A New Alternative for Temporary Wafer Mounting

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Abstract

Gallium arsenide (GaAs) wafer manufacturing often requires the reduction in overall wafer thickness in order to allow the device to achieve its intended performance specifications. GaAs wafers are extremely difficult to handle when they become very thin, so a carrier wafer is often used to support the wafer during thinning and subsequent operations. The GaAs wafer must be temporarily bonded to this carrier and then be able to be demounted cleanly and efficiently. This paper will discuss a new product system family on the market that incorporates temporary adhesives and the solvents that are used to demount the wafer.

INTRODUCTION

Temporary mounting of GaAs wafers to sapphire carriers is used to help support the brittle GaAs material during the wafer thinning process. The carrier's support and the choice of mounting adhesive become increasingly important as the wafer thickness is reduced to below 100 microns.[1-3] Desirable properties for temporary mounting adhesives include an elevated softening point, ease of application, good thickness control, ease of curing and mounting, low out-gassing, resistance to process chemicals, and ease of demounting.[4] After the adhesive is applied, it should be have a high transparency and be free of voids. Finally, the de-mount process must ensure that all adhesive is removed quickly with no residual material left behind. Although there may be many adhesives commercially available, the ability for one to meet all of these objectives is a tall order. Rising to this challenge is a new spin-on adhesive, GenTak™, which has been shown to provide significant benefits for backside wafer processing.

GENTAK™ SPIN-ON ADHESIVE

GenTak™ is a new polymer system developed by General Chemical Corporation (GCC) specifically for the III-V industry. It is part of the GenSolutia™ family of products designed for backside wafer processing.[5] GenTak™ is under review at Motorola for use as a temporary mounting media. The product is a ready-to-use adhesive that is applied directly to the wafer, much like a photo-resist, using a spin-on method commonly available in coat track systems. GenTak™ goes on clear and evenly, meeting the desired thickness control. The adhesive has been found to meet many of Motorola's objectives and to withstand process chemicals without producing unwanted residues.

Although GenTak™ is shipped in a ready to use liquid for spin-on applications, its fully cured polymer system is a thermoplastic with a moderately high softening point. A modified ASTM method (D1002, D2295) shows the product to have a softening point to be 130-135 when under shear stress of <5psi.

The coating and curing process for most applications requires two coats of GenTak™. One coat is always applied to the wafer for planarization. The substrate to which the second is applied is dependent upon the presence of perforations in the carrier. When no perforations are present, the second coat is applied and cured onto the carrier. With perforations, the second is applied to the planarization layer on the wafer. Upon completion of curing, a thermal mounting process is conducted. The mount is secured by cooling under pressure. See Figure 1 for a depiction of the coating and mounting method for non-perforated carriers.

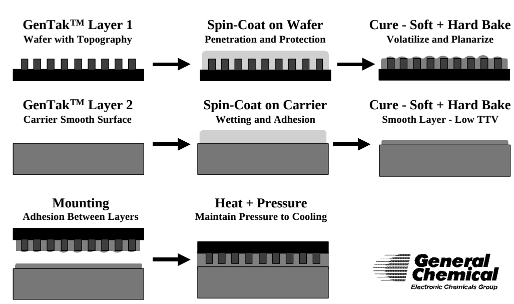

Fig. 1. Coating, Curing, and Mounting of GaAs Wafers to Non-Perforated Carriers with GenTak™ Adhesive.

Motorola applies GenTak™ according to GCC's recommendations for perforated carriers. The first coat is applied by dispensing the adhesive solution onto a static wafer. The wafer is accelerated to achieve an even coat. A top and bottom edge bead removal solvent is applied with the exact size of the removed area determined by subsequent mounting parameters. The wafer then moves to a high temperature bake where the adhesive is cured to planarize the wafer. The second coat is applied in a similar fashion to the first coat and also completes its cycle with a high temperature bake. This high temperature bake removes solvents from the adhesive coating and once again helps to planarize the coating. The first coat, after application, results in an adhesive thickness of 10 microns. A typical spin speed curve is given in Figure 2.

