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

BEC Advanced Packaging: Large Form Factor Project

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.

BEC Advanced Packaging: Large Form Factor Project

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

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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

Why is this Project Important ?

- Industry is rapidly transitioning from single die to heterogeneous packaging requiring more complex assembly operations with significantly larger package sizes and stacked layer construction

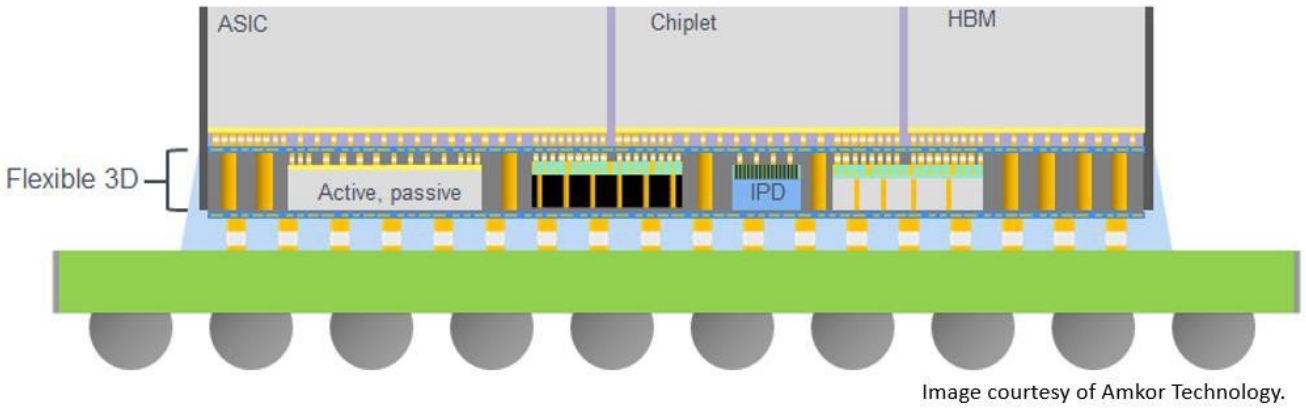
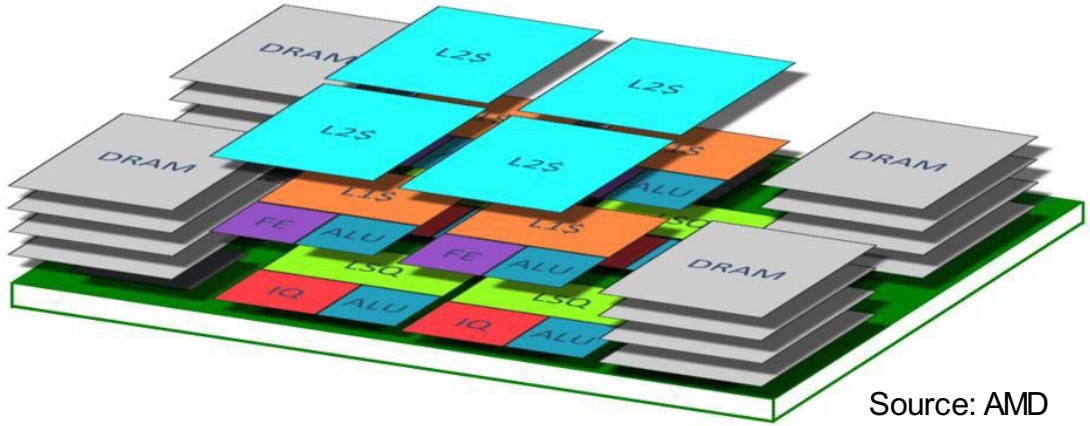


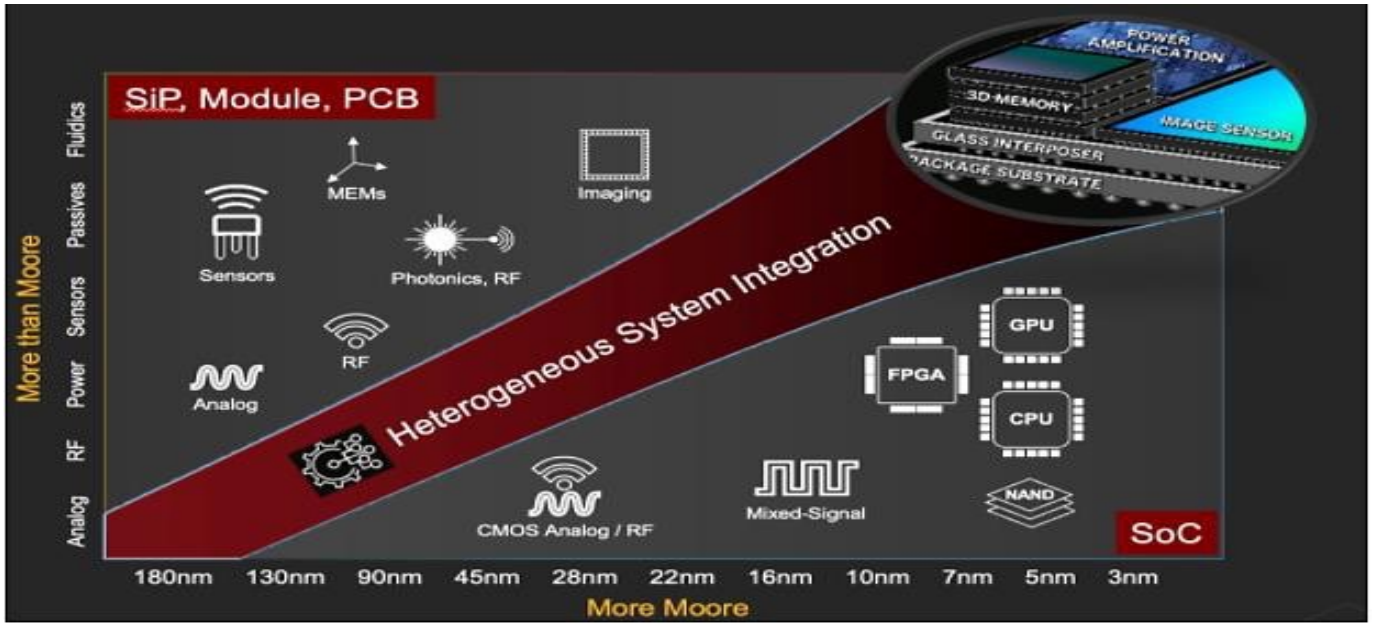
Image courtesy of Amkor Technology.

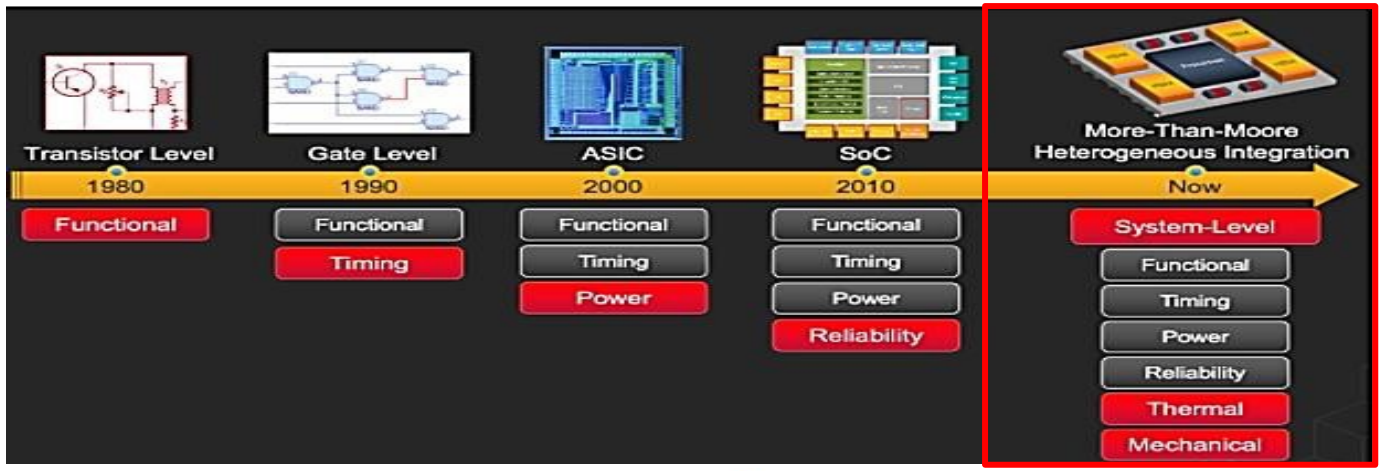


Source: AMD

Heterogeneous Architectures Driving More Integration/Larger Pkgs

- 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

BEC Advanced Packaging: Large Form Factor Project Requirements And Design Phase Approach

