High Temperature Resistant Adhesive for Wafer Thinning and Backside Processing

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Abstract

Wafer backside processing steps that include high temperature exposure may now be simplified with the use of a thermally resistant adhesive, GenTak™ 330.[1] Processing at temperatures of 200ºC and beyond are accepted to include plasma etching, deposition, and the curing of related polymers, such as BCB.[2] By combining the thermoset properties of GenTak™ 330 with the dissolution characteristics of GenSolve™, there is no need to separate the substrate from the carrier until backside processing is complete. Application and mounting times within 30 minutes, outgassing at <1%, and demount and cleaning in a few hours, qualify this adhesive as an aid to manufacturing.

INTRODUCTION

The use of temporary adhesives in wafer thinning and backside processing is common for manufacturing III-V power devices[3,4] and is being explored by silicon.[5] Mounting wafers to perforated carriers helps to support the brittle substrate character, especially with GaAs. Desirable properties in a temporary mounting adhesive include ease of application, good thickness control, thermal and chemical resistance, and ease of demounting.

GENTAK™ 330 ADHESIVE

GenTak™ 330 is high temperature resistant thermoset developed by General Chemical West, LLC, specifically for wafer thinning and backside processing. It is part of the GenSolutia™ family of products designed for backside wafer processing.[1] GenTak™ 330 is under review for both GaAs and silicon wafer processing, for use as a temporary-mounting adhesive.

The adhesive is a 100% solids (i.e. no solvent) blend of silicone polymers having polysiloxane-vinyl and silyl-hydride character. In the presence of a catalyst, the vinyl compounds produce free radicals which undergoes addition polymerization with the silyl-hydride to produce the final product. The thermoset uses chelates to inhibit platinum. During heat exposure, platinum is released to trigger polymerization.[6,7] Figures 1 and 2 show the reaction sequence and DSC analysis of curing.

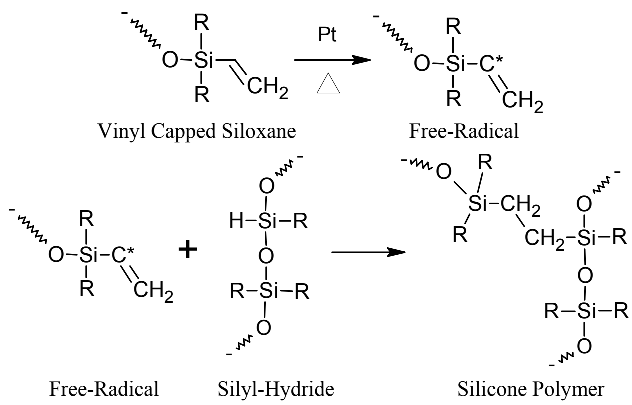

Figure 1. Curing mechanism for GenTak™ 330 showing Pt catalysis of free radical polymerization (R = alkyl group).

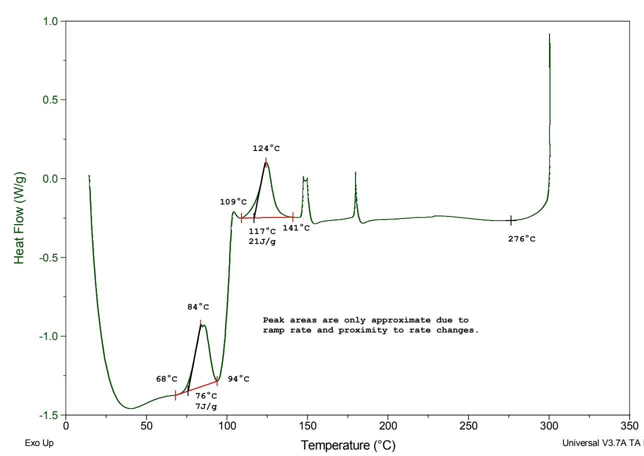

Figure 2. DSC for GenTak™ 330 showing major reaction at 110C and stability through 280C.

The DSC curve describes heat flow at major molecular transitions. A significant increase in energy the endotherm is seen near 110°C, yet it becomes stable through 280°C. This broad endotherm describes polymerization, whereas the small spikes suggest small crystalline rearrangements, fusions, and possible moisture loss.

