Temporary Support Systems to Enable Thin Wafer Handling During Grinding, Backside Processing, and Laser Dicing

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3D Packaging
Wire Bonding vs WLP?

- Wafer Thinning & Backside Processing -
Flip Chip Process Benefits

- Device Speed
- Power and Ground Distribution
- Signal integrity
- I/O Density with Area Array
- Lower impedance interconnection
- Package Size / Form Factor
- Low Stress Over Active Area
- Proven Reliability

[Courtesy - Flip Chip, LLC (AZ)]

- Wafer Thinning & Backside Processing -
3D assembly of integrated circuits

- Higher integration density by stacking die, e.g:
  - Homogeneous Memory Stack
  - Heterogeneous Memory Stack
  - Microprocessor & Memory Stack

- Interconnectivity: at bond-pad level
  - Digital CMOS + analog/rf chip
  - Digital CMOS + Sensor/MEMS chip
  - IC or IC stack On Si-interposer or IPD substrate

- Wafer Thinning & Backside Processing -
Market
- Wafer Thinning & Backside Processing -

Source: Yole Development
Source: Yole Development, 3D-Pkg Symposia, Semicon-West 2008
Bonders w/ Modular Flexibility

CBC 200

Automated

XBC 300

Semi-Automated

CB8

Source: Daetec, LLC, 3D-Pkg Symposia, Semicon-West 2009
Market Size

• Total: ~$4b
• Materials: $0.63b
• Equipment: $1.3b
• Services: $2b

• Source: 3D-Pkg Symposia, Semicon-West 2009
Thin Wafer Handling
What is Wafer Thinning?

- Thermal management by substrate removal
- Reduce thickness @ 700um to <25um
- >20yrs commonly by chem etch to <250um
- Current practice is grinding followed by stress relief etching - wafers with completed devices
- Backside processing follows thinning
- Mandatory with high power chips (e.g. GaAs)
- Silicon at 300mm is emerging
Typical Wafer Handling Means

- Tape
- Corresponding Wafer
- Chuck
- Carrier & Adhesive
Tape Contact

- Simple
- Inexpensive
- Grind/etch to <50um
- Limited chem/therm resistance
- Removal may be tricky (heat or UV)

Source: SEC as distributor for Nitto-Denko
Corresponding Wafer

- Cu-to-Cu bonding
- Tool & inspection for \( \uparrow \) KGD
- Grind/etch to <10um
- Possible license

Source: Patti, Tezzaron, 3D PKG Syposia, 2008
Chuck

- Vacuum or electrostatic
- Single wafer only
- Temporary only
- Substrate sensitive <50um
- Tool required

Source: EVG Debonding tool, 3D Pkg Symposia, Semicon 2009
Carrier & Adhesive

- Several configurations
- Wide range of products
- Temporary
- Therm & Chem resistant
- Stable
- Able to thin <25um
- Production capable
- Inexpensive

![Contour Plot](image1)

**A**
- TTV 6.9675
- Max 13.53
- Min 4.35
- stdev 4.010443357

**B**
- TTV 4.1825
- Max 6.21
- Min 2.1
- stdev 3.593277948

- Wafer Thinning & Backside Processing -

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Adhesive & Carrier
Thermoplastic Spin-On Adhesive Coating and Mounting Model

- Wafer Thinning & Backside Processing -
Commercial Processes

Two leading processes exist

1. Process:
   - Grind, TSV, cleans, metal

2. Process:
   - Grind, TSV, cleans, metal

- Wafer Thinning & Backside Processing -
3D Packaging Processes

Coat & Cure
- Wafer Face-Up
- ~ 600-700 um

Bond to Carrier
- Carrier
- Coated Wafer

Grind

Demount & Cleans

Backside Processing
- Lithography
- Via Etch
- Oxide Dep
- Metallization

- Thinned Wafer < 100um
- TSV, Metal Fill, & Passivation
- Thermal Diss. Layer

- Wafer Thinning & Backside Processing -
3D Packaging Processes

- Wafer Thinning & Backside Processing -
Adhesive Support for Wafer Bumping
Flip Chip Process

- Wafer Thinning & Backside Processing -
Adhesive Key Properties

- Consistent thickness
- Uniform
- Thermal resistant
- Low outgas
- Simple removal
Coating on Smooth Substrates

Thickness vs. Spin Speed

- Thickness achieve >25um
- v = 3,600
- v = 800
- v = 300
- v = 160
- v = viscosity

Spin Speed (rpm)

Thickness (um)
Pkg TTV - Adhesive Development

Formulation A
TTV 4.1825

Formulation B
TTV 6.98

- Wafer Thinning & Backside Processing -
Softening Pt by Thermal Shear

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Diagram: [Diagram of wafer thinning and backside processing]

- Wafer Thinning & Backside Processing -

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Thermal Analysis - Cured

Delta Y = 0.131 %

200C Cured

[Graph showing thermal analysis results]

1) Heat from 30.00°C to 250.00°C at 10.00°C/min
Encapsulants/Molding
Die Encapsulant - 3D Pkg

- Thickness >30um, >200um
- Adhesion to a range of substrates
- Thermal resistant
- Simple aqueous cleans
Acrylic Chemistry

- Similar to negative-tone PRs
- Same initiators as negative PRs
- Same PRs as used in WLP (bumping)
- Exposure similar to PRs
Support Chemistry

Polymethylacrylate (PMA)

Polymethylmethacrylate (PMMA)
Process Development

- Wafer Thinning & Backside Processing -

1. Spin-Coat
2. Spray
3. Heat Cure (Final)
4. UV Cure
5. Molding

Wafer w/devices
Edge Protection

Conventional Stack
- Carrier
- Adhesive
- Wafer

Little/no Edge Protection

Stack → Edge Overlay

Shear Force Grinding

Edge off grinding

- Wafer Thinning & Backside Processing -
Edge Protection

Encapsulant

Thin Carrier
- Encap
- 1st Coat
- Wafer

Stack
- Stacked Support
- Partial - Flush Support
- Total - Flush (Mosaic) Support

Encapsulant

Mosaic Process

- Wafer Thinning & Backside Processing -
Encap Highlights

- Molding process
- Uniform w/carrier attachment
- Stable to high temp, >250C, could be higher
- Large bond line access for cleans
- Aqueous cleans
Process to Tape

- Stack

- Thinned wafer

- Tape Attachment

Partial - Flush Support

Prepare for Cleans

- Wafer Thinning & Backside Processing -
Process to Dicing

- Wafer Thinning & Backside Processing -
Encapsulation Process

Molding - bottom exposure

Molding - top & bottom exposure

- Wafer Thinning & Backside Processing -
Mosaic
Mosaic (Chip Thinning)

Chip or Other (Tile)→Populated Tile Tool→Imbedding Process Tile Work
Mosaic

Embedded Tiles → Grind & Polish → Tile Release (Cleans)
Mosaic

- Wafer Thinning & Backside Processing -
Mosaic may be ground and polished on one or both sides. Once the mosaic is completed, it becomes a handling exercise. Offering polishing to either side of the mosaic provides needed process flexibility.
Summary

- Thinning is an important part of 3D Pkg
- Key processes use adhesives & carrier
- Polymers must meet desired properties
- Encap (molding) provides benefits for thin wafer handling
- Aqueous soluble may use tape-transfer
- Tape-transfer proceeds to rapid dicing
Contact for More Information

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