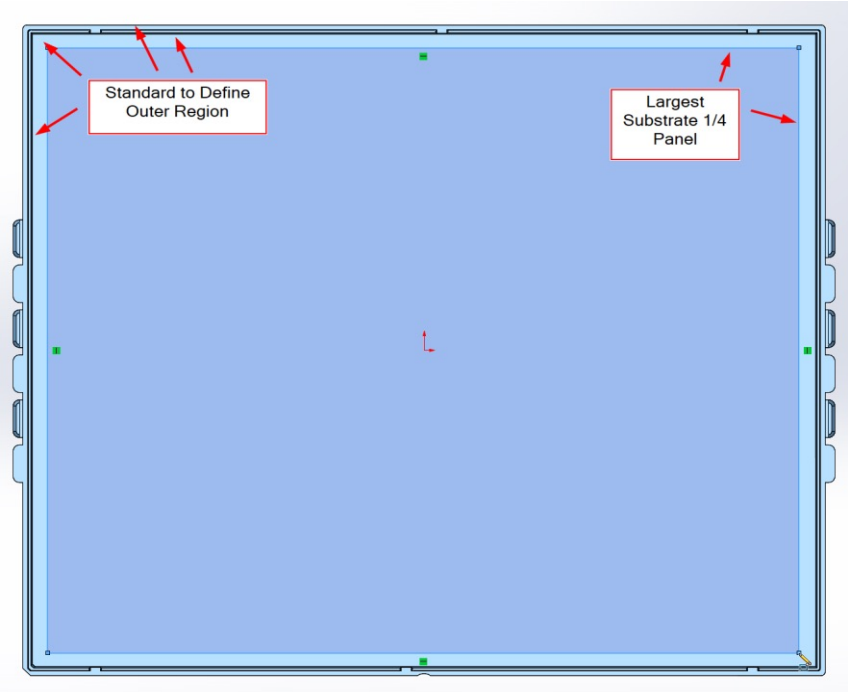
- Extending the JEDEC form factor of handling media trays
  - Improve product density per tray for very large products
  - Maintain commonality with current JEDEC tray design features
  - Eliminate antiquated tray features
  - Afford flexibility to end user for customizing design
  - Maintain/extend 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

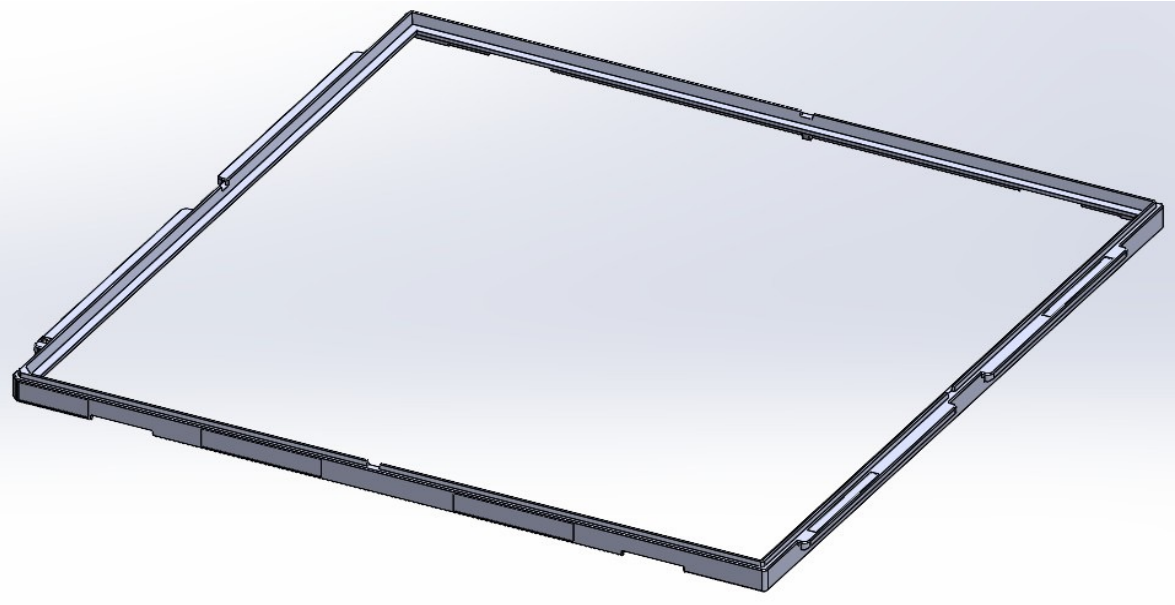
BEC Advanced Packaging: Large Form Factor Project Requirement's Summary

Requirement	Details
This requirement specifies ONLY the outer perimeter, inside is customizable	
Keep one dimension consistent with JEDEC	L = 315 mm (outside length)
Accommodate largest quarter panel size	300mm X 300mm
Thickness	Freestanding Full Thickness = 12.19mm Stacked Thickness = 10.16mm + stacking lip
2DID locations	Propose 1 on topside, 1 on either leading/trailing edge
Keep out area	5-7mm 7.5 mm max
Equipment Restraint	Tool Clamping Locations
Tool/Tray reference location	Initial proposal (relative to Tray 0,0,0) Pin 1 location chamfer
Flatness/warpage spec	Restrained: 762um Unrestrained: 1.5mm
Materials	Metal vs plastic

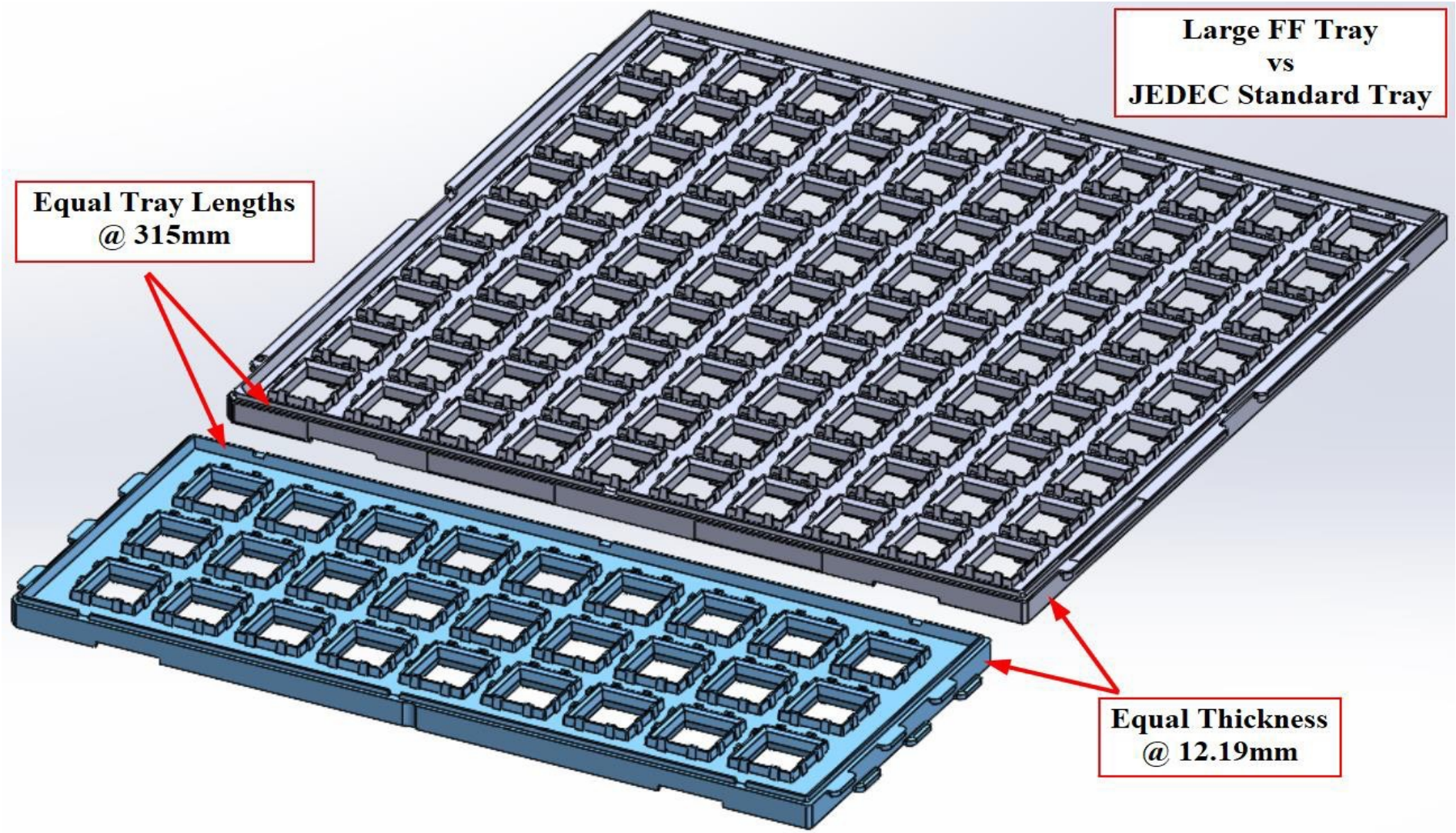
BEC Advanced Packaging: Large Form Factor Project Design Requirement's: Keep Out Zone

- 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



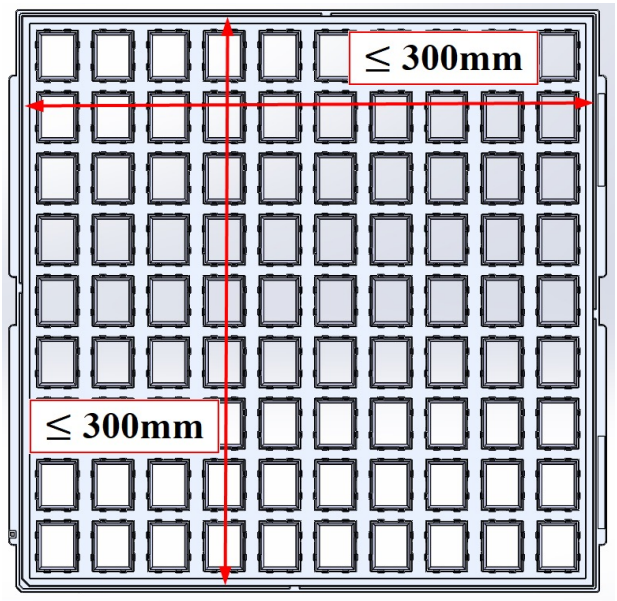


BEC Advanced Packaging: Large Form Factor Project Design Requirement's: Length/Thickness Equal to JEDEC

