and polishing jig developed by Logitech Ltd. We also describe a procedure that successfully automates wax bonding to a temporary support disc. We find that 150mm wafers can be reliably thinned to thickness of less than 100 microns (4 mils) using a lapping process and discuss the impact of wax mounting, thickness control, wafer flatness and parallelism on wafer yields.

INTRODUCTION

Lapping is a very effective mechanical process for removing material from brittle materials. It is widely used in the semiconductor industry for backthinning GaAs, InP, InSb and other compound semiconductors. Compared to silicon, most GaAs substrates are processed as relatively small diameter wafers (< 104mm) and only in the past 12 months have a few semiconductor companies moved to larger substrate sizes.

Despite having a long history in optical manufacturing, lapping is poorly understood by many engineers and is often confused with the completely different processes of grinding and polishing. Lapping is defined as a process where two surfaces are worn together between a free rolling abrasive. This differs from a grinding or turning process, where the abrasive particle is fixed within the wheel and cuts the material. A consequence of this is that the shape of the lapping plate is constantly changing as the plate wears and will greatly influence the flatness of the piece being lapped. This ability has been exploited in many industries to generate optically flat surfaces on glass, ceramics and other crystalline materials.

Another attraction of lapping is that it is believed to produce less stress on the substrate and induce less sub-surface damage, particularly in soft, brittle crystalline materials such as gallium arsenide. This may be due to the lower plate speeds and low loads on the wafer compared to grinding. As a result, it is possible to thin GaAs and InP wafers to 75 microns (3 mils), without causing the substrate to cleave or chip. This work was undertaken to determine if similar results could be achieved on 150mm diameter GaAs wafers.

EQUIPMENT

In order to retain a 6 inch diameter wafer, a new lapping and polishing jig had to be developed and built with a chuckface of 160mm. We have considerable experience with designing and building smaller jigs, with chuckface diameters of 83mm and 106mm, but it is not a simple matter to scale these designs up, as a number of other factors become significant. Figure 1 shows the new jig, the PP8GT, running on an LP80 lapping machine.

Figure 1: PP8GT lapping jig on LP80 lapping machine. Photo courtesy of Logitech Ltd.

The operation of the PP8GT is fairly straightforward. The wafer/carrier disc is held by vacuum to a chuckface that is fixed to a piston. This is free to move up and down in a sleeve that is in turn attached to the body of the jig and drive ring. It is essential that the drive ring and chuckface remain co-planar regardless of the position of the piston within the sleeve and still move freely. Consequently the piston and sleeve have to be machined and then honed to exacting tolerances. The effect of the larger 160mm chuckface is to accentuate any angular deviations, so that formerly insignificant errors become important. To this can be added the need to reduce the weight to similar levels as smaller jigs to aid handling. The bare weight of the PP8GT as tested was equal, at 6kg., to the present PP6GT 106mm lapping jig.

Loading on the wafer can be adjusted by means of a collar at the top of the piston, using a spring to counteract the mass of the jig, or by adding weights. Stock removal can be monitored using an attached dial gage. The fixture is held in position on the lapping plate by a half circle roller arm.

PROCESS

Lapping trials were conducted on six 150mm GaAs wafers ([100]), purchased from Airtron[1]. Prior to backthinning, the wafers were wax mounted to a rigid glass 160mm diameter carrier disc using a Logitech WBT5 bonding system. The wafers were mounted using 0CON-199 Thin Film Bonding Wax, available from Logitech[2], which has a melting point of 75 ^{o}C. The thickness of the bond layer was calculated by comparing the thickness of each wafer, before and after mounting, as shown in Table 1. Interferometry revealed details of the bond uniformity, as illustrated in Figure 2.

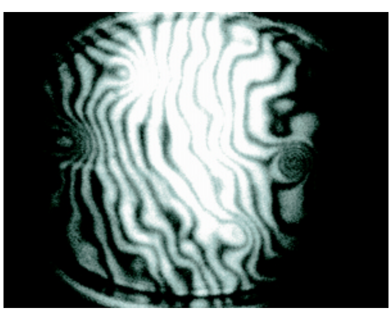

Figure 2: Interferogram of GaAs wafer after bonding, showing some localized high spots. Fringe spacing is 2 microns.

Our experience has been that mounting is the most critical part of the entire backthinning process. The bonding force must be strong enough to produce a wax layer that is uniform to ±3 microns, but not cause the wafer to cleave. Air bubbles are another hazard; a bubble less than 1mm in diameter will produce a high spot in the wafer that can cause the wafer to cleave. Air bubbles can also expand during later metalization stages. The edges of the wafer must also be supported or they will break off and damage the scratch the substrate. The WBT5 has been specifically designed to bond GaAs wafers using a vacuum controlled diaphragm to minimize wafer stress.