APPLICATION AND MOUNTING

GenTak™ 330 is a ready-to-use adhesive that is applied directly to the wafer, much like a photo-resist, using a spin-on method. This adhesive goes on clear and evenly, achieving a potential thickness of >50um and meeting the desired variation control. The final coating thickness can be tailored to specific process needs through changes in dispensed amounts and spin speed (see figure 3).

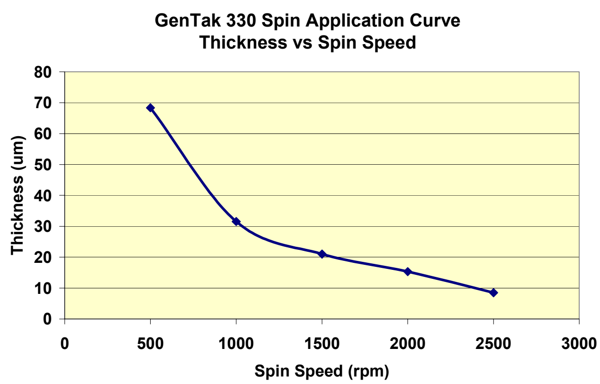

Figure 3. Spin-on thickness vs. speed curve for GenTak™ 330.

Although single coat applications are possible, two are recommended for planarizing and mounting. The first is applied dynamically to the wafer and coated at the speed corresponding to the desired thickness, using a compatible EBR such as NBA. It is then hard bake cured to 150-200ºC, cooled, and the second coat is applied by static puddle and then spun at a higher speed to attain a thin coat. This is then taken to a soft bake, followed by a simultaneous hard bake and mounting with pressure to a perforated sapphire in a vacuum oven. Clean-up of uncured GenTak™ 330 may be done with a variety of solvents to include MEK and NBA. The mounted wafer exhibits a very clear bondline without voids (see figure 4).

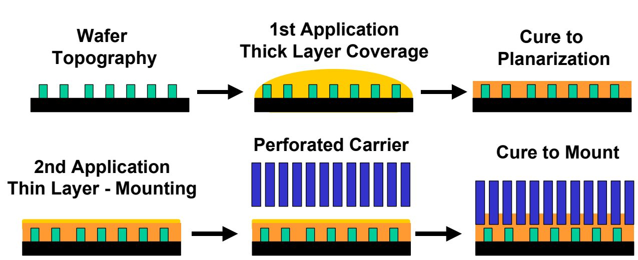

Figure 4. Physical model of wafer to carrier mounting of GenTak™ 330.

Many commercial tools may be used to mount the wafers at atmospheric conditions to achieve bubble-free bond lines. This bond is achieved using relatively low pressures in the 1-5 psi range. Varying the pressure of the tool will slightly affect the desired bond-line thickness.

Full curing occurs during hard bake to produce a stable bond exhibiting good thermal stability and low weight loss at exposures near 250ºC (Figure 5). Momentary processing above these temperatures may be possible.

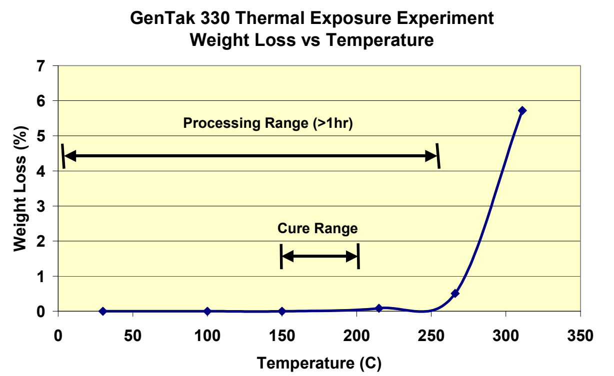

Figure 5. GenTak™ 330 thermal stability as weight loss. Processing is described here for subsequent wafer steps (i.e. deposition, etch, etc.).

After the wafer package has run through final curing in the hard bake cycle, it may be removed from the tool and cooled at ambient conditions. The cycle time can be accelerated through rapid cooling of the tool's chuck.

