Temporary Bonding of Wafers, Displays, and Components

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Abstract

Many packaging practices are conducted on work units while they are temporarily held in place. It is the objective to promote a simple bonding process, easy removal, and reduced cleaning. Substrates may be wafers, displays, or components, organic or inorganic, flexible or rigid, and may contain large topography such as solder bumps. The bonding medium is dependent upon the process, usually resistance to heat and chemicals. Thermal resistant materials have been created into temporary adhesives as polyimide (PI)[1], bisbenzocyclobutene (BCB, DOW Cyclene™)[2], and silicone.[3] In some cases, PI is the desired substrate in flexible displays and require a separate adhesive.[4] Creating micro devices on flexible PI a tuned adhesive with low outgas, inert character, and thermal resistance to 450C. Adhesive tuning allows attaching discrete, thin, fragile components by dry bonding, and are removed by simple peeling without residue. Temporary bonding processes of die include feature encapsulation during selective bumping or vacuum deposition.[5-6] Successful force tuning depends on several factors, including substrate surface energy, texture, and the bonding process. Daetec will discuss their experience in creating adhesives for thin substrates down to 4um and thermal resistance to 600°C.[7]

Key words: temporary bonding, adhesive, bumping, detergent, green products

I. Introduction

A wide range of adhesives has been reported in temporary bonding practices for electronics. Adhesives are available to temporarily bond a range of substrates (Table 1).

Table 1. Applications of DaeCoat™ products.

Work Unit	Market	DaeCoat™	Method
Organic Film	OLED, flexible displays	355	Cure on carrier, bond w/pressure
Organic Film (cast)		315	Cure on carrier, cast & cure liquid
Thin glass	TFT LCD	355	Cure on carrier, bond w/pressure
Foil	OLED, flexible displays	355	Cure on carrier, bond w/pressure
Wafer	3DIC	355, 365, 615, 625	Planarize (option), coat, bond w/pressure
Die (chip)		355	Cure on carrier, bond w/pressure

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A. *Semiconductor Wafers*

Wafer temporary bonding involves two active stages, (Fig. 1); bonding is similar while the mechanics of debonding varies (Fig. 2).

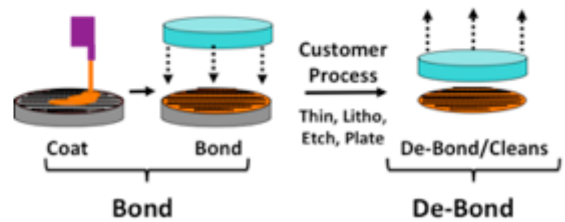

Fig. 1. Two active stages to the use of any temporary adhesive and carrier, bonding and de-bonding.

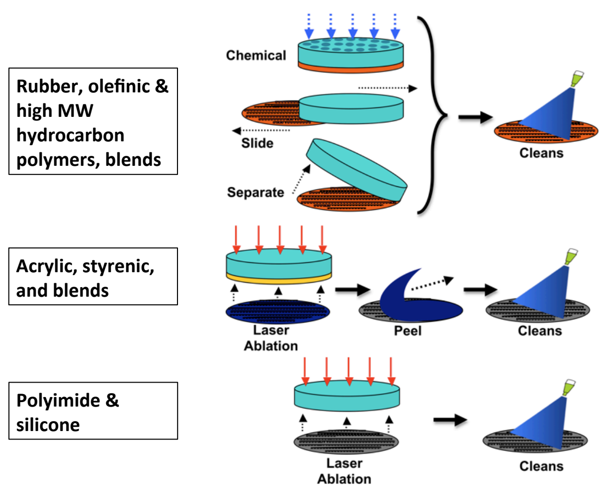

Fig. 2. Leading practices of wafer debonding.

Wafers are ground and polished to at least 100um while front side devices are protected during backside processing. Carriers offer surface planarity at ≤2um TTV and reduce bow from internal stress during grinding. Spin-on adhesives control TTV and seal the wafer. Many adhesive chemistries are used for thin wafer handling, including: a) rubber/olefin [8-9], b) acrylic [10], c) silicone [3], d) polyimide [1], e) rosin-urethane [11], and BCB[2]. Bonding is similar, where material is coated on the device wafer, cured, and bonded to a carrier.

B. Displays

In display processes, temporary bonded substrates are removed by peeling practices without the need for adhesive cleaning. The process flow applies DaeCoat™ 315 to the carrier (glass) prior to liquid PI curing. It is processed to device completion and peeled after laser cutting it by laser cutting (Fig. 3).