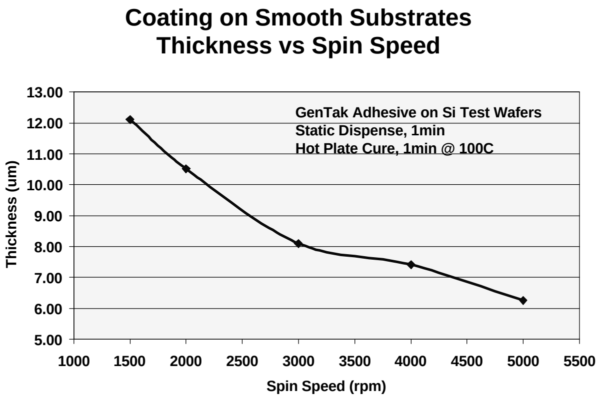

Fig. 2. Coating Thickness on Test Wafers with GenTak™ Adhesive.

The second coat achieves a final thickness of approximately 25 microns. It is common for the second coating to witness an increase in thickness due to material drag during application. The final coating thickness can be tailored to specific process needs through changes in dispensed amounts and process settings. Coating measurements are obtained using a 2-sided air gauge. Thickness measurements may also be taken optically with a refractometer using the Cauchy coefficients in Table 1.

GenTak 230	a = 1.5199	b = 2473.1

Table 1. Cauchy Coefficients Determined for GenTak™ Adhesive.

Acceptable statistics in coating thickness and TTV (Total Thickness Variation) have been achieved on a patterned product wafers. See Table 2 for coating measurements.

# Coatings	Thickness	Std Dev	TTV
Single	10.6	0.39	1.1
Double	25.5	0.51	1.5

Table 2. GenTak™ Adhesive Measurements on 6" Product Wafers.

After each adhesive coating is applied, the carrier is mounted to the wafer. There are several commercially available tools that can be used to achieve the final mount. Some tools use vacuum to remove the entrapped air between the carrier and the wafer during the mounting process. Other systems mount the wafers at atmospheric conditions but use a strategically applied stress to achieve a wafer bow which forces out entrapped air. Initial testing at Motorola CS-1 has been successful at atmospheric conditions. Work is continuing in this area to maintain a reduced cycle time.

A commercially available wafer-mounting tool is used to mount the wafers at atmospheric conditions and has been proven to achieve relatively bubble-free bond lines. This bond is achieved using relatively low pressures in the 5 – 15 psi range. Varying the pressure and temperature of the tool will affect the desired bond-line thickness. A wafer bow mechanism is believed to help the mounting process but is not present on the current wafer-mounting tool. This should help to reduce the magnitude of air entrapment.

Wafer mounting is achieved through the following process. The wafer and carrier are aligned externally to the equipment and then placed on the mounting tool, which is at a temperature of 135 – 150C. An enclosing lid is placed over the mounting area and the temperature is allowed to stabilize at the set point. The mounting cycle is then started, which pulls a low vacuum in the chamber and applies a pre-defined pressure through a diaphragm system. At completion of the cycle, the lid remains on the mounted composite until it is cooled to 120C, a temperature below the softening point of GenTak™.

At this point, the adhesive has set well enough to remove the wafer from the mounting area, where it can cool to ambient conditions. The cycle time can be accelerated through rapid cooling of the mount tool's chuck (if so equipped) or can be extended to reduce stress in the bond-line. Acceptable statistics in mounting thickness and TTV are shown in Table 3.

Thickness	Std Dev	TTV
1414.3	1.4	3.9

Table 3. GenTak™ Adhesive Measurements on Final Mounted 6" Composite of the Product Wafer and Carrier.

The transparency of GenTak™ offers benefit for easy alignment of reference marks during lithography processes. Figure 3 demonstrates this benefit.

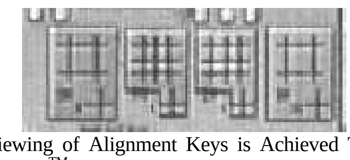

Fig. 3. Easy Viewing of Alignment Keys is Achieved Through the High Transparency of GenTak™ Adhesive. 100X Magnification.