MATERIAL RESISTANCE

After completion of wafer mounting, the composite is ready for thinning, which may include grinding, chemical thinning or CMP, and a stress-relieve chemical etch. During a chemical etch, GaAs substrates may use a variety of chemistries as stated in table 1. With the exception of certain concentrated acids (e.g. conc. sulfuric), GenTak™ 330 is observed to have no deleterious effects. This may eliminate the need for protective tapes or other polymers.

Table 1. Chemical resistance of GenTak™ 330, all held at 70 minutes.

Chemical	Temperature	Result
H2O2, 30%	20ºC	No Effect
H2SO4, 6N	20ºC	No Effect
HCL, Conc.	20ºC	No Effect
H2O:NH4OH:H2O2 (5:1:1)	20ºC	No Effect
Bleach:H2O (1:1)	20ºC	No Effect
H2O:H2SO4:H2O2 (8:1:1)	20ºC	No Effect
H2SO4, Conc.	20ºC	Attack
N-Methylpyrollidone	20ºC	No Effect
Isopropanol	20ºC	No Effect
Acetone	20ºC	No Effect

Thermal exposure of the mounted wafer and carrier package 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^{TM} 330 has been proven to exhibit minimal out-gassing.

The TGA scan in figure 6 indicates out-gassing at <0.5% up to 250°C, as measured in reference to a curing profile at 150-200°C. Although limited weight loss is witnessed near 300°C, there is observed molecular change in the DSC (figure2).

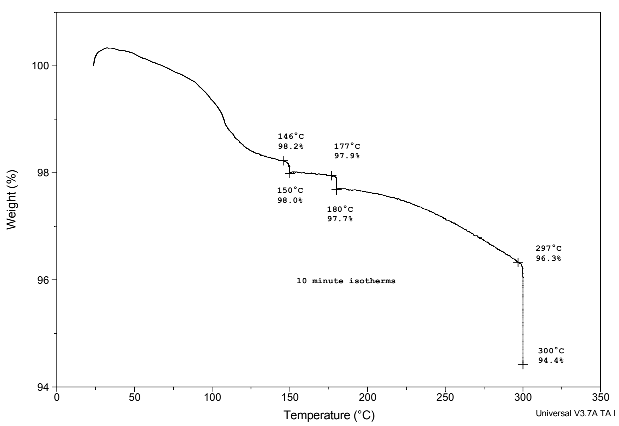

Figure 6. GenTak^{TM} 330 TGA study indicating weight loss to be approximately 0.5% when taken to 250°C from a 200°C cure.

Demount and Clean

When backside processing is complete, the wafer is demounted from the carrier in a heated immersion tank with one of General Chemical's GenSolve^{TM} solvents. They are capable of demounting the wafer in a few hours, depending on the temperature and whether ultrasonic agitation is used. When using sonication, adjustments to generator power or novel fixturing may be required to minimize damage from inertial cavitation.[6]

Table 2. Wafer demount and clean of GenTak^{TM} 330 using GenSolve^{TM}.

Chemistry	Temperature (°C)	Time (hrs)
GenSolve^{TM} 335	90-100	1-2
GenSolve^{TM} 550	90-100	4-5
GenSolve^{TM} 365	90-100	6-7

The GenSolve^{TM} chemistries noted in table 2 have been specifically designed to break-down and dissolve silicone polymers such as GenTak^{TM} 330. The products contain a reactive constituent, which penetrates the silicone matrix and cleaves the bonds between the Si-O linkages, releasing the complexed reactants where they may be rinsed away. Due to the small bondline, rinsing is recommended with a compatible solvent such as IPA with DI water to follow.

The products, GenSolve^{TM} 335, 550, and 365, exhibit a range of polarity and reactivity to provide many options to manufacturing. In some cases, substrate incompatibility may be observed. For example, it has been determined that certain materials may be compromised (see table 3).

Table 3. Material compatibility upon exposure to GenSolve^{TM}.

Item	PI*	BCB	SiNx	SiOx	Au	TiW	Cu	Al
335	OK	OK	No	No	OK	No	OK*	No
550	OK	OK	No	No	OK	OK	OK	No
365	OK	OK	OK	OK	OK	OK	OK	OK

*Observations may vary, depending on how Cu is applied

A quick review of tables 2 and 3 suggest that GenSolve^{TM} 335 may have the best performance in demount and clean, however, it is aggressive to the majority of substrates. To ensure success in your design of backside processing with GenTak^{TM} 330, attention must be given to demount performance and compatibility.

