Back End Commonality for Advanced Packaging: Large Form Factor Project

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BEC Advanced Packaging: Large Form Factor Project

**Agenda:**

- Problem Statement
- Project Goals and Objectives
- Design Requirements
- Design Elements
- Design Flexibility
- Modeling and Simulations
- Prototype Fabrication and Evaluation
- Summary and Conclusions
- Next Steps
Problem Statement:

• With the emergence of Advanced Packaging (heterogeneous integration (HI) and system in package (SiP)), the trend is for larger packages with unique challenges both in semiconductor assembly (chip to package), as well as PCB assembly (package to board)

• Package sizes are trending well above 50X50mm with product roadmaps well over 100X100mm

• In almost all cases, each product goes through a development and NPI process with expensive tooling and NRE that adds substantially to the cost and development timelines of the product.

• One Example: Standard JEDEC form-factor handling media is limiting maximum product size and well as assembly tool efficiency. These trays provide low product density for very large products and limited density on smaller products reduces the efficiency and flexibility of the expensive assembly tools.
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Goals:

- Increase Effectiveness and Productivity in Backend Manufacturing by adopting best practices for next generation media/carrier through IC package assembly production.
- Reduce Development and NPI process investments (Custom tooling and NRE)
- Set requirements for next generation carrier trays
- Design and validate using Finite element simulation
- Fabricate prototypes
- Demonstrate user feasibility through typical IC assembly processes
Objective:

• Address key gaps for advanced packages through complex assembly processes and provides flexibility for handling different body size package
• Enable new products and product segments not limited by current JEDEC body sized
• Demonstrates the cost effectiveness of leveraging tool commonality
• Increase Backend operational efficiency
• Define large form factor product handling media that allows for flexibility and higher density
  • Ability to maximize footprint: # of packages in held in the “handling media”
  • Minimize tooling changeover times
  • Provide the same “outer design” for many different package sizes/types, thereby minimizing NRE and Increased Tool Flexibility
• Industry is rapidly transitioning from single die to heterogeneous packaging requiring more complex assembly operations with significantly larger package sizes and stacked layer construction.
IC Packaging may require heterogeneous architectures by 2030 amounting to 90% of production
- Chiplets driving assembly/test complexity
- FCBGA, Modules, and Photonic devices require more component integration which requires new backend improvements and updated standards

Move to larger packages requiring an improved handling solution
Move to assemble chiplets – up to +30 die and silicon stacking
New panel level fanout packages needing higher density and increased sized carriers
Designed for 3D and Semiconductor + photonic integration process flows
Increased FCBGA maximum body size
Design Requirements
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Requirements And Design Phase Approach

• Extending the JEDEC form factor of handling media trays
  • Improve product density per tray for very large products
  • Maintain commonality with current JEDEC tray design features
  • Eliminate antiquated tray features
  • Afford flexibility to end user for customizing design
  • Maintain/extend machine readable parameters for mfg traceability
  • Meet key mechanical requirements, e.g., Warpage, Strength, Moldability
  • Flexibility to accommodate multiple packaging formats, e.g., substrates, wafers, quarter panels, and 3D stacked structures
### Requirement’s Summary

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>This requirement specifies ONLY the outer perimeter, inside is customizable</td>
<td></td>
</tr>
<tr>
<td>Keep one dimension consistent with JEDEC</td>
<td>L = 315 mm (outside length)</td>
</tr>
<tr>
<td>Accommodate largest quarter panel size</td>
<td>300mm X 300mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>Freestanding Full Thickness = 12.19mm</td>
</tr>
<tr>
<td></td>
<td>Stacked Thickness = 10.16mm + stacking lip</td>
</tr>
<tr>
<td>2DID locations</td>
<td>Propose 1 on topside, 1 on either leading/trailing edge</td>
</tr>
<tr>
<td>Keep out area</td>
<td>5-7mm</td>
</tr>
<tr>
<td></td>
<td>7.5 mm max</td>
</tr>
<tr>
<td>Equipment Restraint</td>
<td>Tool Clamping Locations</td>
</tr>
<tr>
<td>Tool/Tray reference location</td>
<td>Initial proposal (relative to Tray 0,0,0)</td>
</tr>
<tr>
<td></td>
<td>Pin 1 location chamfer</td>
</tr>
<tr>
<td>Flatness/warpage spec</td>
<td>Restrained: 762um</td>
</tr>
<tr>
<td></td>
<td>Unrestrained: 1.5mm</td>
</tr>
<tr>
<td>Materials</td>
<td>Metal vs plastic</td>
</tr>
</tbody>
</table>
• New Tray Standard Definition to Focus on Feature Geometry Along the Trays Perimeter Only
  • Plus a small area adjacent to the perimeter, ~ 7.5mm

• Design Flexibility: Provides end-users with flexibility to accommodate unique product types and material flexibility to accommodate various process conditions/temperatures
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Design Requirement’s: Length/Thickness Equal to JEDEC

Equal Tray Lengths @ 315mm

Equal Thickness @ 12.19mm
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Design Requirement’s: Product Size and Traceability

- Must accommodate materials up to 300mmx300mm

- Machine Readable features for Smart MFG Automation
  - Defined Locations for 2DID, Barcode, and Text Characters on the Top, Leading Edge and Along the Length of the Tray to Facilitate Automated Identification
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Design Requirement’s: Tooling Engagement for Max Accuracy

- Tooling Reference Planes for Maximum Potential Positional Accuracy

- Restraining/Clamping the Tray Should Bias the Tray Towards the 3 Datum Planes for Maximum Accuracy
Design Elements
- Elimination of Scallop Alignment Feature