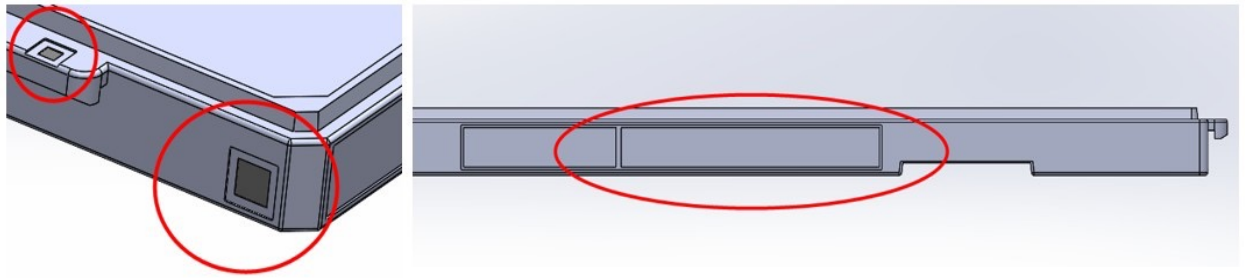


BEC Advanced Packaging: Large Form Factor Project Design Requirement's: Product Size and Traceability

- Must accommodate materials up to 300mmx300mm

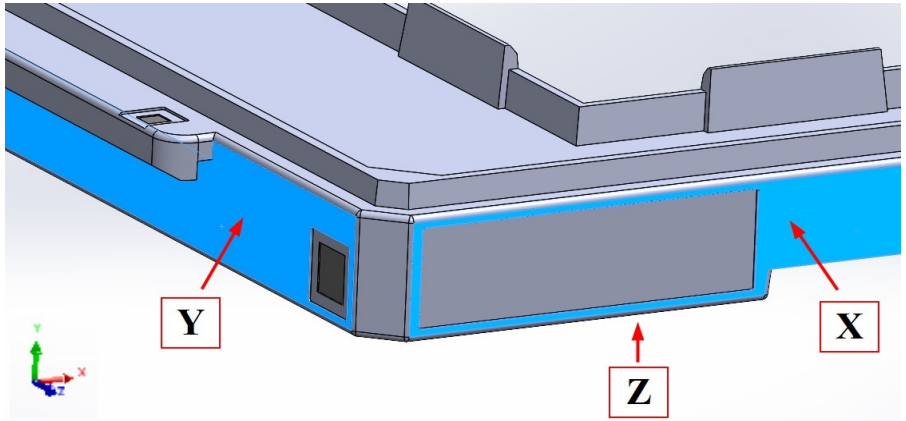


- Machine Readable features for Smart MFG Automation
  - Defined Locations for 2DID, Barcode, and Text Characters on the Top, Leading Edge and Along the Length of the Tray to Facilitate Automated Identification

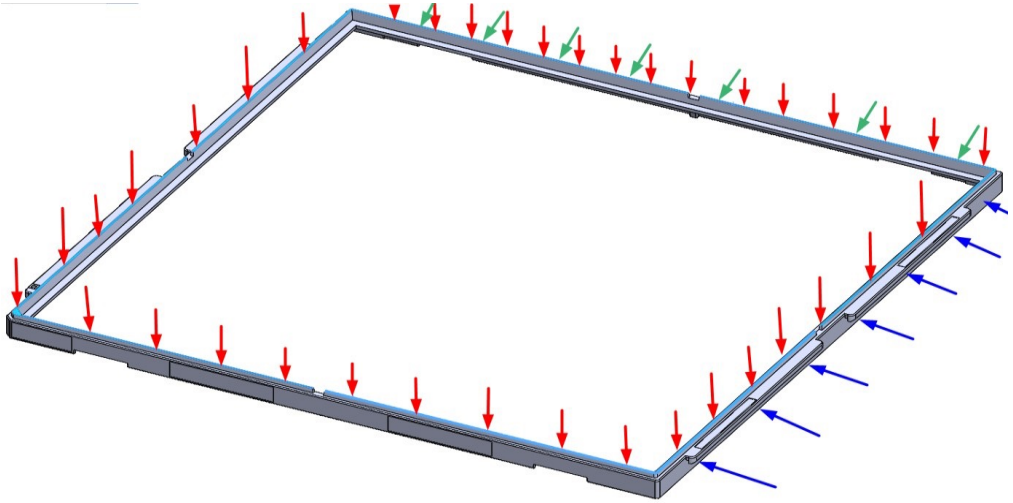


BEC Advanced Packaging: Large Form Factor Project Design Requirement's: Tooling Engagement for Max Accuracy

- Tooling Reference Planes for Maximum Potential Positional Accuracy



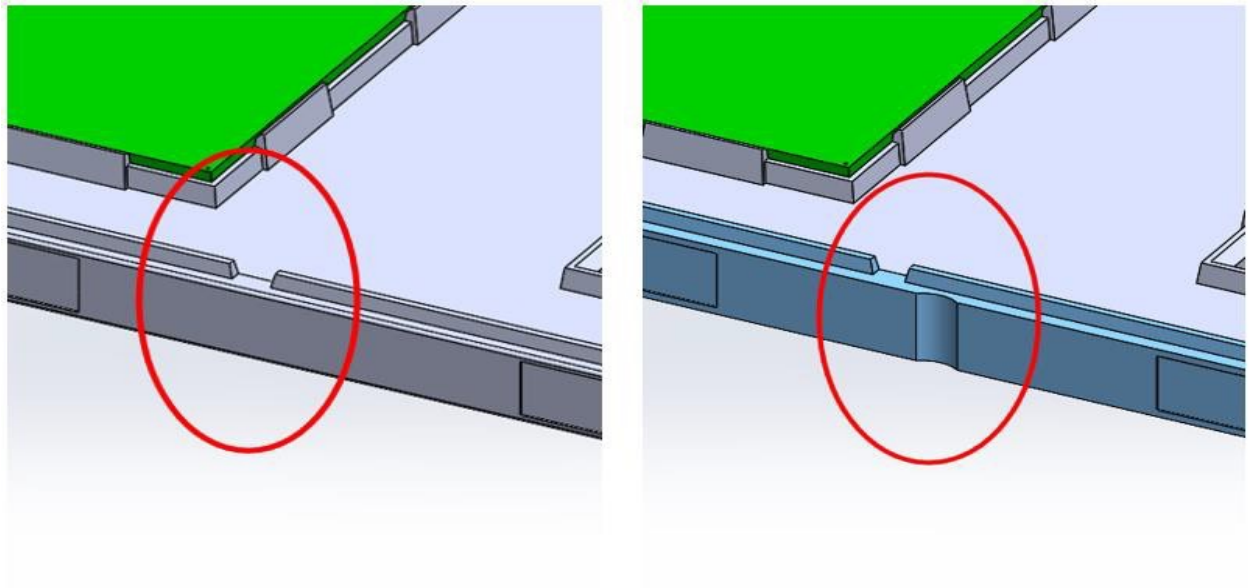
- Restraining/Clamping the Tray Should Bias the Tray Towards the 3 Datum Planes for Maximum Accuracy



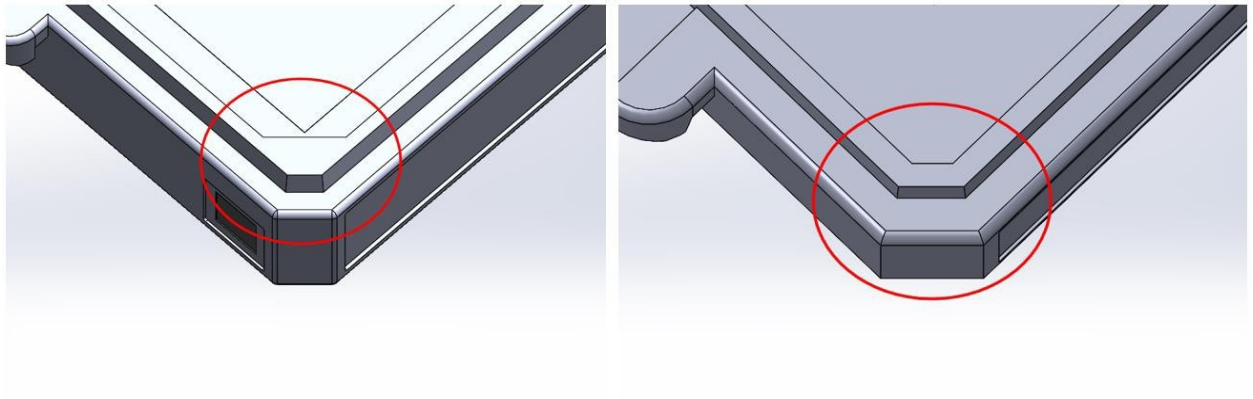
Design Elements

BEC Advanced Packaging: Large Form Factor Project Design Elements: Tray Orientation Detection

