# Advanced Thin Wafer Support Processes for Temporary Wafer Bonding

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## Abstract

The ZoneBOND$^{TM}$ process has been developed to allow temporary wafer bonding at acceptable temperatures (usually less than 200ºC), survival through higher-temperature processes, and then demounting at room temperature. The technology utilizes standard silicon or glass carriers and current thermoplastic adhesives developed by Brewer Science, Inc. The separation process consists of three components: removal of the adhesive in the outer zone, lamination of the device side of the pair, and separation of the carrier wafer from the adhesive. Developments of these key areas are the focus of this paper.

Key words: silicon wafer bonding, temporary wafer bonding, thin wafer support, through-silicon vias, TSVs, semiconductor wafer bonding

## Introduction

Wafer-to-wafer bonding is widely used to support the production of both integrated circuits and MEMS devices. Bonding may be accomplished in a variety of ways including anodic, thermal compression, and adhesive bonding. The bond may be either permanent or temporary. Permanent wafer bonding is used to combine two materials together that remain together for the life of the device, for example, in the production of Si/GaAs wafer heterostructures for integration of an optoelectronic device into silicon integrated circuit technology. Temporary bonding is used to support the device wafer during certain processing steps, and then the support substrate is removed once the device wafer is completed. Currently, several temporary bonding processes are being developed in industry. The leading technology utilizes some form of polymeric material to temporarily fasten or bond a rigid backing material, usually silicon or glass, to the device wafer for processing. The main issues associated with these techniques are temperature stability of the adhesive through backside processing, removal of the fragile device wafer from the support wafer, and cleaning the adhesive from the device wafer. This paper will cover advancements in techniques associated with solving these issues. Included are methods for encapsulating microelectronic features, such as solder bumps, and eliminating voids in the temporary bonding materials. Information will be reported on methods to handle higher temperatures and increased stress in thin wafer processes while maintaining the ability to debond with low stress and temperature. Post-debonding cleaning will also be discussed.

## Methodology

The key goals are to develop a process to temporarily bond a device wafer to a carrier substrate, protect it through high-temperature backside processing, and then remove the carrier from the thinned device wafer without subjecting it to high stress or high temperature. The work is focused on decoupling the bonding and debonding requirement for reflowing the adhesive, as seen with traditional thermoplastic temporary bonding. The new bonding methodology allows separation of the device wafer from the carrier without adding heat or high shear stress. The general scheme for this process is shown in Figure 1. The basic process flow consists of the following steps:

1. Coat polymer adhesive on Device
2. Fabricate Zone 1 of Carrier (release zone)
3. Bond face to face
4. Process device wafer (thin, pattern, etc.)
5. Remove adhesive from Zone 2 (stiction zone)
6. Separate Carrier from adhesive left in Zone 1
7. Clean adhesive from Device

In this illustration, the device is shown as being edge trimmed prior to coating and bonding.

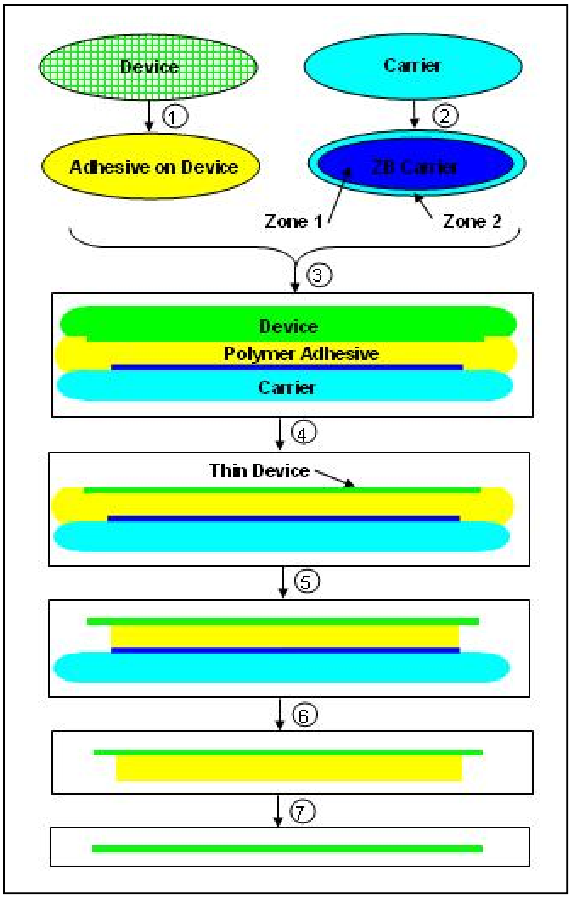

**Figure 1: Brewer Science® ZoneBOND™ process.**

The development effort consists of several technology areas of focus: advanced polymer development, process development of coating and bonding on topographical substrates, separation process, and adhesive removal from the device after separation.

The work on advanced polymers consists of formulating chemistries that take advantage of the ability to bond at one temperature, usually between 150ºC and 200ºC, and then survive temperatures of ~ 300ºC. Because the separation process for ZoneBOND™ occurs at room temperature, it is not necessary for the polymer to maintain the ability to reflow at or near the original bond temperature. With this decoupling of the bond and separation temperatures, the breadth of material possibilities is increased dramatically.

For the process development, work centers on coating over high topography on device wafers and thickly coating carrier wafers. The effort includes developing multiple processes that can coat either the carrier or the device substrate. Proper coverage and protection of the topography and the space created during edge trimming through backside processing is accomplished in both the coating and bonding steps. The coating must provide enough material in the proper location across the wafer to be able to reflow and fill the topography during bonding at melting temperature and pressure to yield good bond quality. As shown in Figures 2 and 3, processes have been developed that give good bond quality regardless of which wafer is coated with the adhesive. The test wafers contain solder bumps having a height of 80 µm.