TABLE 1: Wafer uniformity after wax mounting (Bond thickness in microns)

	P1	P2	P3	P4	P5
Wafer 27-33	2	2	3	4	7
Wafer 27-39	4	3	2	2	6
Wafer 27-43	5	4	3	5	6
Wafer 27-44	3	2	2	4	5
Wafer 27-45	4	2	2	5	4
Wafer 27-46	2	5	4	5	6

From this data, the average bond thickness was 3 microns, with a total thickness variation of 5 microns.

Each wafer/carrier disc was held by vacuum to the chuckface of the PP8GT fixture and lapped on a 45cm radial grooved cast iron (glass plates are available for chemically sensitive applications) lapping plate, with 9 micron aluminum oxide slurry and lapped to a thickness of 320 microns. Plate speed was constant at 60rpm throughout and gave an average removal rate of 4 microns/ minute. This corresponds to a lapping time of about 60 minutes for a typical backthinning operation.

Even for backthinning operations, it is recommended that the backside of the wafer be polished to produce a highly reflective surface. There are two good reasons for doing this. First, polishing removes and anneals micro-fractures produced by lapping. Although these are typically very small, there is some evidence that during the normal heating/cooling cycle of a packaged device, the cracks may propagate and cause premature failure of the device. A second reason is that polishing relieves any internal stress in the wafer that has built up during lapping. This can be observed; a lapped wafer will often ‘curl’ like a potato chip after de-mounting.

TABLE 2: Wafer uniformity after Chemlox polishing. (Total thickness of wafer + bond.)

	P1	P2	P3	P4	P5
Wafer 27-33	306	304	307	304	304
Wafer 27-39	290	295	295	292	294
Wafer 27-43	296	294	296	293	295
Wafer 27-44	310	308	304	309	310
Wafer 27-45	300	302	304	304	304
Wafer 27-46	308	306	305	308	308

After cleaning, each wafer was again held in the PP8GT fixture and polished for five minutes using Chemlox[2] polishing solution on a 45cm Chemcloth[2] polishing cloth. Around 20 microns of GaAs was removed. Because sodium hypochlorite based polishing fluids are very caustic, the PP8GT fixture is constructed from resistant +316 stainless steel. After polishing, the wafers were quickly immersed in DI water to arrest the oxidation of the GaAs wafer by the solution and dried with N_2 to minimize staining. The thickness of each wafer was measured after polishing using a NG2 non contact measurement gage, to avoid scratching the polished surface. Results are shown in Table 2. Surface roughness, as measured using a Dektak instrument, was 8nm Ra.

Flatness of the lapped and polished, bonded wafers was assessed using a Logitech GI10 interferometer, as shown in Figure 3.

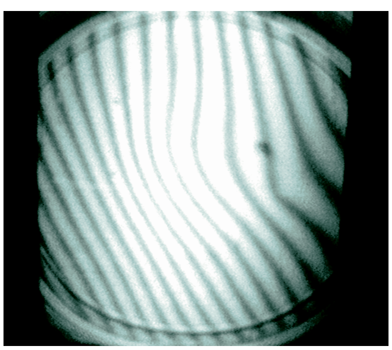

Figure 3: Interferogram of a bonded GaAs wafer after polishing Fringe spacing is 2 microns

RESULTS

The results for the six trial wafers are summarized in Table 3. Five of the six wafers were within a spec of ±2 microns, which is considered acceptable for most wafer applications. Subsequent wafers have been lapped and polished to 100 microns final thickness. The results suggest that bonding is probably the most significant source of thickness variation.

TABLE 3: Summary of Results.

	Initial Thickness	Bonding Uniformity	Final Thickness	Uniformity	Flatness
Wafer 27-33	663	7	305	3	5
Wafer 27-39	667	6	293	3	4
Wafer 27-43	682	6	295	3	3
Wafer 27-44	683	5	308	6	5
Wafer 27-45	684	4	303	4	4
Wafer 27-46	682	6	307	3	4

SUMMARY

We conclude that lapping/polishing is a viable methods of backthinning 150mm GaAs wafers that offers potentially high yields. As GaAs devices have moved from research and pilot line production to full production, there has been a trend from lapping to grinding systems. However, this study has shown that lapping is a feasible alternative, particularly for wafer fabs and research laboratories who need the flexibility to thin different wafer sizes and also smaller pieces.

1 Airtron, 200 E Hanover Avenue, Morris Plains, NJ
2 Struers Inc., Logitech Group, 810 Sharon Drive, Westlake OH 44145