- Elimination of Scallop Alignment Feature

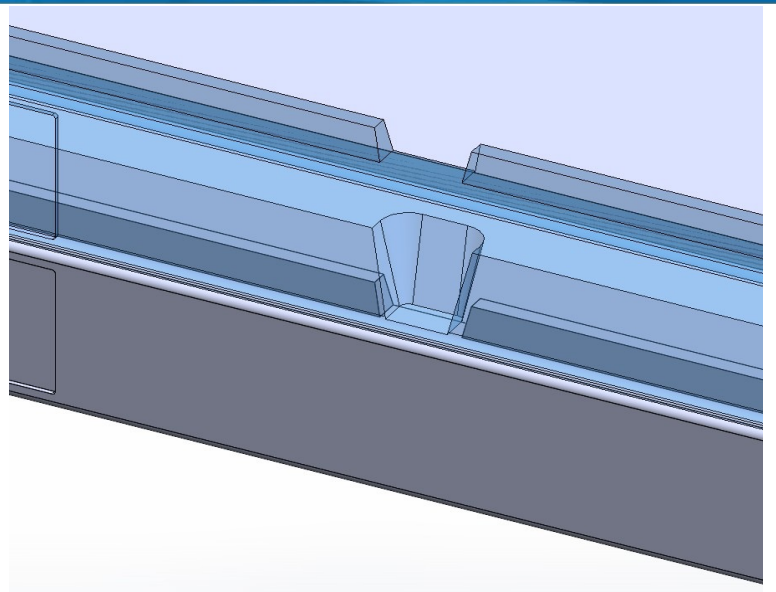


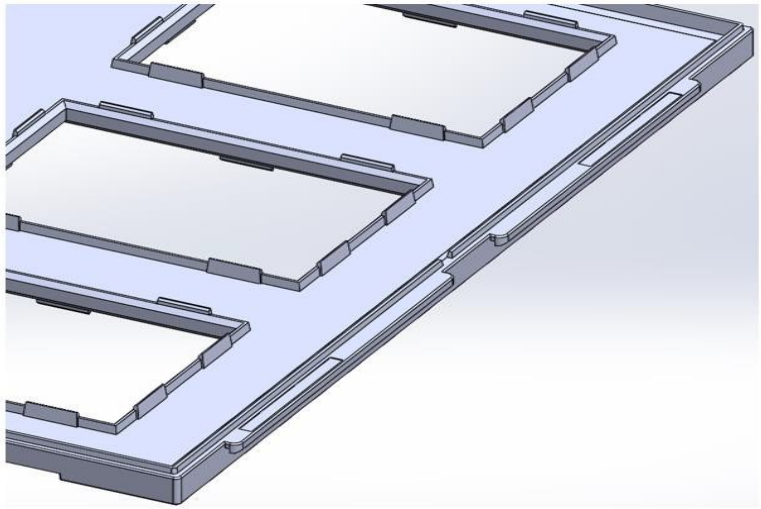
- Additional 'Pin1' Feature for Improved Orientation Detection for both Human and Machine Vision Detection Systems

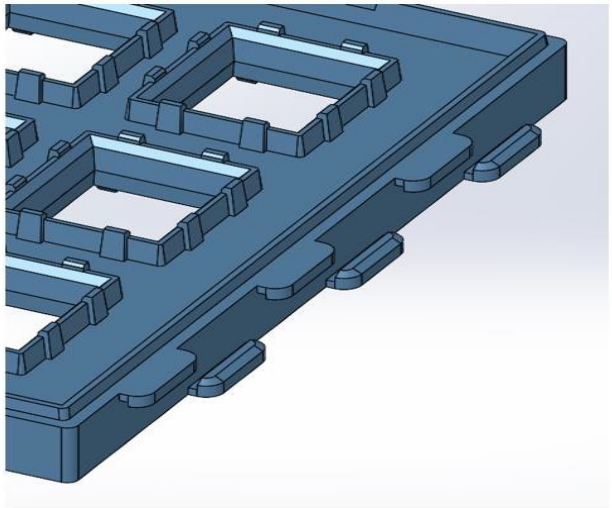


BEC Advanced Packaging: Large Form Factor Project Design Elements: Tray Intermixing and End Tabs

- 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

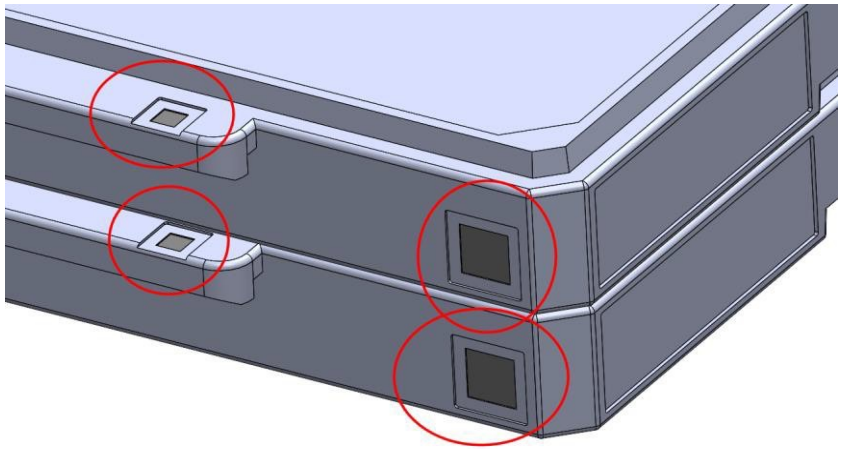




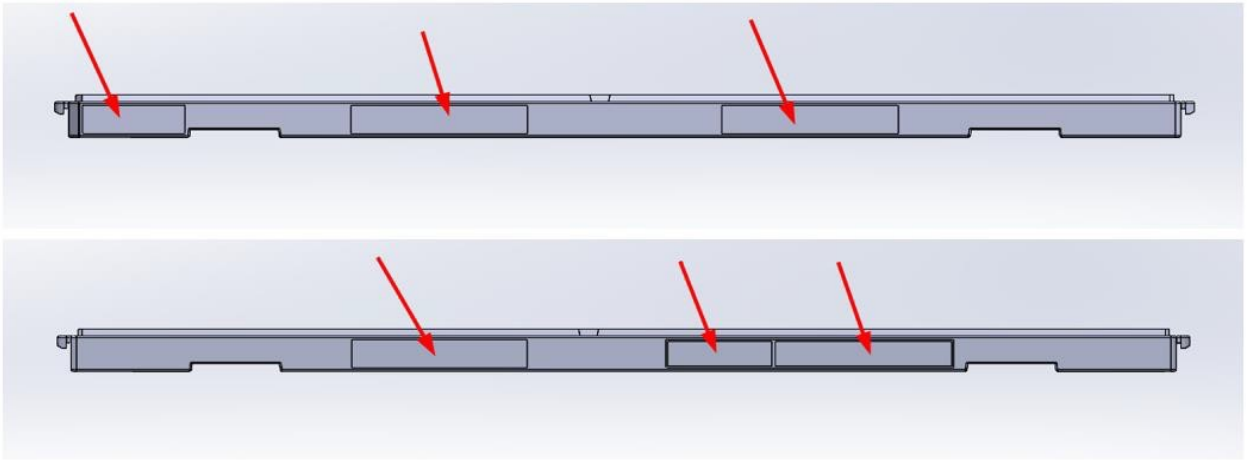


BEC Advanced Packaging: Large Form Factor Project Design Elements: Recessed 2DID/Data Pockets

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



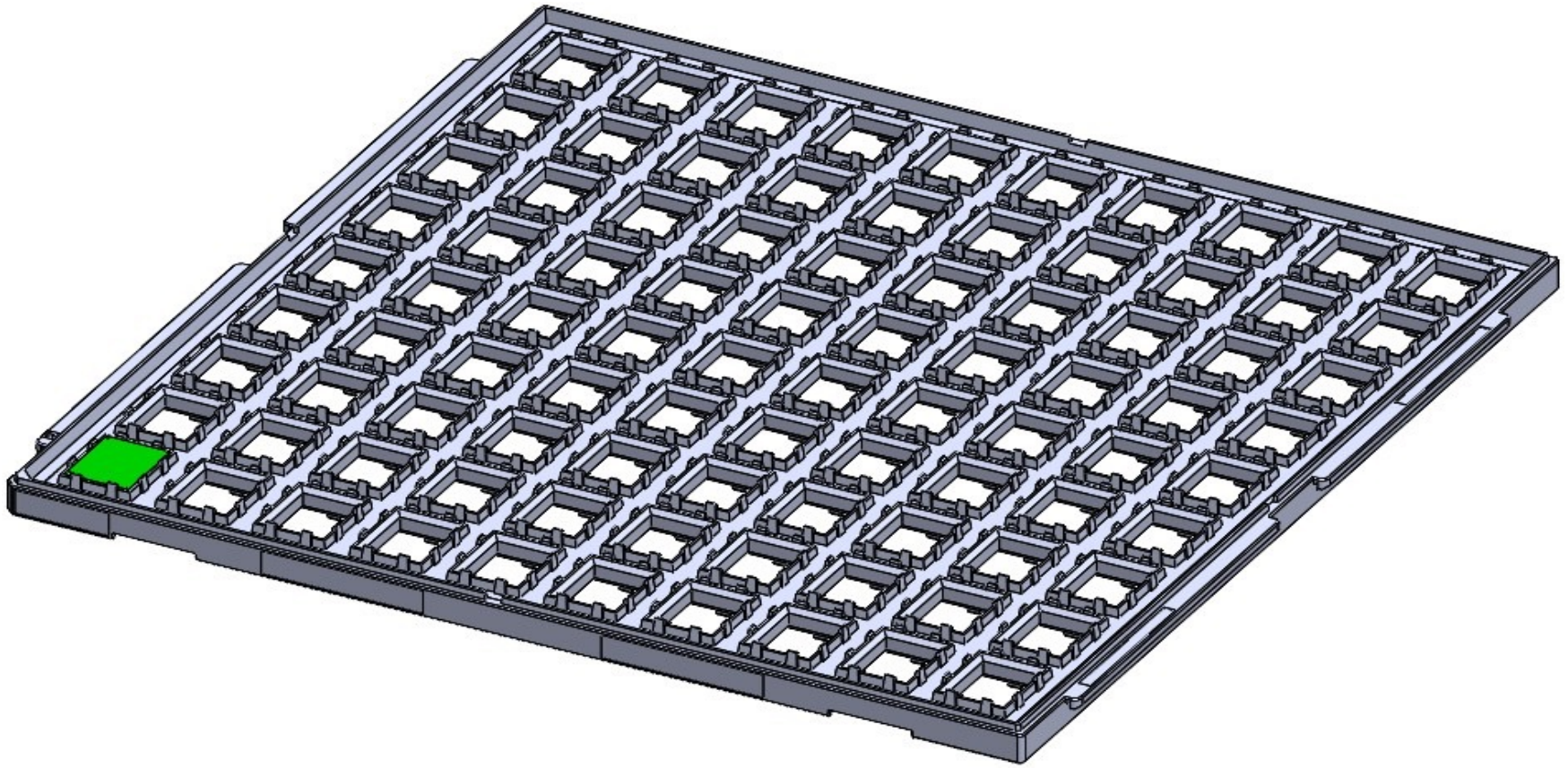
- Recessed Pockets Along the Trays Length to House Barcodes, Tray Identifiers, and Human Readable Text
  - Retained from JEDEC Standard