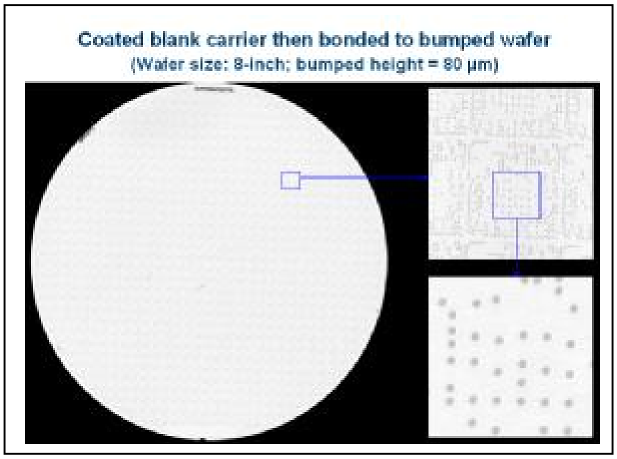
Coated blank carrier then bonded to bumped wafer
(Wafer size: 8-inch; bumped height = 80 µm)

**Figure 2: CSAM image, carrier coated.**

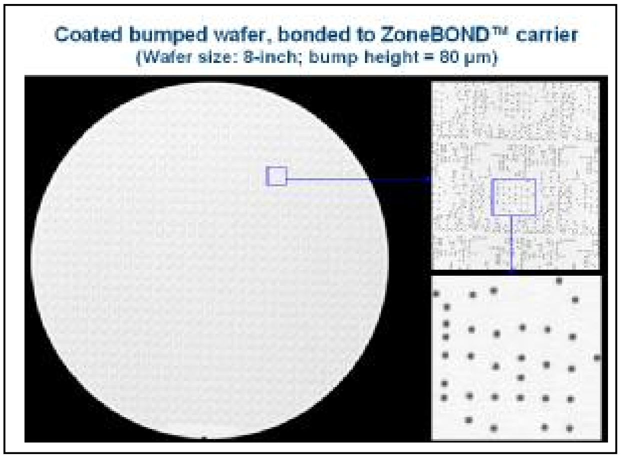
Coated bumped wafer, bonded to ZoneBOND™ carrier
(Wafer size: 8-inch; bump height = 80 µm)

**Figure 3: CSAM image, device coated.**

As reported at the 2010 IMAPS Device Packaging conference in Phoenix, AZ, the separation process consists of two fundamental steps: 1) removal of the adhesive material from the perimeter, Zone 2, of the pair and 2) separation using a novel peeling mechanism. For the first step, the adhesive is dissolved in a solvent bath. The solvent and time depend on the adhesive used for the temporary bond.

The current practice is a batch process using a solvent soak in a wet bench. The wafers are submersed in the appropriate solvent for 1 to 2 hours and then are rinsed in IPA. The intent of the rinse is to dry the outside of the stack so the stack can be handled in subsequent steps. The material in Zone 2 is dissolved, but not necessarily removed completely. In practice, it is only necessary to break down or soften this material to reduce its ability to hold the wafers together. For the second step, separation, the pair is laminated to a dicing frame with the device wafer towards the laminating tape. Once laminated, the carrier is removed using a Brewer Science® ZoneBOND™ separation tool, shown in Figure 4. This process consists of loading the assembly onto a chuck, pulling vacuum to securely hold the assembly in a planar state, then utilizing a novel technology of Brewer Science, which peels the carrier wafer away from the adhesive. The edges, Zone 2, of both the carrier and the device substrates typically have residual adhesive remaining. The adhesive in Zone 1 remains entirely on the device wafer. Therefore, Zone 1 on the carrier is free of any adhesive. Both the carrier and the device undergo solvent cleaning to remove the adhesive.

**Figure 4: Brewer Science® ZoneBOND™ separation tool.**

Following the separation step, the thin device wafer is cleaned with solvent. The cleaning is usually performed in a typical spin coater by dispensing solvent to cover the surface and spinning dry. The process is repeated until the adhesive is removed completely, as shown in Figure 5. At this point, because the device wafer is very fragile, it is necessary to clean it while it is still mounted to the dicing frame. Therefore, special mounting chucks are used to secure and support both the device wafer and the frame. A compatibility study of dicing films with the cleaning solvents is underway to make sure that proper support and protection for the device wafer is maintained.

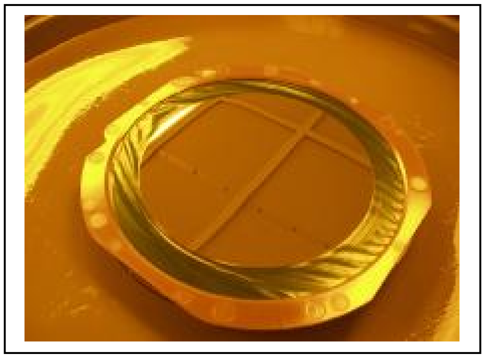

**Figure 5: Cleaning on dicing frame.**

### Discussion Summary

The ZoneBOND™ temporary wafer bonding process consists of creating multiple adhesion zones on the carrier to allow for proper adhesion through backside processing and room temperature release. The steps described earlier are being further developed in parallel with industry backside process development. The process provides very low stress both thermally as well as mechanically. By eliminating the need for thermal reflow subsequent to backside processing for separation, alternate adhesive development methodologies are enabled. The process also has flexibility to allow for alternate processing schemes and stack setups. Currently, advanced material development is underway at Brewer Science, with the focus on increasing thermal stability and enhancing performance through backside processing while maintaining good clean ability.

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