Process methodologies for temporary thin wafer handling solutions

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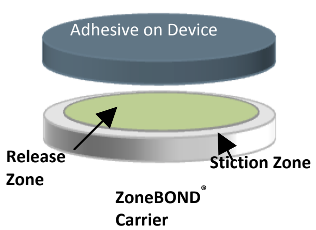
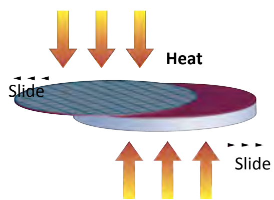
Use of temporary bonding/debonding as part of thin wafer handling processes is rapidly increasing in the chip stacking (memory and logic), high-power radio-frequency (RF) device, light-emitting diode (LED), and solar energy market segments. Several temporary bonding technologies have been developed which feature different methods for debonding fragile device wafers from carriers: chemical release, thermal slide separation, and ZoneBOND® debonding.

ZoneBOND® Technology



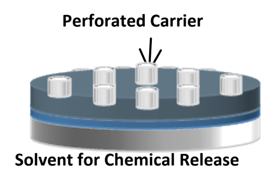
- Low-stress, room temperature debonding
- Manual debonding tool available
- ZoneBOND® process bonding materials

Slide Debonding Technology



- Automated and manual debonding tools available
- Wafer sizes 50 mm to 300 mm
- WaferBOND® HT-10.10 bonding material
- Materials with higher thermal budget available

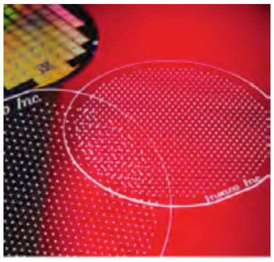
Chemical Release Technology

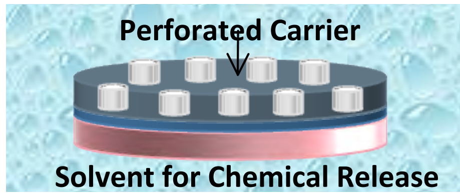


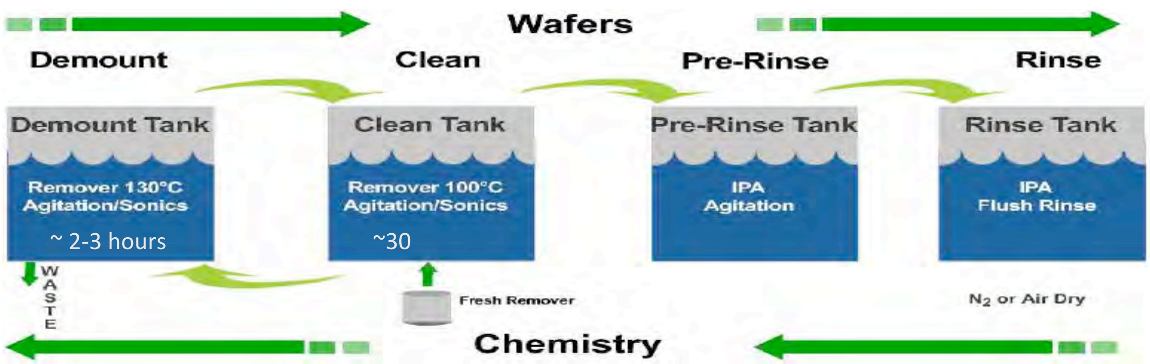
- Low initial investment
- Suitable for low-volume production
- WaferBOND® CR-200 bonding material

For all three methods, a polymer-based material is spin coated onto the device substrate. The coated device substrate is then transferred to a bonding chamber where it is aligned with a carrier and press bonded to the carrier, usually under vacuum and at high temperatures, to ensure a uniform bonding layer. Often application engineers must determine which temporary bonding/debonding method is the most appropriate process flow for their specific application.

