Process 2.1

Handle Wafer Bonding For Etch Processing

1.0 Process Summary

1.1 Certain processes in the Nanolab require handle or breakthrough wafers to handle exotic substrates or through wafer processing. Reversible bonding attaches chips and wafers to these handle wafers with a secure bond that can handle robust mechanical handling.

2.0 Material Controls & Compatibility

2.1 Selection of bonding material is process dependent and critical to the success of subsequent processes. Be sure to consult with staff if you are unsure of your ideal bond material.

3.0 Applicable Documents

3.1

4.0 Definitions & Process Terminology

4.1 Crystalbond 590: A polymer wax that maintains solid structure at room temperature and liquefies at ~120 C.

4.2 Santovac 5: A diffusion pump oil with vapor pressure <1x10E-10 Torr. Does not solidify.

4.3 Cool Grease: A thermal grease which can be used for temperature-control-critical etch processing.

4.4 I-line Photoresist: Nanolab standard i-line resist

4.5 KMPR: Specialty negative resist made by MicroChem

4.6 Heat Release tape: Double sided tape that debonds at a specific temperature.

4.7 Handle Wafer: Any wafer upon which a bonded device is attached

4.8 Breakthrough Wafer: A special handle wafer used in Deep Reactive Ion Etch (DRIE) processing when the device substrate is expected to etch through the wafer and potentially damage the chuck underneath the substrate.

5.0 Safety

5.1 Several processes use heated bonding methods. Wafers can become quite hot and care should be used while handling them.

5.2 Several debonding processes use solvents to dissolve bonding chemistries. Read the Nanolab Chemical Hygiene Plan for details with solvent safety.

6.0 Process Data

6.1

7.0 Process Explanation

7.1 Pitfalls: There are two primary goals of wafer bonding: thermo-mechanical integrity, and chemical stability during process

7.1.1 Thermo-mechanical Integrity

7.1.1.1 The most likely place for a bonded wafer to fail mechanically is within the bonding material itself.

7.1.1.2 If bonded at atmosphere, wafer bonding materials at best have absorbed gases and at worst can have small bubbles within the bond matrix.

7.1.1.3 These trapped gases are typically trapped at atmospheric pressure and then enter a high vacuum system. Large enough bubbles can exert atmospheric pressure on the handle and bonded devices.

7.1.1.4 Bonded systems with these large internal pressures typically bow outside of the ability of the processing chamber's mechanical tolerances, or shatter in the subsequent processing steps.

7.1.1.5 Additionally, these problems are exacerbated by subsequent plasma processes as plasma processing tends to alternately heat and cool a substrate.

7.1.1.5.1 Crystalbond in particular is likely to undergo phase changes during long DRIE processing and allow extreme bubble growth between the bonded objects. Crystalbond can also exhibit thermal creep as the wafer heats, crystalbond melts, and the bonded objects thermally expand. After the heat is removed, the crystalbond can re-solidify prior to fully cooling the substrate materials, resulting in extreme wafer bow to the point that mechanical handling pins and arms for many etchers cannot properly remove the substrate from the tool.

7.1.1.6 When bonding a material, weight is a concern. Almost all of the Nanolab mechanical arms are built to carry a single wafer, rather than two at once. Additional weight can cause the mechanics to behave abnormally. Check with staff for guidelines on a given tool.

7.1.1.7 Under no circumstances should any bonding material aside from KMPR come in contact with the mechanics of any system you place a bonded wafer into. For use as a wafer replacement, KMPR requires specific staff approval from the Process Engineer in charge of the tool in which you are processing the wafer.

7.1.1.8 The solution to thermo-mechanical issues is to apply a **clean, continuous, and thin** layer of bonding agent to the handle wafer. Standard adhesive "less is more" methods are best. The less bonding agent between your wafer and your handle, the better the heat transfer and the more mechanical integrity the bond will provide.

7.1.2 Chemical Stability

7.1.2.1 Wafer bonding compounds must be selected to survive the processes being run.

7.1.2.1.1 Almost all of our compounds dissolve or are affected by solvents. Do not place any bonded wafer into a solvent tank which has not been specifically called out for use with bonded wafers.

7.1.2.2 The bonding compouds used at the lab typically are very resistant to etch chemistries, but in general keeping them out of contact with plasma etch bombardment prevents major process shifts in the tool. Always remove any bonding agent that is not directly under your device wafer or chips.