Design Flexibility

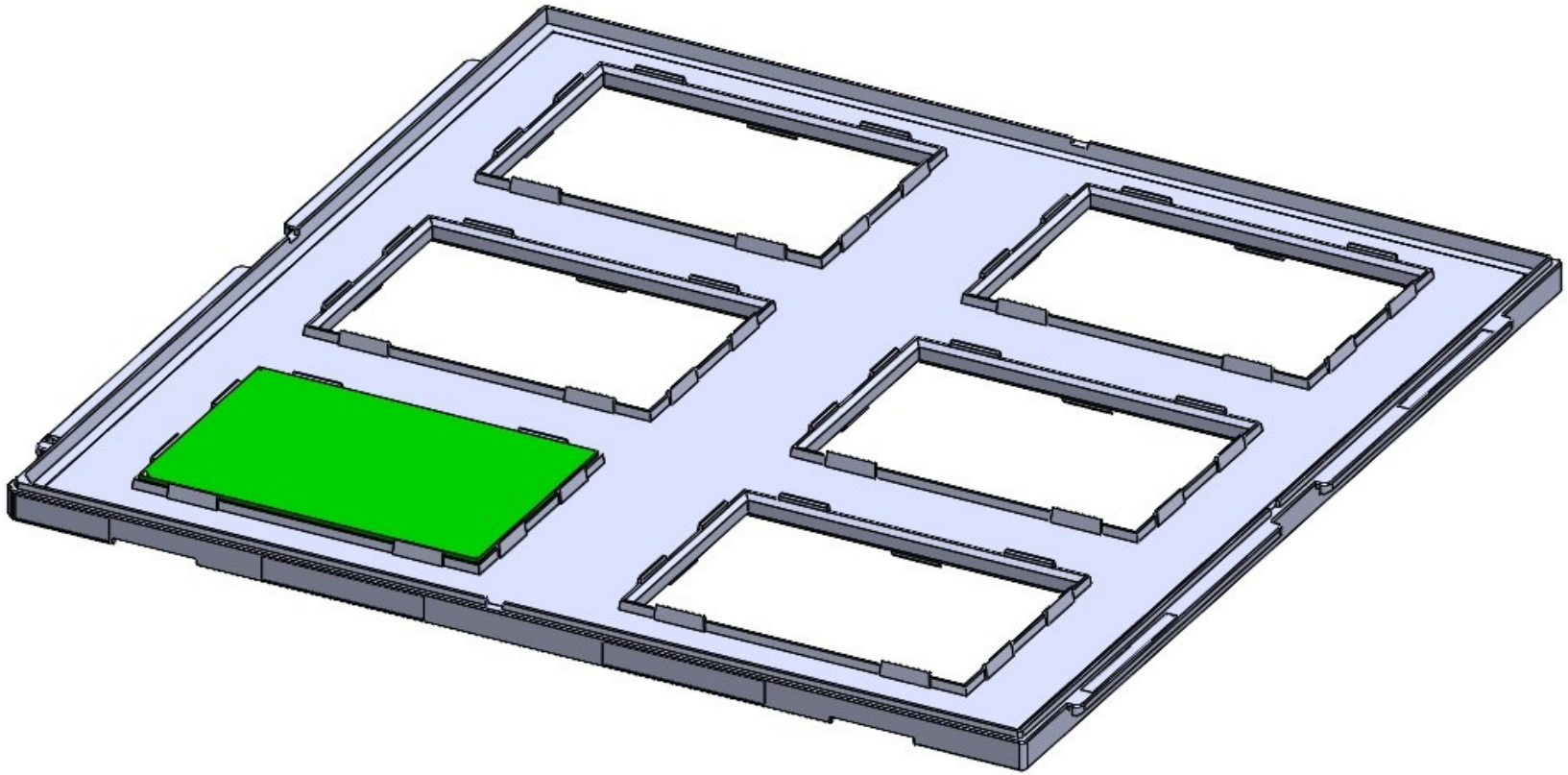
BEC Advanced Packaging: Large Form Factor Project Design Flexibility: High Density/Small Form Factor

- Accommodates most current packages
- Example: 20mmx25mm Product Size packages – 90 up



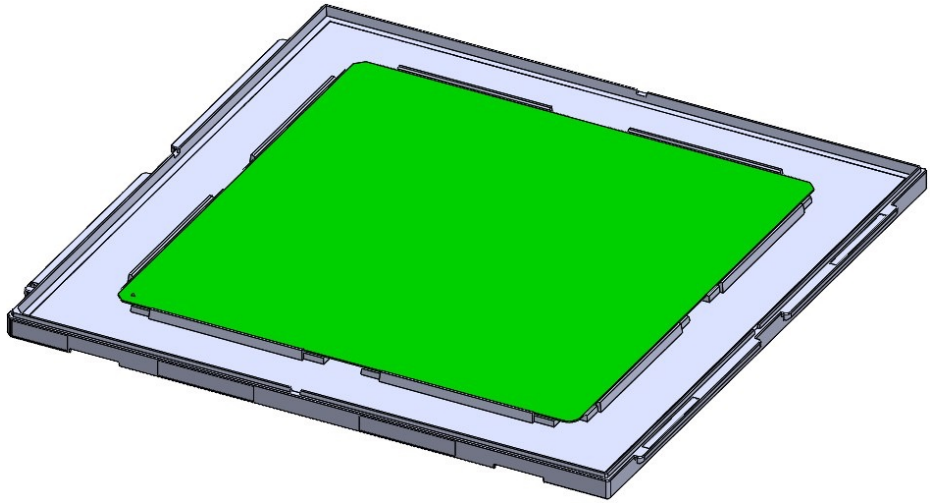
BEC Advanced Packaging: Large Form Factor Project
Design Flexibility: Low Density/Large Form Factor

- Most Suitable for HI and SIP, 2.5D, 3D packages
- Example: 104.5mmx70.5 mm packages – 6up

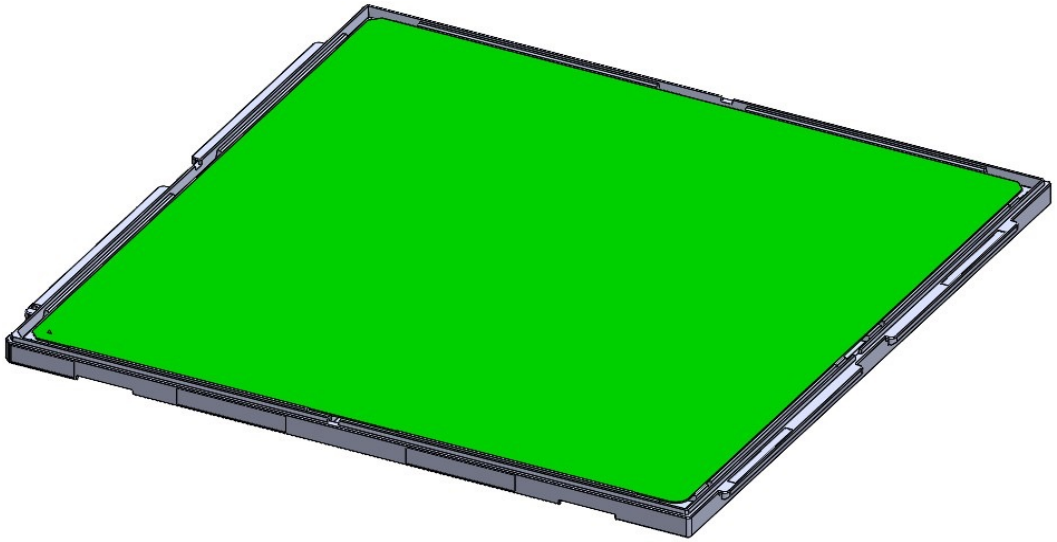


BEC Advanced Packaging: Large Form Factor Project Design Flexibility: Quarter Panel Options

- Suitable for Fan Out Wafer Level Packages
  - Example: 241mmx240mm Quarter Panel Size