In many cases, the initial stage of development consists of proving the feasibility of using a spin-applied chemical release temporary bonding material layer. The chemical release process requires very little force to release the thinned device wafers from carriers, so it can be implemented without significant capital investment. Essential equipment includes a precision spin coater for applying the polymeric bonding material, a hot plate for thermally curing the film, and a tank for completing the debonding process. This process also utilizes a perforated carrier wafer to expose the bonding material layer to the removal solvent during the post-thinning immersion step. The bonding material remover migrates through the perforations, softening and eventually liquefying the bonding material, thus allowing the carrier wafer to be released gently from the thinned device substrate. Typical soak time to achieve wafer release ranges from 2 to 4 hours depending on bonding material composition and thickness, perforation pattern, and substrate diameter. The chemical release process is often recommended for low-volume, small-format, and compound semiconductor (CS) III-V materials.





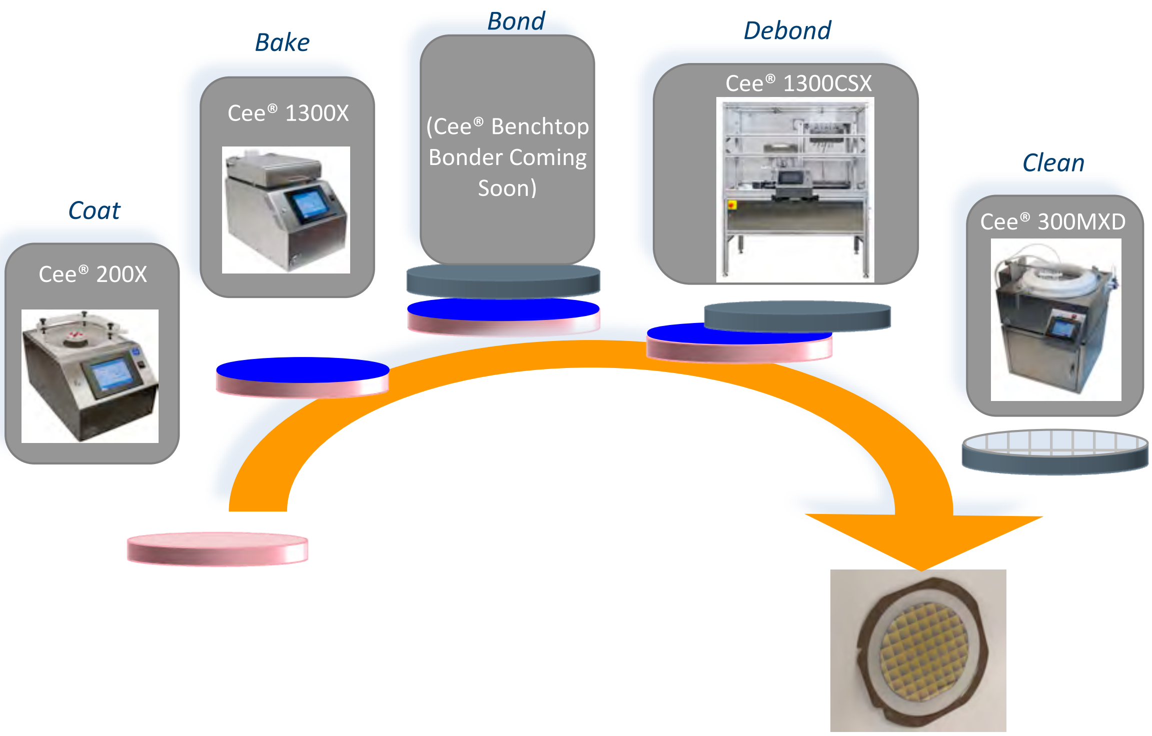


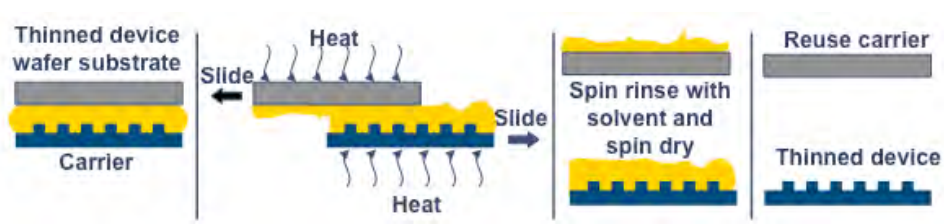
Thermal slide debonding is ideal for small-format applications with throughput requirements of 500-600 wafers (50-150 mm in diameter) per week and with thermal budgets up to 220°C. This technique requires a planar backside surface on both the device wafer and the carrier for applying vacuum and generates throughputs of 8-14 wph for wafer sizes ≤ 150 mm. Thermal slide debonding technology is currently being successfully utilized with process yields of ≥ 90% for both CS and Si materials, including high-power RF, LED, and solar applications. As with the chemical release technique, a thermoplastic material is spin coated uniformly in a layer 50-100 µm thick on a device substrate and is thermally cured with a high-uniformity bake plate. Bonding media thickness is determined by the overall height of device topography and by bonding material selection.