Although GenTak™ is transparent, it is formulated with an ultraviolet dye, allowing both visible and UV light inspection for reference points and voids. Using a UV light, the image shows striking contrast between areas with and without the presence of UV dye, which in turn, suggests voids or a reduced penetration of adhesive. See Figure 4 for a comparison between optical and UV light inspection – presented here as a gray scale image.

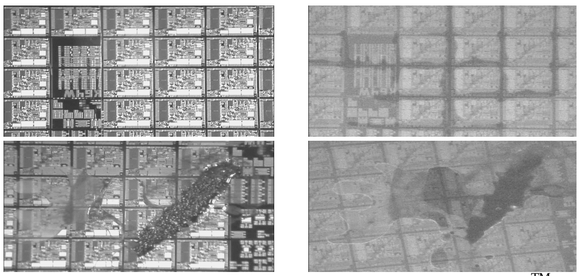

Fig. 4. Observations Through Mounted Carrier with GenTak™ Adhesive, Visible (Left Side) and the corresponding same image under UV light (Right Side). Dark Areas Suggest a Lack of Adhesive with Dye.

After completion of wafer mounting, the composite is then ready for process thinning, which can consist of grinding, chemical thinning and CMP, or some combination of these processes. The GenTak™ adhesive has a high shear strength, which allows mechanical thinning to reach an extremely low thickness below 75 microns with ease and full integrity.

One area under study at Motorola CS-1 is the benefit of the GenTak™ adhesive in reducing induced wafer stress. When mounting a gallium arsenide wafer to a carrier for thinning, stresses can be imparted in the wafer. By reducing the induced stress from the grinding process, irregularities in thickness are minimized to produce smooth surface profiles. See Figure 5 to describe the surface uniformity on a bare wafer, mounted prior to grinding, and after grinding.

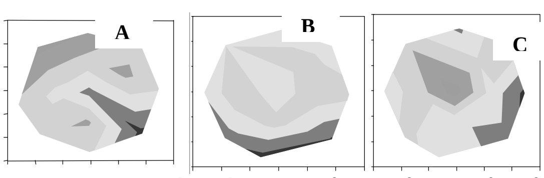

Figure 5. Contour Plots Showing Surface Uniformity of Wafer Grinding with GenTak™ Adhesive. Plots are Described: A) Bare Wafer, B) Mounted – Prior to Grinding, and C) Post Grinding. Dark Areas are Peak Thickness.

As seen in Figure 5, wafers processed with GenTak™ show a reduction in peak thickness, acting as an aid in wafer planarization. The same benefit in stress reduction during the grinding process can also aid in wafer dicing after demount. Namely, the same wafers processed with GenTak™ appear to have less bow at the end of the process and do not curl to the same extent as seen with other temporary wafer bonding adhesives. A reduction in bow and curl improve yields and process speeds through better dicing uniformity.

Following wafer thinning, additional backside processing involves chemical and thermal exposure. It is critical for GenTak™ integrity to be maintained throughout these steps. The data in Table 4 suggests many process chemicals proven to be safe.

Process Chem.	**GenTak 230 - Cured**
H2SO4, 6N	No Effect
HCl, 6N	No Effect
H3PO4, 20%	No Effect
HOAc, 20%	No Effect
H2O2, 15%	No Effect
NaOH, 10%	Effect

Table 4. Process Chemical Compatibility of GenTak™ Adhesive.

Although Table 4 suggests an interaction with GenTak™ and alkali, this is believed to be minor and can be easily overcome by minimizing exposure or with mechanical protection. Additionally, GCC's support staff may suggest alternative chemistry, inhibitor, or process adjustments to achieve success.

Thermal exposure of the mounting adhesive occurs during backside processing. It is important that adhesive integrity is maintained with minimum out-gassing. During a thermal program, there is a risk of evolving low molecular weight species and their redeposit into critical areas. This could be detrimental to surface sensitive processes, such as metal adhesion. GenTak™ has been proven to exhibit minimal out-gassing, even at temperatures beyond its softening point. A TGA scan in Figure 6 shows out-gassing at <0.5% at temperatures that exceed 130C, the softening range.