7.2 Material Selection

Bond Material	Cost/bond	Thermal Performance	Rec. Solvent	Pros	Cons	Application
Crystalbond	Low	Thickness Dependent	Acetone	Well Understood	Solid/liquid transform temp	Chip Bonds Wafer Bonds
Santovac	Low	Thickness Dependent	Acetone	No Phase Change	Messy	Full Wafer Bonding Room Temp Bonding
Cool Grease	Low	Excellent	Acetone	Excellent Heat Transfer	Particle Generator	Extreme Thermal Requirement
I-line Photoresist	Low	Thickness Dependent	PRS-3000	Available on track	Poor Heat Xfer	Chip/Wafer Bonds
KMPR- **STAFF APPROVAL ONLY**	High	Fair	Remover PG	No Breakthrough wafer Req'd	Expensive	Breakthrough Wafer Replacement
Thermal Tape	Low	Good	Heat Release	Easy to use	Short process only	Chip/Wafer

Table 1. Bonding Material Selection Chart

7.2.1 The above chart is useful when selecting your preferred bonding material. Note the application column. Make sure to use an appropriate material for your process application. Consult process staff if you are working with a new material and need assistance in choosing your bond method.

7.3 Practice, Practice, *Practice*

7.3.1 Wafer bonding is a craft skill, not a science. Practice is key to obtaining proficiency. It is highly recommended to check out a clear borosilicate wafer from the Nanolab and practice bonding technique with that wafer until you complete a bond that is bubble-free on the interface. Most wafer bonding methods used for etching are reversible and you can try many times with just one wafer.

8.0 ***Process Procedure***

8.1 Select your handle wafer. Consult with process staff for a given tool when selecting a handle wafer as these are typically process specific.

8.2 Generally, the process of bonding a wafer to a handle has three steps: Cleaning, Bonding, and Removal

8.3 Cleaning:

8.3.1 (Optional) Wipe all bonding with acetone to remove any organic contaminants

8.3.2 Wipe all surfaces with IPA to remove residue from acetone wash

8.3.3 Wipe all surfaces with DI water to remove IPA residue

8.3.4 Dry surfaces with N2 gun

8.3.4.1 If tolerable for the given substrate and handle wafers, bake at 125C for 2 minutes on a clean hot plate

8.4 Bonding

8.4.1 Bonding depends on the material chosen

8.4.2 Crystalbond (non-spinning process):

8.4.2.1 Heat substrate & handle wafer to 125 C

8.4.2.2 Apply crystalbond wax to the bonding surface of the handle wafer

8.4.2.3 Using a glass slide or razor blade, thin the bonded material as much as possible

8.4.2.4 Increase heat (Max 150 C) until bubbles trapped in crystalbond film pop. Expect ~10 minutes.

8.4.2.5 Place chips onto bonding zones

8.4.2.6 Use razor blade to scrape away any wax not under the chip

8.4.2.7 Slow cool substrate to room temperature by placing on techwipe

8.4.2.8 Check in IR camera/scope to determine presence of bubbles

8.4.2.9 Wipe remaining wax away with acetone swab.

8.4.2.10 Wipe away acetone with IPA, wipe away IPA with DI water. Heat to 150C to dry ~5 minutes.

8.4.3 Crystalbond (Spun Process):

8.4.3.1 Mix 20g crushed crystalbond into 101ml acetone

8.4.3.2 Spin coat mixture at 1500 rpm onto handle wafer

8.4.3.2.1 Clean lid of crystalbond bottle thoroughly to prevent wax sealing of lid.

8.4.3.3 Allow to air dry for 5 minutes

8.4.3.4 Heat to 90 C for 1 min to evaporate remaining acetone.

8.4.3.5 Heat to 125C for 3 min or until crystalbond is melted.

8.4.3.6 Place device wafer onto melted crystalbond.

8.4.3.7 Align flats

8.4.3.8 (Optional) Place weight on wafer to ensure good contact. Wait 4 minutes

8.4.3.9 Remove wafer from heat, allow to cool 30 minutes.

8.4.3.10 Check in IR camera/scope to determine presence of bubbles

8.4.4 Santovac 5

8.4.4.1 Dispense about 1cc of Santovac 5 onto your handle wafer.

8.4.4.2 (Optional) Heat to 100C

8.4.4.3 Spread Santovac 5 with glass slide or razor blade

8.4.4.4 If heating, allow bubbles in film to grow and pop (~10 min)

8.4.4.5 Place device wafer onto Santovac 5 surface

8.4.4.6 (Optional) Place weight onto wafer stack to ensure good contact.