The coated device and a full-thickness carrier substrate (commonly glass, Si, or sapphire) are loaded together into an evacuated process chamber and bonded using heating and compression. After the bonding process, the wafer pair undergoes processing such as edge trimming, backgrinding, and chemical-mechanical polishing. The wafer pair is then ready for the thermal slide debonder.

Thermal slide debonding requires precise control of platen temperature uniformity, x-positional pull force, vacuum fluctuation between carrier/device and platen, lower platen z-position, and co-planarity between platen surfaces. Bonded pairs are generally processed with the thinned device wafer oriented to contact the upper platen surface, and the carrier is held with vacuum to the lower platen, as seen in the graphic below.

After the pair is successfully loaded, the lower platen moves to the process (press) position directly under the upper platen. After reaching this location, the lower platen is raised to a predetermined z-position (height). When the appropriate level of vacuum is sensed on both the upper and lower platens, the upward movement stops to ensure the wafer pair is not over compressed. The pair is then allowed to stabilize to ensure minimal thermal gradient, and the lower platen then begins to move in the opposite x-direction with process-specific pull force and speed parameters. Movement continues until the wafers are separated. In a Brewer Science® Cee® 1300DB or 1300CSX slide debonder, z-position, x-position, force, speed, upper and lower vacuum, upper and lower temperature, and duration of the process cycle are monitored, controlled, and logged. The consistent profile of these variables is evidence of appropriate debonding parameters and may be used for statistical process control.