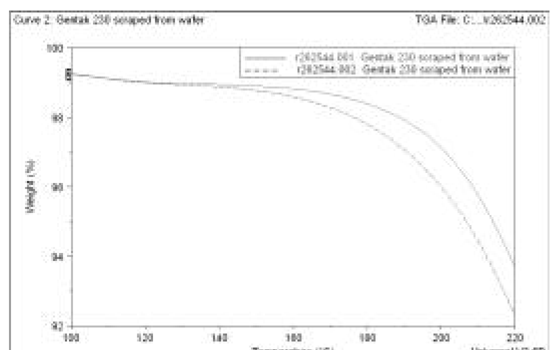

Figure 6. TGA scan of GenTak™ Indicating <0.5% at Temperatures Exceeding 130C, the Softening Range.

When the backside processing is complete, the wafer is demounted from the carrier in a heated immersion tank with one of GCC's GenSolve™ solvents. GenSolve™ is capable of demounting the wafer in time frames between minutes to hours, depending on the temperature and whether ultrasonic agitation is used. For thermoplastic adhesives such as GenTak™, temperature has been shown to provide the greatest benefit in demount operations. Low temperature demount performance can be achieved with certain GenSolve™ products. Trends in demount performance are shown in Figure 7.

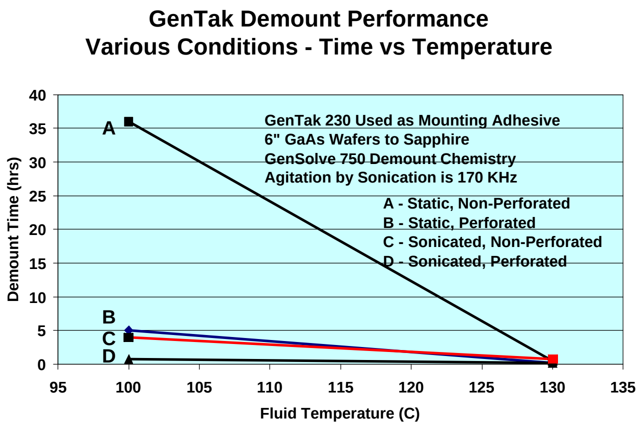

Figure 7. Demount Performance of GenTak™ Adhesive.

Although agitation is recommended, demounting wafers is best achieved at elevated temperature. Processing at temperatures near the softening point of GenTak™ will offer a physical benefit towards penetration and removal. As seen in Figure 7, immersion temperatures at 130C vs. 100C offer more than a 30-fold benefit for wafers on non-perforated carriers demounted in non-agitated chemistries. Sonication provides significant benefit even at low temperature, however, adjustments to generator power or novel fixturing must be done to minimize damage due to inertial cavitation.[6]

Once penetration is achieved, solvent is further incorporated into the polymer layer, leading towards gel formation, saturation, and dissolution as described in a common polymer model.[7] Once an effective penetration method is achieved and polymer dissolution continues, a pre-rinse is recommended to remove dissolved solids and particulate from the thin bond line and complex geometries. GenClean™, GCC's line of aqueous products, is designed to emulsify dissolved polymer, prevent redeposition, and maintain a reduced surface tension. These benefits are described in another publication.[8] Final rinsing is performed with DI water. All processing to date has shown no indication of any non-dissolving residue product left by the GenTak™ adhesive.

CONCLUSION

The search for a new temporary adhesive can lead down many paths. There are several choices available to the manufacturing environment. Many of those choices have undesirable effects incorporated with their chemical make-up, such as chemical compatibility and residue. Through the use of the GenTak™ adhesive, several process benefits are realized which include simple application, improved planarization, easy viewing of alignment keys, UV detection of voids, minimal process chemical interaction and outgassing. A significant advantage over certain other adhesive systems is residue elimination. Taken together, this can translate directly into higher product yields. In addition, faster demount times can be found using the GenSolve™ solvents with the GenTak™ adhesives, which help throughput through the backend manufacturing process.

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ACRONYMS

III-V: Elements common to columns III and V of the periodic table to include GaAs, InP, and others.
ASTM: American Society for the Testing of Metals.
TGA: Thermogravimetric Analysis

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