8.4.4.7 Allow to rest for 5 minutes.

8.4.4.8 If heating, cool wafer on cooling plate

8.4.4.9 Check in IR camera/scope to determine presence of bubbles

8.4.5 Cool Grease

8.4.5.1 Use a clean glass slide to spread Cool Grease on the handle wafer. The thickness of the Cool Grease after spreading should be about 300 μm to 600 μm.

8.4.5.1.1 For die level bonding, use just enough cool grease to bond the die to the handle wafer (i.e. it is not necessary to cover the entire handle wafer with Cool Grease)

8.4.5.2 Heat the handle wafer to 50C, align and place chips or device wafer

8.4.5.3 (Optional) Place weight onto wafer stack to ensure good contact.

8.4.5.4 Bake at 50C for 10 minutes

8.4.5.5 Inspect bonded wafers and remove any excess material (Do not expose cool grease in line of sight to plasma)

8.4.5.6 Check in IR camera/scope to determine presence of bubbles

8.4.6 Thermal Release Tape

8.4.6.1 Place stack without removing adhesive backing layers.

8.4.6.2 Use razor blade to shape tape

8.4.6.3 Remove backing layer of one side of double sided tape

8.4.6.4 Attach to handle wafer – use glass slides to apply without wrinkles

8.4.6.5 Remove other backing layer from top surface of tape

8.4.6.6 Apply device wafer to handle wafer

8.4.6.7 (Optional) Place weight onto wafer stack to ensure good contact.

8.4.7 Photoresist

8.4.7.1 Coat handle wafer with 2um G-line photoresist

8.4.7.2 Align device wafer to handle wafer and lightly press together

8.4.7.3 Check in IR camera/scope to determine presence of bubbles

8.4.7.4 (Optional) Place weight onto wafer stack to ensure good contact.

8.4.7.5 Load into vacoven, hold wafer under vacuum at 90C for 30 minutes

8.4.8 KMPR Spin on breakthrough wafer replacement

8.4.8.1 Always see staff for specific guidance when using KMPR backside coatings. This process is wafer specific.

8.5 Removal

8.5.1 Removing your handle wafer is necessary to do some processes after the process requiring a handle wafer.

8.5.2 Crystalbond, Cool Grease

8.5.2.1 Acetone should be used to remove your handle wafer from your devices. Typically this can take from 5 minutes to a few hours depending on size of wafer and/or chip.

8.5.2.2 Rinse in IPA and then DI Water

8.5.3 Santovac 5

8.5.3.1 If possible, separate wafers laterally

8.5.3.2 Immerse in or spray with acetone to remove santovac 5.

8.5.3.3 Rinse in IPA and then DI Water

8.5.4 Thermal Release Tape

8.5.4.1 Heat wafer to 180 C and separate device wafer.

8.5.4.2 Clean residue with Acetone/IPA/DI Water

8.5.5 Photoresist

8.5.5.1 Remove in acetone or PRS-3000 immersion baths.

8.5.5.2 Wafers that are known to be particle-free during stripping may enter PRS-3000 dedicated baths with proper fixturing to contain released wafers

8.5.6 KMPR

8.5.6.1 Immerse in RemoverPG at 80C for 10-20 minutes.

9.0 Troubleshooting Guidelines

9.1 Wafer Shattered

9.1.1 Application of bonding agent likely too thick. Try using a razor blade or a glass slide to thin the compound.

9.2 Photoresist burned on handle wafer

9.2.1 Wafer bonding agent is too thick, spend more time on thinning step. Ideal wafer bonding agents are <200um thick. (Exception: Cool grease <600um)

NanoLab Qualification Form

Reversible Wafer Bonding For Etch Processing

Name ____________________ **Office** _________________ **Date** ________________

Campus Phone _____________________ **Home Phone** _____________________

Login _____________________________ **Trainer** _______________________

Oral Qualification Checklist

- o What are the three goals for solutions to handle layer thermo-mechanical integrity?
- o Describe the crystalbond thermal creep cycle.
- o Do you need staff approval to use a KMPR spin-on breakthrough wafer?
- o Are any bonding materials allowed to be in line of sight to plasma chemistry?
- o Do you need to understand the mechanical handoff equipment of your targeted processing tool before you develop a bonding scheme?
- o What are the two room temperature bonding methods?
- o Which bonding methods are compatible with photoresist development and strip chemistry?

Superuser Login Name __________________ Date ___________

Superuser Signature________________