- Additional ‘Pin1’ Feature for Improved Orientation Detection for both Human and Machine Vision Detection Systems
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Design Elements: Tray Intermixing and End Tabs

- Tray Slip-Lock Feature Used to Prevent Intermixing of Dissimilar Trays
  - Semi-transparent view

- Mechanical Breakage of the Trays End Tabs is the Primary Failure Mode of JEDEC Trays
  - New Longer Split End-Tab Design to Improve Fracture Strength
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Design Elements: Recessed 2DID/Data Pockets

- Recessed Pockets to House 2DID Markings to Reduce In-Service Mark Wear

- Recessed Pockets Along the Trays Length to House Barcodes, Tray Identifiers, and Human Readable Text
  - Retained from JEDEC Standard
Design Flexibility
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Design Flexibility: High Density/Small Form Factor

- Accommodates most current packages
- Example: 20mmx25mm Product Size packages – 90 up
- Most Suitable for HI and SIP, 2.5D, 3D packages
- Example: 104.5mmx70.5 mm packages – 6up
Suitable for Fan Out Wafer Level Packages
- Example: 241mmx240mm Quarter Panel Size

Example: 300mm x300mm Quarter Panel Size
Tray can also accommodate 300mm wafers
Modeling and Simulations
- End Tab FEA:
- ~36% Strength Increase
- Modeling Performed Over Multiple Body Sizes Indicates Acceptable Molding Performance is Achievable

- Mold Flow Analysis: Fill Time = 1.6 s
- Mold Flow Analysis: Gating Suitability = 1.00
- Mold Flow Analysis: Max Injection Pressure
Prototype Fabrication and Evaluation
### 30 prototype trays fabricated by major tray supplier: 104.5mm x 70.5mm design

- Detailed FAI completed, meeting all requirements
- Dimensional analysis: 27 different measurements were taken of the different critical features - excellent compliance with low standard deviation and >1.33 CpK
- Warpage/Flatness measurement: measured flatness well below the specification of 0.760mm.

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
<th>Spec</th>
<th>LSL</th>
<th>USL</th>
<th>Min</th>
<th>Max</th>
<th>Avg</th>
<th>Stdev</th>
<th>CpK</th>
<th>P/F</th>
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<tbody>
<tr>
<td>1</td>
<td>Flatness</td>
<td>0.7622mm</td>
<td>0.000</td>
<td>0.762</td>
<td>0.240</td>
<td>0.28</td>
<td>0.261</td>
<td>0.013</td>
<td>13.04</td>
<td>P</td>
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<tr>
<td>2</td>
<td>Overall Length</td>
<td>315.050</td>
<td>314.750</td>
<td>315.250</td>
<td>315.070</td>
<td>315.096</td>
<td>315.085</td>
<td>0.008</td>
<td>6.67</td>
<td>P</td>
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<tr>
<td>3</td>
<td>Surface Resistance</td>
<td>10^5-10^6</td>
<td>10^4</td>
<td>10^5</td>
<td>10^5</td>
<td>10^5</td>
<td>10^5</td>
<td>-</td>
<td>-</td>
<td>P</td>
</tr>
<tr>
<td>4</td>
<td>Static charge</td>
<td>±125volts</td>
<td>±125volts</td>
<td>±125volts</td>
<td>±66</td>
<td>±30</td>
<td>±50</td>
<td>-</td>
<td>-</td>
<td>P</td>
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</table>

- New Tab: Fabricated prototype showing improved end tab strength

<table>
<thead>
<tr>
<th>STRENGTH Ø (END TAP – CHAMFER)</th>
<th>X ≥ 35.0</th>
<th>55.6</th>
<th>55.3</th>
<th>55.9</th>
<th>55.7</th>
<th>54.6</th>
<th>55.7</th>
<th>54.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRENGTH Ø (END TAP – OPPOSITE)</td>
<td>X ≥ 35.0</td>
<td>55.3</td>
<td>55.9</td>
<td>56.1</td>
<td>56.4</td>
<td>56.0</td>
<td>56.4</td>
<td>55.3</td>
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</table>

- JEDEC Tab: Showing Reduced Mechanical Strength

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<th>STRENGTH Ø (END TAP – CHAMFER)</th>
<th>X ≥ 35.0</th>
<th>39.4</th>
<th>38.6</th>
<th>39.2</th>
<th>40.3</th>
<th>39.2</th>
<th>40.3</th>
<th>38.6</th>
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</thead>
<tbody>
<tr>
<td>STRENGTH Ø (END TAP – OPPOSITE)</td>
<td>X ≥ 35.0</td>
<td>39.9</td>
<td>38.4</td>
<td>39.1</td>
<td>39.8</td>
<td>40.2</td>
<td>40.2</td>
<td>38.4</td>
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</tbody>
</table>
Multiple Users on the Project team validated the fabricated prototypes in the assembly environments – including Pick and Place Evaluation.

New format increases the assembly carrier density by 2-3X over today’s standard.
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Project summary and Conclusions

• Heterogeneous Packaging Architectures are evolving quickly and driving much larger packaging formats

• Project achieved a more flexible assembly format for:
  • Larger component assembly (more parts/tray)
  • 3D stacking capability
  • Reinforced features
  • Compatibility with elements of prior generations of equipment handling, sensing and lot monitoring as well as expanding coverage for most wafer level, panel level, and stacked component processing

• Customizable by companies based on their technologies

• Tested and validated by the key assembly companies on the team
• Provides more compatible handling between Front end and Back end of lines
• Allows Equipment Input/Output Port Flexibility
• Bridges the Growing Gap Between Typical Fab Wafer-Only Handling and Packaging Assembly
Next Steps

- Propose new standard to JEDEC
- Disseminate results through workshops and conferences
Thank You

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