Temporary Bond Material and Process: Survey Drivers and Reference Flow

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Outline

• 3D TSV Outlook
• 3D TSV Integration Reference Flow and Temporary Bonding Challenges/Survey Drivers
3D options
(ref: 2009 ITRS)

- 3D system-in-package
  - Eg: wire bonding, package-on-package
- 3D wafer-level packaging
  - TSVs used at bond pads
  - Eg: stacked memory, CIS
- 3D global interconnects
  - Stacked IC, 3D system-on-chip, “through silicon stacking”
  - TSVs connect circuit blocks at the global wiring level
- 3D intermediate interconnects
  - Higher density than global
  - Interconnects smaller circuit blocks
- Local (device) level
  - Transistor level stacking
3D TSV Outlook

- Near future (2011 - 2013)
  - Interposer products
  - Wide IO DRAM (mobile)

  - Heterogenous integration (beyond memory on logic)
  - Higher (>> 5 stacking levels)
  - Smaller (<< 5 micron width, >> 10 aspect ratio)

- Far future (2017 - 2025)
  - Beyond CMOS (photonics, sensors, etc)
• Other products and integrations exist
  • Wide IO provides context for SEMATECH development work
• Tier 2 could be a single die or multiple dies (Eg: a 4-tier Wide IO DRAM stack)
Various Key Process Modules and 3D-stacking Options  
(source: ITRS 2009, ISMI 2009)
Industry Reference Flows and Temporary Bonding Adhesive Challenges

Option 1 (WtW)

- Carrier wafer
  - Glass or Si

- Adhesive coating
  - Spin coating
  - Bake

- Wafer bonding
  - T/T/P

- TSV process
  - Back-grind
  - Cu reveal
  - Passivation
  - Planarization
  - RDL/Bumping

- Final bonding
  - Cu-Cu
  - Cu-Sn-Cu w/ WLUF

- De-bonding
  - De-bonding
  - Thermal/chemical/UV laser release
  - Cleaning

Issues

- Thickness tolerance
- No residual solvent
- Void free
- Alignment
- Large TTV & chipping
- Side etching
- Delamination
- Void & Delamination
- Warpage
- Void & Delamination
- Bump deformation
- Residue

Option 2 (WtW)

- Glass or Si
- Thickness tolerance
- No residual solvent
- Void free
- Alignment
- Large TTV & chipping
- Side etching
- Delamination
- Void & Delamination
- Warpage
- Void & Delamination
- Bump deformation
- Residue

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Industry Reference Flows and Temporary Bonding Adhesive Challenges

Option 3 (DtW)

Process Flow
- Carrier wafer
  - Glass or Si
- Adhesive coating
  - Spin coating
  - Bake
- Wafer bonding
  - T/T/P
- TSV process
  - Back-grind
  - Cu reveal
  - Passivation
  - Planarization
  - RDL/Bumping
- Dicing tape transfer
  - Lamination
- De-bonding
  - De-bonding
  - Thermal/chemical/UV laser release
  - Cleaning

Issues
- Thickness tolerance
- No residual solvent
- Void free
- Alignment
- Large TTV & chipping
- Side etching
- Delamination
- Void & Delamination
- Warpage
- Void & Delamination
- UV layer damage
- Residue

Option 4 (DtW)

Process Flow
- Spin coating
- Bake
- T/T/P

Issues
- Thickness tolerance
- No residual solvent
- Void free
- Alignment
- Large TTV & chipping
- Side etching
- Delamination
- Void & Delamination
- Warpage
- Void & Delamination
- UV layer damage
- Residue
Reference Flow Options

- Sematech 3D baseline: DtW, bumpless, Cu-Cu
- Reference flow options
  - Logic TSV (DtS) => Memory cube to Logic TSV (DtD) => Backend (Molding/BA/singulation)

Option 3

Option 2 or 4

Option 4
Logic die w/NCF (C4 bump face down)

C4 process for Tier 1

Tier 2 Die to Tier 1 die attach process (T/C bonding)

Molding, etc

Various temporary bonding/debonding supports are required for WtW and DtW processes.
### Temporary Bond Process Flow Issues

**ISSUE / CHALLENGE**
- Thickness
- Uniformity
- Room Temp?
- Method
- Throughput

**METHODS**
- Spin coat
- Laminate
- Zone
- Combination

**APPLY**
- Thickness
- Uniformity

**ALIGN & BOND**
- < 10 um
- Room Temp?
- Bond Strength

**WAFER PAIR PROCESSING**
- up to what max. temp?
- Chemicals
- Grind/polish
- Handling

**DEBOND**
- Room Temp?
- Method
- Throughput

**CLEAN**
- C4 or ubump?
- Cleaning
- chemical at dicing tape?

**Process Requirements Must be Established to Identify Temporary Bond Materials (adhesive and carrier) as well as Associated Debond Methods**
3D Temporary Bonding Adhesive Requirements

- Si or glass carrier wafer compatible
- Protect the topography of the device wafer
  - Bumped (C4 or micro-bumped) or non-bumped wafers
  - 5 um TTV (thin adhesive and thick adhesive)
- Strong enough to withstand wafer backside process
  - Thermally stable to withstand backside process
  - Chemically stable to withstand backside process
- Easily de-bonded
- Residue free
  - Device wafer side & carrier wafer side for re-use
- Other thermo-mechanical properties considerations
  - Low out-gassing, low or higher modulus for low stress and warpage, etc
Temporary Bonding Materials

• These temporary bonding materials are generally chemically stable to temperatures of 250 ºC, above which some decomposition or out-gassing occurs

• Broad range of process conditions depending on materials and bonding/de-bonding methods
  – Bonding method: thermal (High, Medium or Low temperature) or UV or others?
  – De-bonding method: Room to Low, Medium or High temperature de-bonding?
  – Adhesive thickness: any thickness guideline?
  – Thermal stability during TSV backside processes and permanent bonding
  – Cleaning chemical??

• How to differentiate the materials is primarily dependant to (1) TSV applications, (2) backside process conditions, (3) release process conditions and where to release, etc
  – Real temporary adhesive material capabilities should be evaluated not only by back end process temperatures, but also by other factors including time at those temperatures, the presence of a vacuum or pressure environment, energy level in a PECVD, and the residual wafer stress at elevated temperature
Bond Material Application Space

Max Process Temp. of Materials in Bumped Flow
Max Process Temp. of Materials in Bumpless Flow

Sn-based Solder Liquidus Start

Thermal Stability of Dicing Tape (desired debond temperature is 25 C)

Max Process Temp. of Materials in Bumped Flow

Bond Material and Debond Process Must Satisfy Process Requirements Space
Limited options if high temp processing & low temp debonding needed
Industry User Community Survey

- **Temporary Bonding / Debonding Landscape Unsettled**
  - Process / Material Selection Dependent on Reference Flow
  - Material and Tool Suppliers offer multiple solutions

- **3D TSV Reference Flow Critical to Identifying Consensus Solution**
  - Limited Feedback suggests a desire for room temperature bond and debond processes with an adhesive material which can withstand temperatures of up to 400C

- **Build Consensus**
  - Temporary Bonding / Debonding is an ENABLING technology; lowering costs requires broad acceptance of application requirements
  - Industry User Survey to help set technical requirements of Temporary Bond Materials and Debond Process; validation of reference flow approach

- **Accelerate Innovation and Collaboration**
  - Identify supplier partners to develop temporary bond solutions.