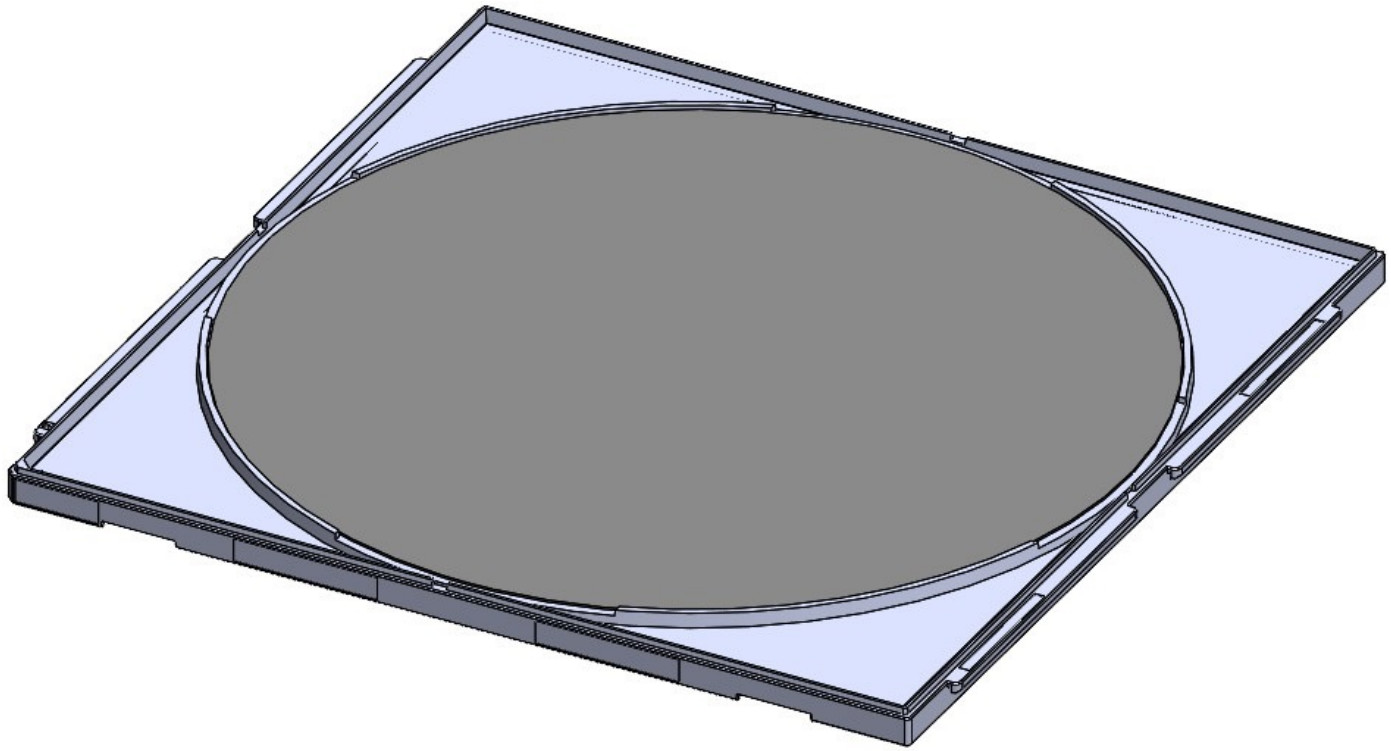


  - Example: 300mm x300mm Quarter Panel Size



BEC Advanced Packaging: Large Form Factor Project Design Flexibility: 300mm wafer option

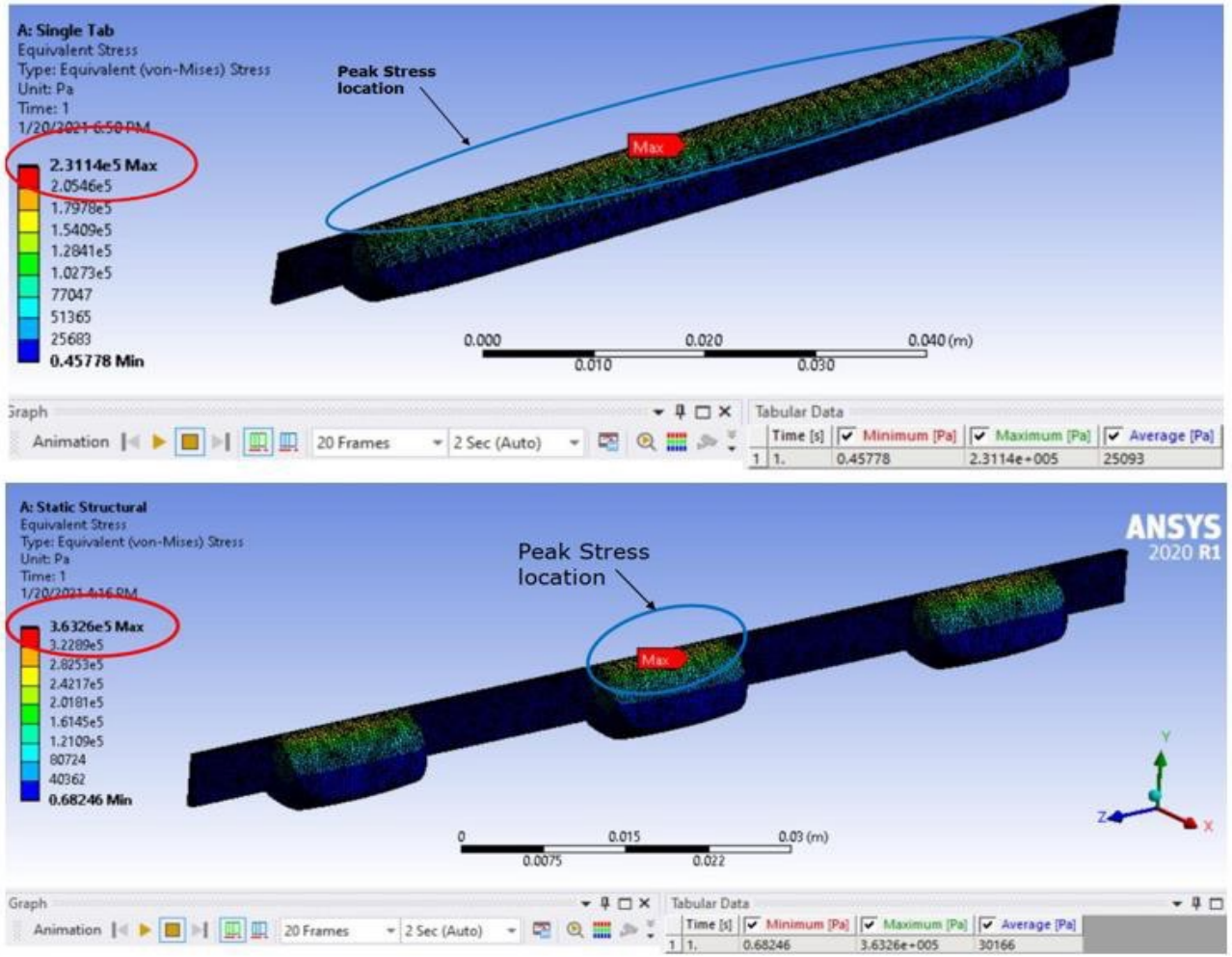
- Tray can also accommodate 300mm wafers



Modeling and Simulations

BEC Advanced Packaging: Large Form Factor Project Modeling and Simulation: Key Highlights