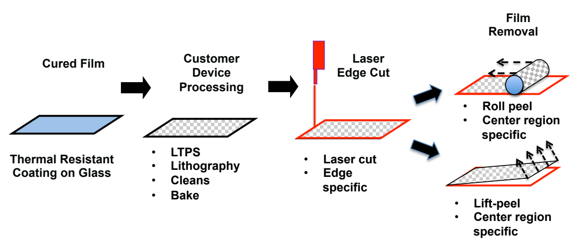

Fig. 3. Process flow for displays.

The removal of large-area substrates use peel methods where its physics are force vectors where adhesion is measured over removal distance (Fig. 4).

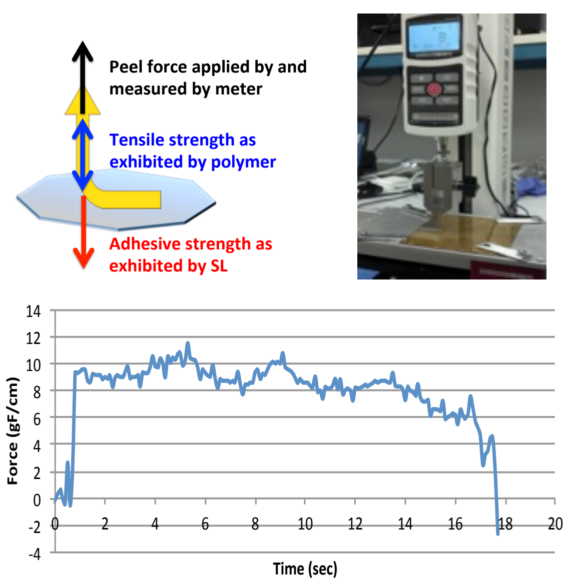

Fig. 4. Vector modeling (top), measurement, and graph of peel force (bottom).

C. Small Die

The same approach is common for small die that are bonded to elastic adhesive and simply pulled away without residue when finished processing Temporary bonding of small devices has been demonstrated by affixing onto adhesive and subsequent debond with a final cleans. Interposer bow is reduced while post-bonding of micro-bumped chips occurs. DaeCoat™ 365 encapsulates and protects existing bumps during bow reduction and bonding (Figs. 5-6).

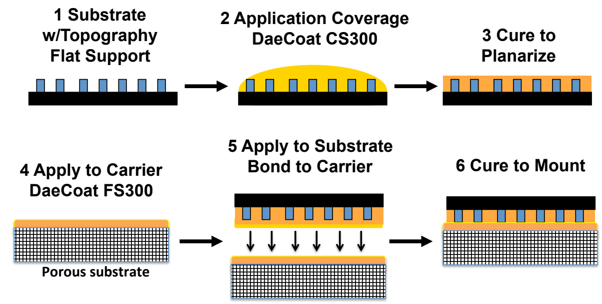

Fig. 5. Process flow for affixing interposer die.

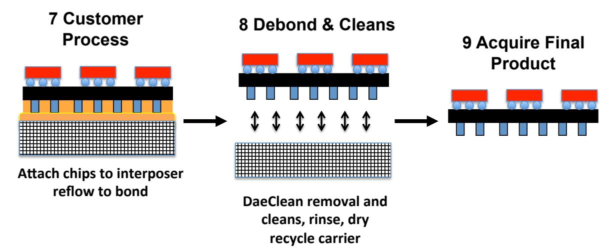

Fig.6. Die processing, demount, and cleans (option).

The adhesive, DaeCoat™ 365, is cleaned from a porous carrier using DaeClean™ 300, leaving the substrate in pristine condition.

D. Green Products

The electronics market continues to reduce risk by minimizing the use of chemicals. Daetec creates products that are 100% solids (solvent free) or use water to apply or process. Examples include DaeCoat™ 515 used for washable coatings that planarize features prior to processing (Fig. 7) and rinsing laser HAZ debris (Fig. 8) [12], or detergent washable adhesives (DaeCoat™ 615, Fig 9).

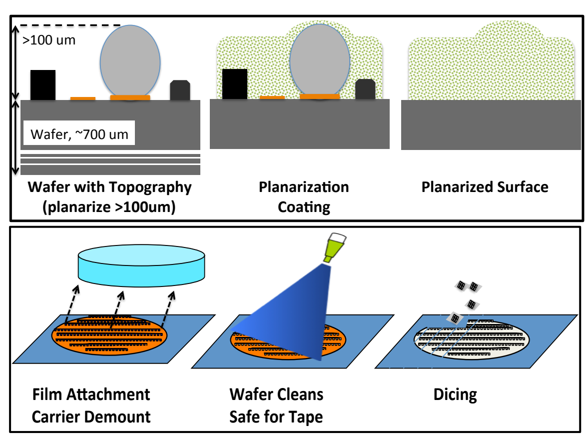

Fig. 7. DaeCoat™ 515 washable planarizing coating.