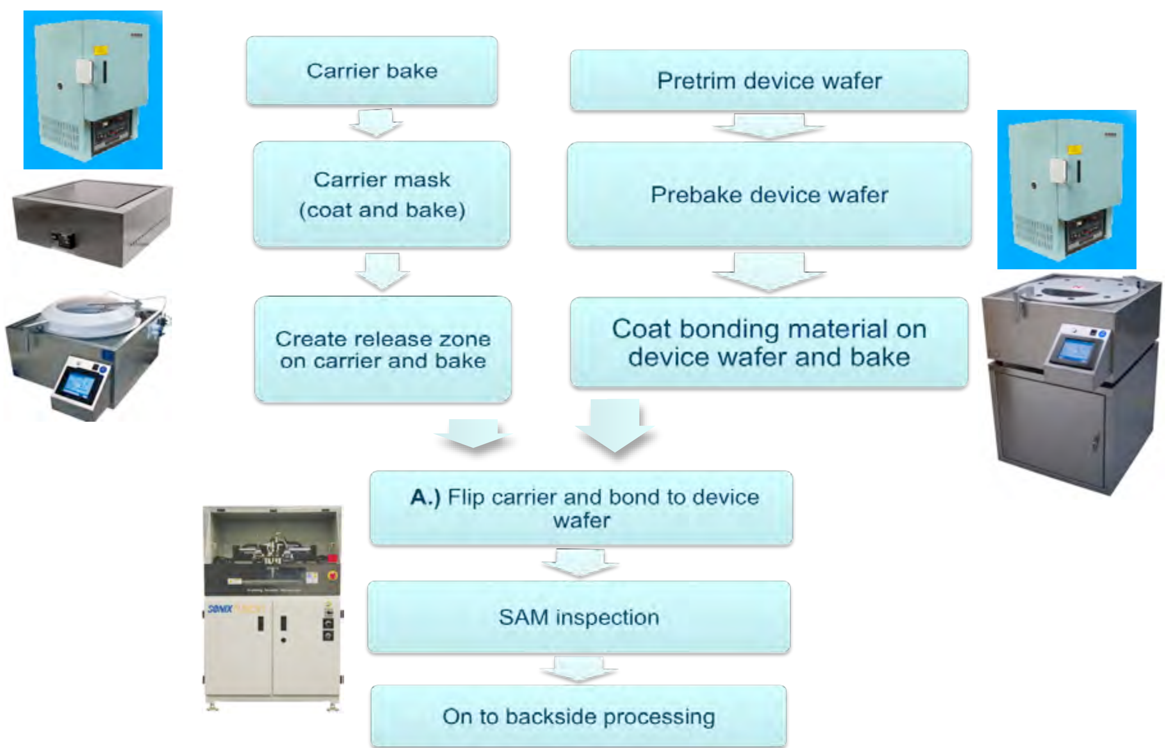


The latest low-stress, high-volume bonding technology is known as the Brewer Science® ZoneBOND® process. This process is capable of separating large-format wafer pairs (with diameters of 200 mm or larger) containing large topography and/or perforations at ≤ 4 minutes per debonding cycle (≥14 wph for 200-mm wafers). This technique features a high-tack stiction zone about 1.5 to 4.5 mm wide at the outer circumference of the carrier, and the center is treated with a low-stiction material. The device wafer is then coated with the thermoplastic bonding material and is thermally compressed to the carrier, as with the two previous bonding techniques.

Following the thinning and backside processing, the device wafer is separated from the carrier at room temperature. However, before separation, the stiction zone at the edge must first be weakened or removed. This preparation can be performed on a ZoneBOND® edge preparation tool, which features a rotary system designed to hold a full cassette of bonded pairs and rotate the substrates at 0.3-0.5 rpm while exposing the outer 5 mm of the wafer pairs to a solvent that removes the temporary bonding material.

After the edge zone is prepared, the device wafer is mounted to another temporary carrier such as a film frame and is then loaded into the ZoneBOND® separation tool. In the Brewer Science® ZoneBOND® separation tool, the mounted device wafer is supported with vacuum applied through a full-surface porous ceramic chuck and a concentric clamping ring completely surrounds the perimeter of the carrier wafer during the separation sequence. During the debonding step, the porous vacuum chuck is precisely lowered by means of a pneumatic proportional valve while the positively gripping clamp ring applies force to at least one edge of the carrier in the away from the device wafer and completes the peel separation. After debonding is completed, the mounted device wafer is extracted.

The ZoneBOND® process is compatible with all wafer sizes, thicknesses, materials, and surface topographies. It is also uniquely suited to safely handle substrates without planar surfaces (that is, surfaces that are not vacuum compatible) containing large through-hole perforations and/or front-side topography. This methodology uses the following process flow.