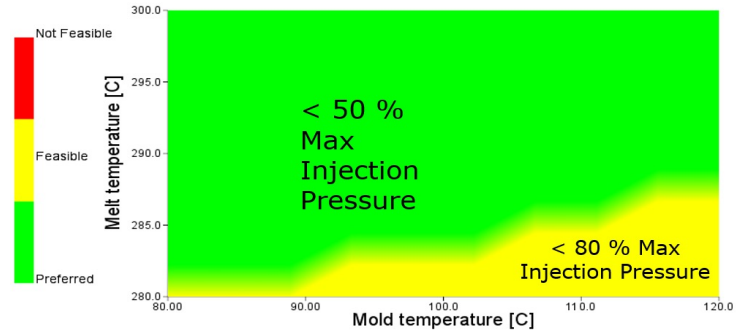
- End Tab FEA:
- ~36% Strength Increase

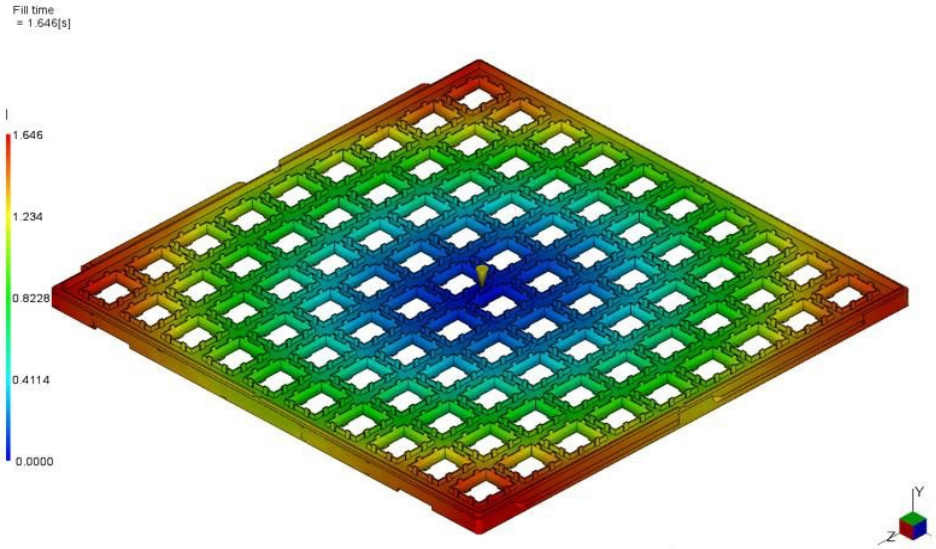


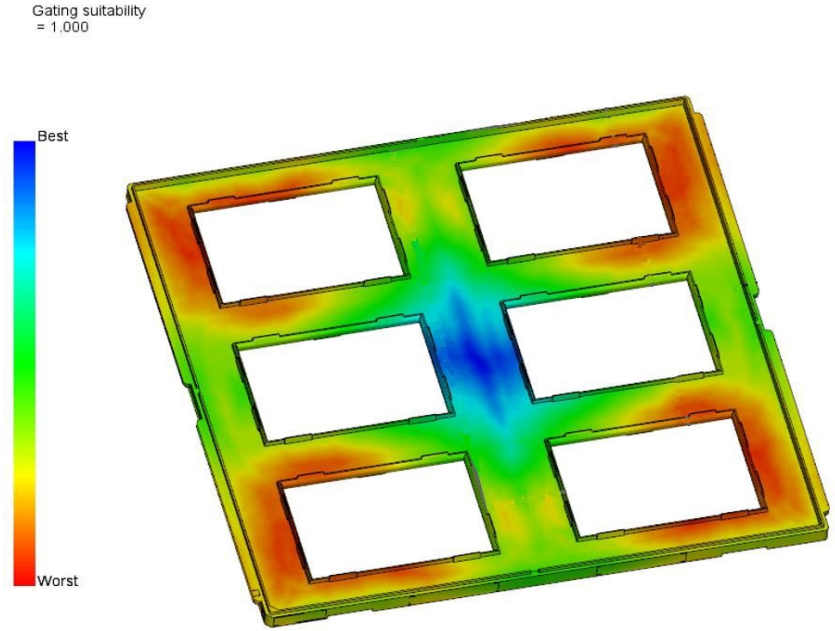
BEC Advanced Packaging: Large Form Factor Project Modeling and Simulation: Key Highlights

- 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

BEC Advanced Packaging: Large Form Factor Project Fabrication and First Article Inspection

- 30 prototype trays fabricated by major tray supplier : 104.5mm x70.5mm 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.

No.	Items	Spec	LSL	USL	Min	Max	Avg	Stdev	Cpk	P/F
1	Flatness	0.762mm ↓	0.000	0.762	0.240	0.28	0.261	0.013	13.01	P
2	Overall Length	315.000	314.750	315.250	315.070	315.096	315.085	0.008	6.67	P
3	Surface Resistance	$10^{4\sim10}$	10^{4}	10^{10}	10^{5}	10^{5}	10^{5}	-	-	P
4	Static charge	±125volts	-125volts	+125volts	-66	-30	-50	-	-	p

- New Tab: Fabricated prototype showing improved end tab strength

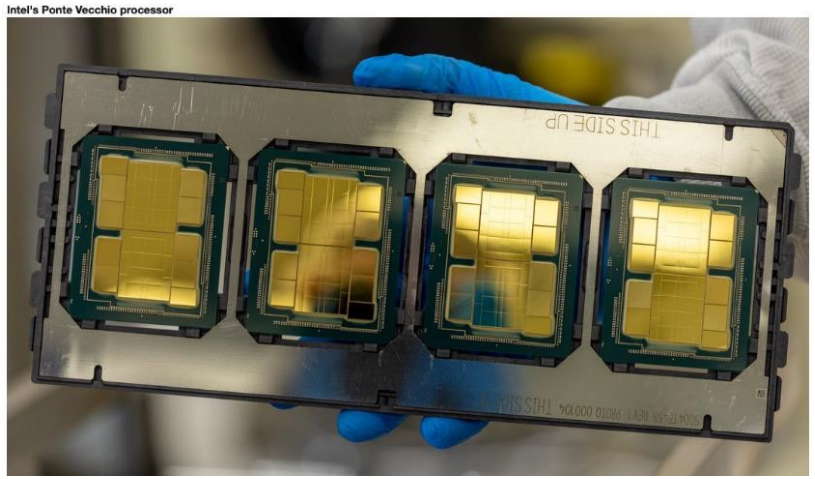
STRENGTH ⑥ (END TAP – CHAMFER)	X ≥ 35.0	55.6	55.3	55.0	55.7	54.6	55.7	54.6
STRENGTH ⑦ (END TAP – OPPOSITE)	X ≥ 35.0	55.3	55.9	56.1	56.4	56.0	56.4	55.3

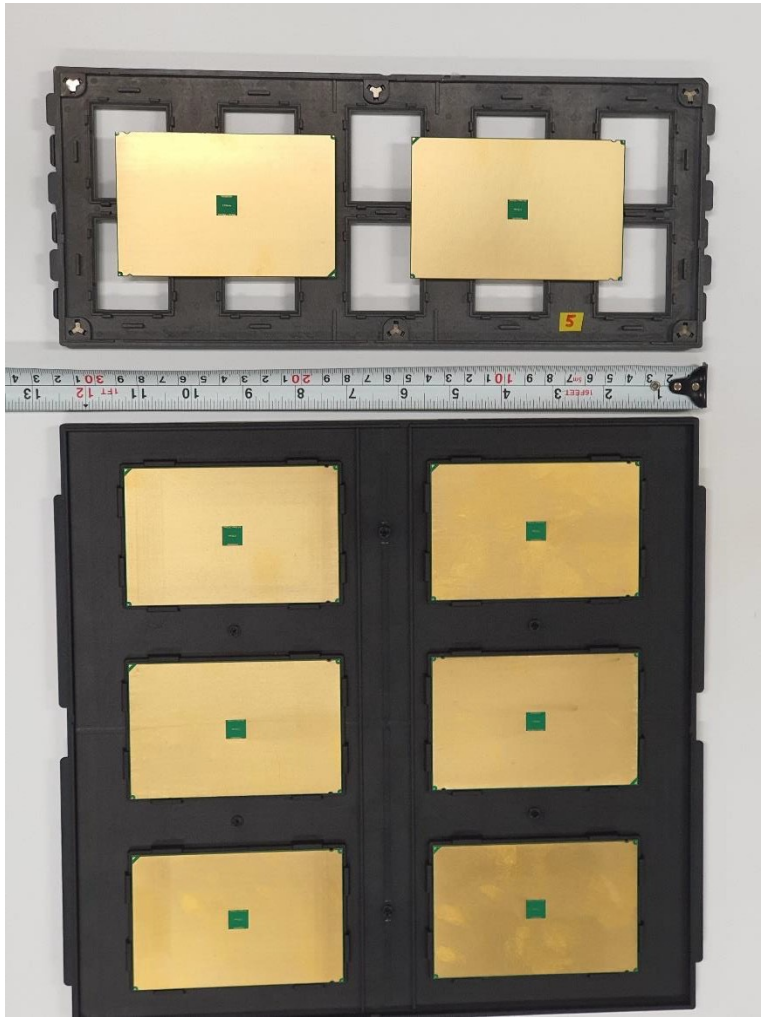
- JEDEC Tab: Showing Reduced Mechanical Strength

STRENGTH ⑥ (END TAP – CHAMFER)	X ≥ 35.0	39.4	38.6	39.2	40.3	39.2	40.3	38.6
STRENGTH ⑦ (END TAP – OPPOSITE)	X ≥ 35.0	39.9	38.4	39.1	39.8	40.2	40.2	38.4

BEC Advanced Packaging: Large Form Factor Project Prototype Validation

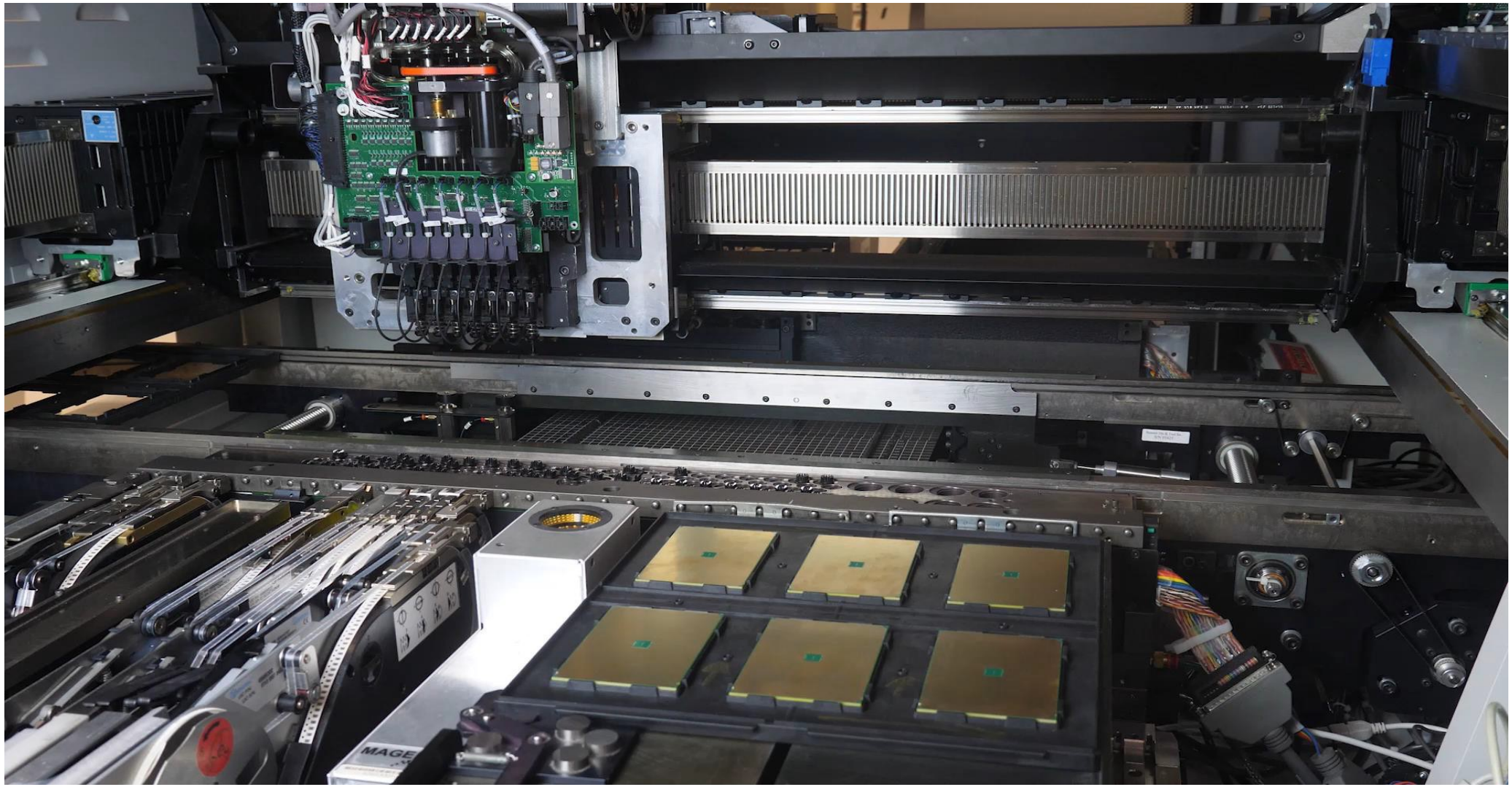
- Multiple Users on the Project team validated the fabricated prototypes in the assembly environments – including Pick and Place Evaluation