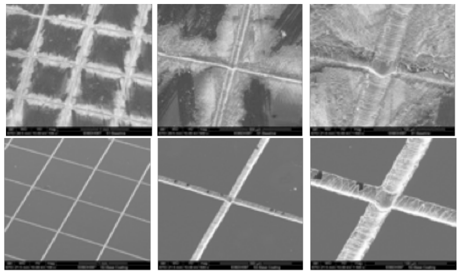

Fig. 8. SEM photos of laser processing without DaeCoat™ 515 (top) and with coating (bottom).

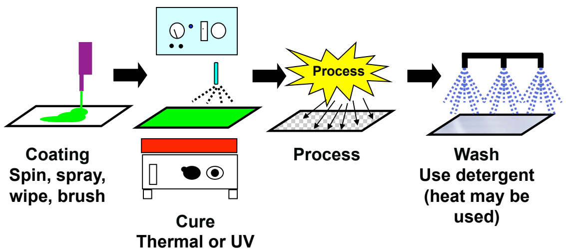

Fig. 9. Process description for using detergent washable adhesive DaeCoat™ 615.

II. Experimental

A. Materials

For subsequent analytical testing, quartz substrates as are chosen and prepared at Daetec along with 100-200 mm (4-8”) silicon wafers (1-0-0, ~525 µm) re-manufactured from Wollemi Technical, Inc. (Taiwan, www.wollemi.com.tw). Materials used include commercially available spin-coated adhesives and other developmental products produced at Daetec. UV-cure applications are conducted with free-radical resins available from BASF. Solvents and other chemicals considered to be common to a development laboratory are available.

B. Equipment

Coatings are produced on a Brewer Science, Inc. CB-100 spin-coater, while spray and encapsulation uses custom tooling designed at Daetec. Metrology data is generated by a XP-1 stylus profiler, AFP-200 atomic force profiler, and a Xi-100 optical profiler [24]. Where applicable, equipment settings include a 5 mg stylus load, minimum 4 mm distance, and speed of 0.5 mm/sec. Modified thermogravimetric test methodology for outgas is conducted by typical laboratory electronic gauges (+/- 0.1mg). UV cure equipment includes the Intelli-Ray 400 microprocessor controlled light curing system (Uvitron International, www.uvitron.com). Adhesion is measured by force gauge with measurement software (www.mark-10.com) using traceable method (Daetec SOP #45, ASTM D3330).

III. Results

A. Adhesion Tuning

The temporary bonding of liquid form PI uses DaeCoat™ 315, a mixture of two key components resin A & B. DaeCoat™ 215 PI is applied to glass substrates (Fig. 10), pretreated with DaeCoat™ 315 A & B at 10-50% relative to each other, resulting in adhesion force from 15-90 g/cm^2 (Fig. 11).

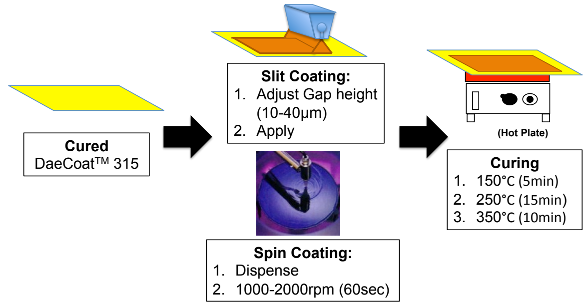

Fig. 10. DaeCoat™ 215 PI coating process.

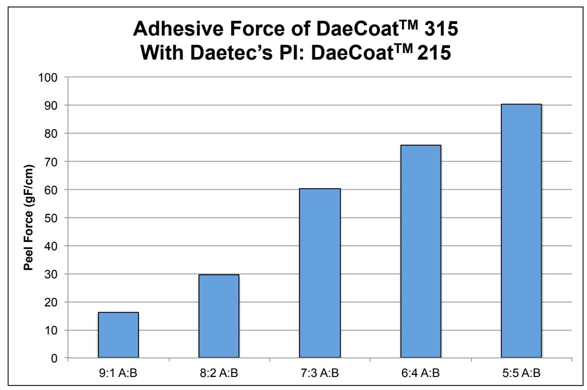

Fig. 11. Adhesion vs. resin ratio of DaeCoat™ 315.