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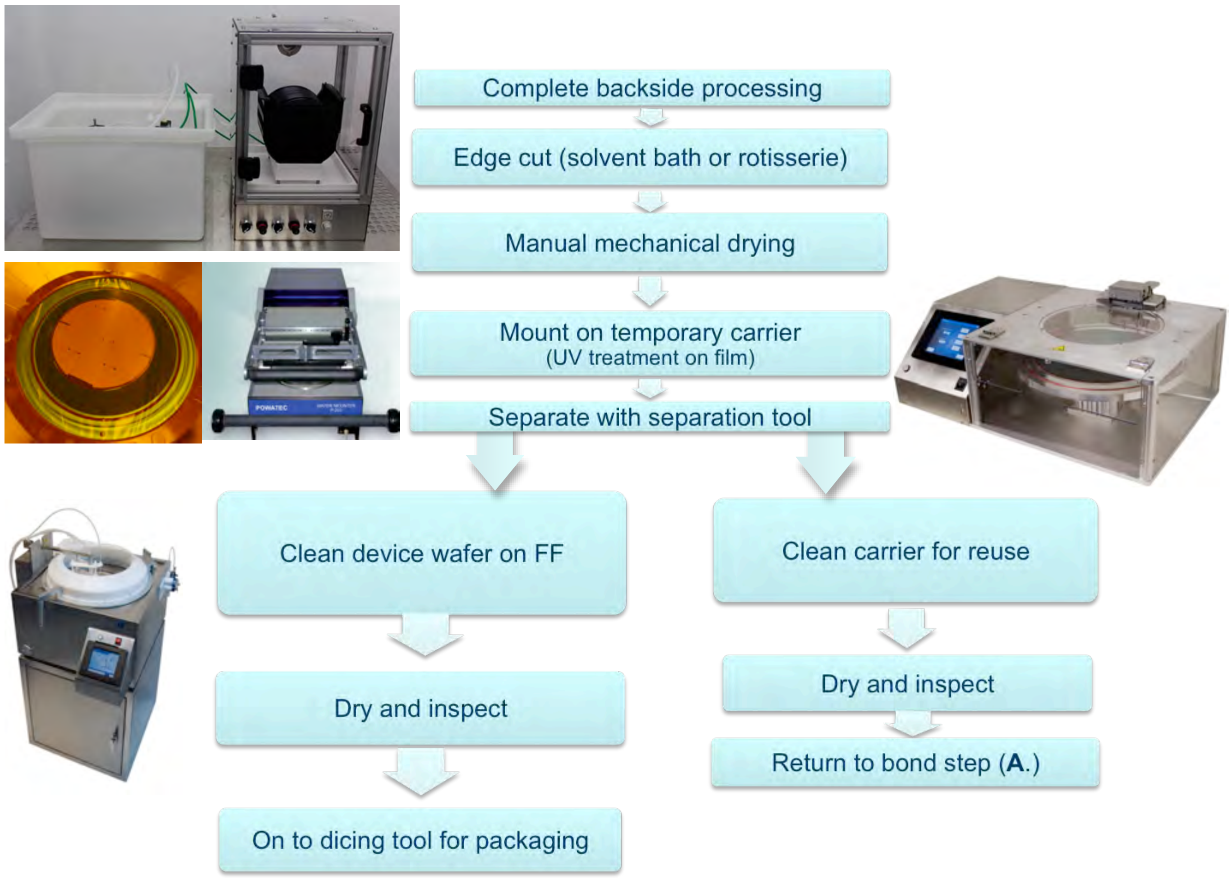

Conclusion
All three of these thin wafer handling technologies have been used successfully in device production. When you are deciding on the best process for your device, consider your thermal budget, throughput, and volume.

For questions about process methodologies for temporary thin wafer handling solutions, please email info@brewerscience.com, or visit http://www.brewerscience.com/thin-wafer-handling-packaging.

About Brewer Science
Brewer Science is a global technology leader in developing and manufacturing innovative materials, processes, and equipment for the reliable fabrication of cutting-edge microdevices used in electronics such as tablet computers, smartphones, digital cameras, televisions, and LED lighting. Brewer Science provides process flexibility and a competitive edge for its customers and plays a critical role in the supply chain. Since 1981, when its ARC® materials revolutionized lithography processes, Brewer Science has expanded its technology to include products enabling advanced lithography, thin wafer handling, 3-D integration, chemical and mechanical device protection, and products based on carbon nanotubes and nanotechnology. With its headquarters in Rolla, Missouri, Brewer Science supports its worldwide customers through a service and distribution network in North America, Europe, and Asia.