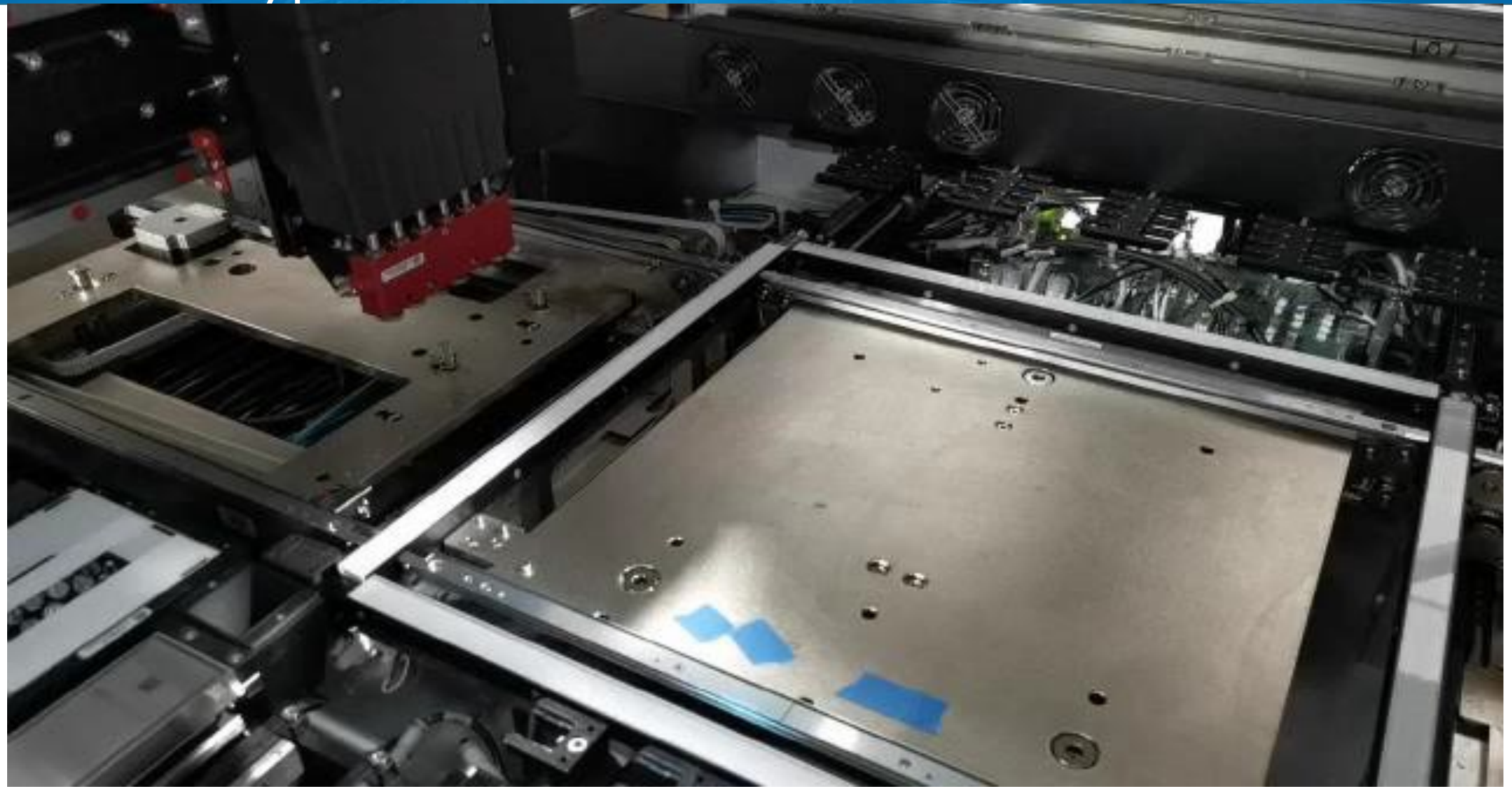


New format increases the assembly carrier density by 2-3X over today's standard

BEC Advanced Packaging: Large Form Factor Project Prototype Validation: Video from Universal Instruments Corp



BEC Advanced Packaging: Large Form Factor Project Prototype Validation: Video from Kullicke & Soffa



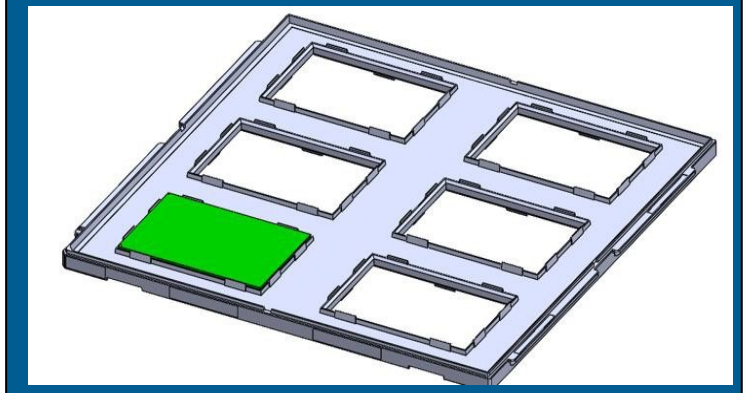
BEC Advanced Packaging: Large Form Factor Project
Project summary and Conclusions

- 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

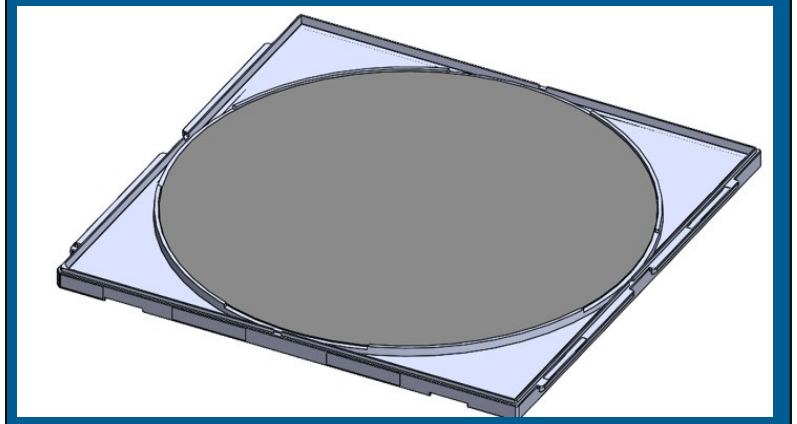
BEC Advanced Packaging: Large Form Factor Project Project summary and Conclusions

- 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

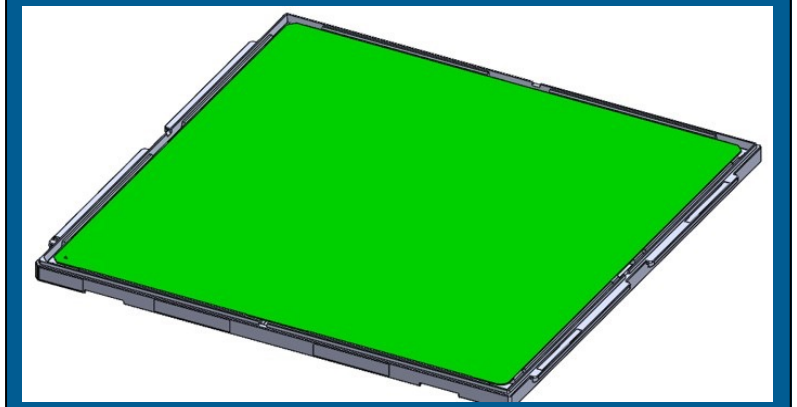
Individual Units & 3D Stacking



Wafer Level Integration



Substrate/Fan-out Panel Formats & Integration



Next Steps

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

Thank You

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