Small devices are bonded to thermal resistant adhesive, DaeCoat™ 355. Adhesion force is tuned by mixing different resin molecular weights (MW) and activator levels shown to have a direct effect on peel force. Adhesion appears to follow MW with the highest actually tearing apart as activator is driven down, leaving residue (Fig. 12).

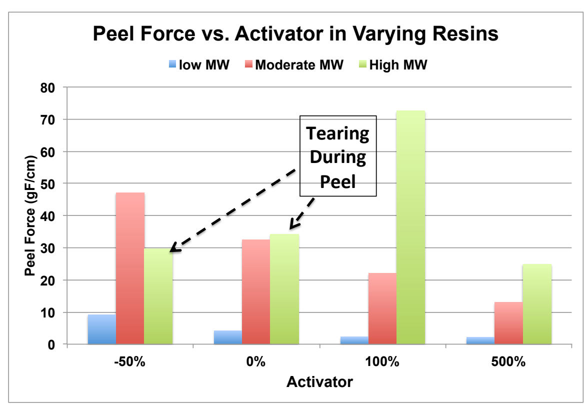

Fig. 12. Adhesion vs. resin MW of DaeCoat™ 355.

B. *Thermal Resistance*

Thermal stability of DaeCoat™ 355 suggests a high temperature of 355 ºC for oxygen/air environments and higher for more inert conditions (i.e. N_2, Ar, etc.). Post baking at the desired high temperature will confirm this stability (Fig. 13).

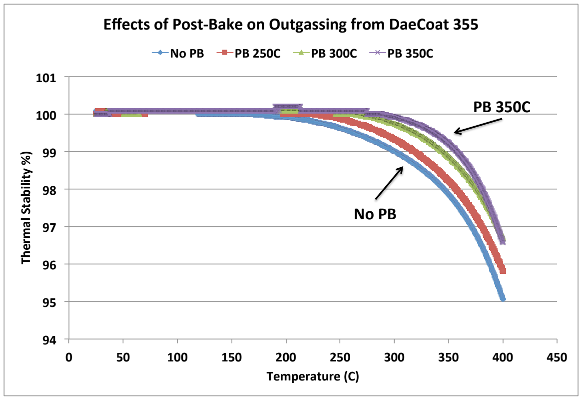

Fig. 13. Thermal stability DaeCoat™ 355 with PB.

For simple grind/polish with limited backside processing or directly proceeding to dicing, a detergent soluble adhesive, DaeCoat™ 615 may be a match. Minimum thermal resistance is demonstrated at >200C. This figure has been tuned down <100 ºC for rapid debond in hot DIW or driven up to >250 ºC.

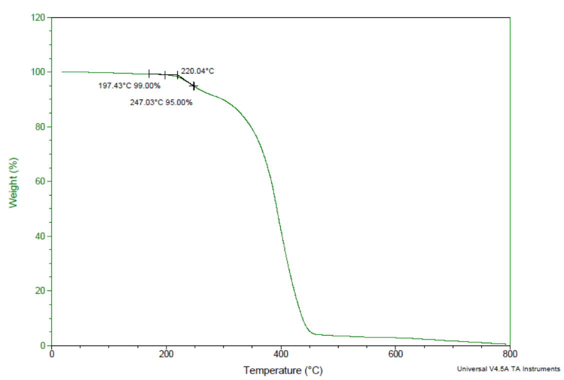

Fig. 14. Thermal stability DaeCoat™ 615 detergent washable adhesive.

IV. Conclusions

Temporary adhesives are used to affix one substrate to a carrier and allow handling and processing of thin fragile materials. Adhesion chemistry and force can be adjusted to bond wafers, displays, and small components to allow simple cleaning or no-cleans during removal. Adhesion is tuned using DaeBond™ 3D for wafers, DaeCoat™ 315 for thin PI, and DaeCoat™ 355 for components.

V. Discussion

Tuning adhesion for wafers is dependent upon the presence of topography and its composition. For flat surfaces, bonding is a matter of wetting. Adhesives of low surface energy (i.e. phobic products, rubber, silicone) rapidly wet high-energy surfaces as glass, and metals. The ability to vary surface energy defines many peeling technologies in the market.

For displays, adhesion force is tuned to interact with PI to achieve a desired value and sustain a process. Adhesive force depends upon several factors, including glass carrier surface, PI chemistry, thickness, and the process conditions. Specific areas of the carrier may be treated with varying ratios of DaeCoat™ 315 to provide adhesion gradients.

Acknowledgment

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