Applications - III/V

During III/V wafer backside processing, wafer thinning, plasma etching of vias, clean, metallization, etch, resist strip, plating, and passivation with BCB, must be performed with complete compatibility to the adhesive. Prior to thinning,, the wafers are bonded to sapphire carriers with the use of GenTak^{TM} 330. Typically, the resin is applied in two layers: the first layer is coated up to 15 um and cured at 180°C (planarization), while the second coat is applied near 5 um and left uncured to allow for bonding. The wafers are then bonded to the sapphire using a Logitech Bonder. The control of wafer flatness is very critical to the overall backside process. It is, therefore, important to control the coating and bonding processes. It is believed that flatness is achieved by resin planarization during the first coat and the bonding program, leading to a total thickness variation (TTV) of a few microns. The wafers are lapped down to 100 microns using a Logitech PM5. Once the wafers are thinned, backside vias are etched using a Unaxis SLR 770 etcher.

Many compatibility and controls must be addressed during backside processing. Due to the high density plasma, if not properly cooled, the substrate may heat up to cause resist reticulation and poor etch profile. The choice of adhesive must exhibit high thermal resistance and low outgas characteristics to minimize adverse effects on the etch process. Resist stripping after etching must be thorough to ensure successful metal adhesion without blistering. GenTak^{TM} 330 has been determined to be compatible with aggressive strippers, the plating solution, and etchants. This margin of safety protects from any attack to the frontside of the wafers. After the metal is patterned and etched, the wafers are ready for passivation with BCB.

BCB requires curing temperature of up to 250°C. When using conventional low temperature thermoplastic adhesives, BCB may need to be applied *after* demount and clean. In this scenario, handling thinned and via etched wafers may be difficult, if not impossible, especially in a production environment. With GenTak^{TM} 330, the application of BCB and curing are made possible while the wafers are still mounted, therefore, simplifying the process and making the process production worthy. After the backside processes are completed, the wafers are demounted with GenSolve^{TM} 335, however, a dilution is necessary to achieve compatibility to PECVD nitride. A diluted version has offered good demount parameters with minimal attack on the nitride film.

APPLICATIONS - SILICON

Although scenarios in processing III/V and silicon may appear similar, there are many material differences and therefore, tool variations. The popularity of using thinned silicon substrates with copper integration includes many applications in IC packaging. GenTak^{TM} 330 is applied when bonding a carrier to Si wafers and thinned to less than 150µm. The TTV of the post bonded assembly is typically 2-3 µm and the post thinning TTV resulted in about 2 um.

The substrate package (bonded carrier and Si wafer) is then processed for 5 minutes at high temperatures of up to 350ºC during deposition of CVD oxide (SiOx). Once deposition is complete, the wafer is ready for demount. GenSolve^{TM} 335 is used as a solvent for debonding Si wafers from the carrier and cleaning any GenTak^{TM} 330 residue. The demount time varies between 2-3 hours. As noted in table 3, some processing adjustments may be necessary to achieve compatibility. Therefore, a diluted mixture of the GenSolve^{TM} 335 is used to achieve the desired substrate safety, reducing the effects on the SiOx layer while meeting throughput needs.

CONCLUSION

There are limited paths available for one who is searching for a high temperature resistant temporary adhesive. Many of those choices require unique designs and processes. Through the use of the GenTak^{TM} 330 adhesive, several process benefits are realized to include simple application and mounting, minimal outgassing, and easy demount and cleaning. Taken together, this can translate directly into higher product throughput for the backend manufacturing process.

ACKNOWLEDGEMENTS

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ACRONYMS:

EBR: Edge Bead Removal
MEK: Methyl Ethyl Ketone
NBA: N-Butyl Acetate
CMP: Chemical Mechanical Polishing
DSC: Differential Scanning Calorimetry
TGA: Thermogravimetric Analysis
PECVD: Plasma-Enhanced Chemical Vapor Deposition
CVD: Chemical Vapor Deposition