Fan-out IC Packaging Trends
Impact On Equipment Capital Structures

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SiPAQ, LLC
Quality Solutions in Silicon Packaging & Assembly

Supply Chain Squeeze

SHINKO

Unimicron

IBIDEN

KYOCERA

SAMSUNG

SAMSUNG ELECTRO-MECHANICS

TTM Technologies
Time-To-Market Interconnect Solutions™

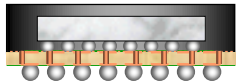
NANYA

DAEDUCK

PCB with Embedded Silicon

BB/
Modem

Amkor Technology®



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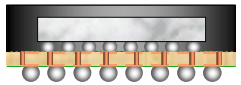
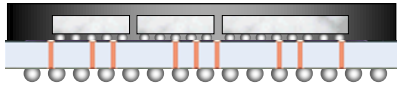


WLAN
Combo

tsmc

AP



Fan Out Adoption

- What is fan out
  - Its structure
  - How it is unique
- What obstacles exist
  - Lost OSAT's Revenue Streams
  - Depreciation is replacing Material Costs
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  - Lower cost processing
  - Faster Payback
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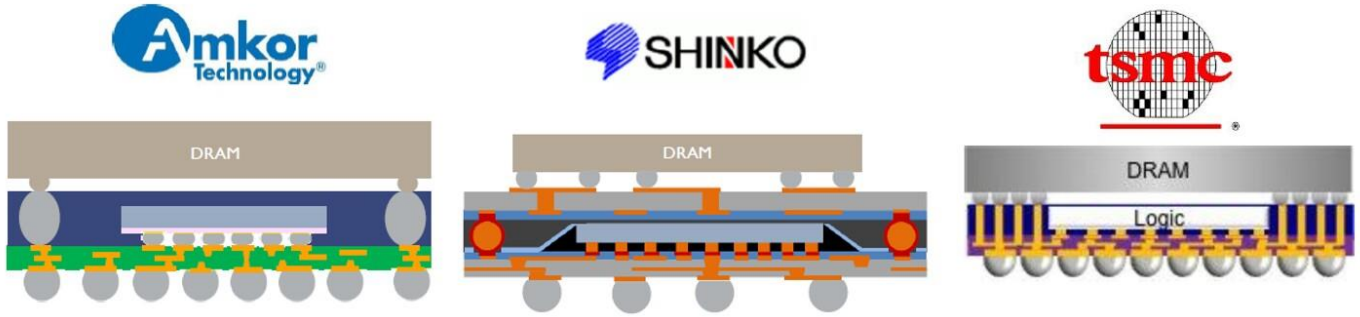
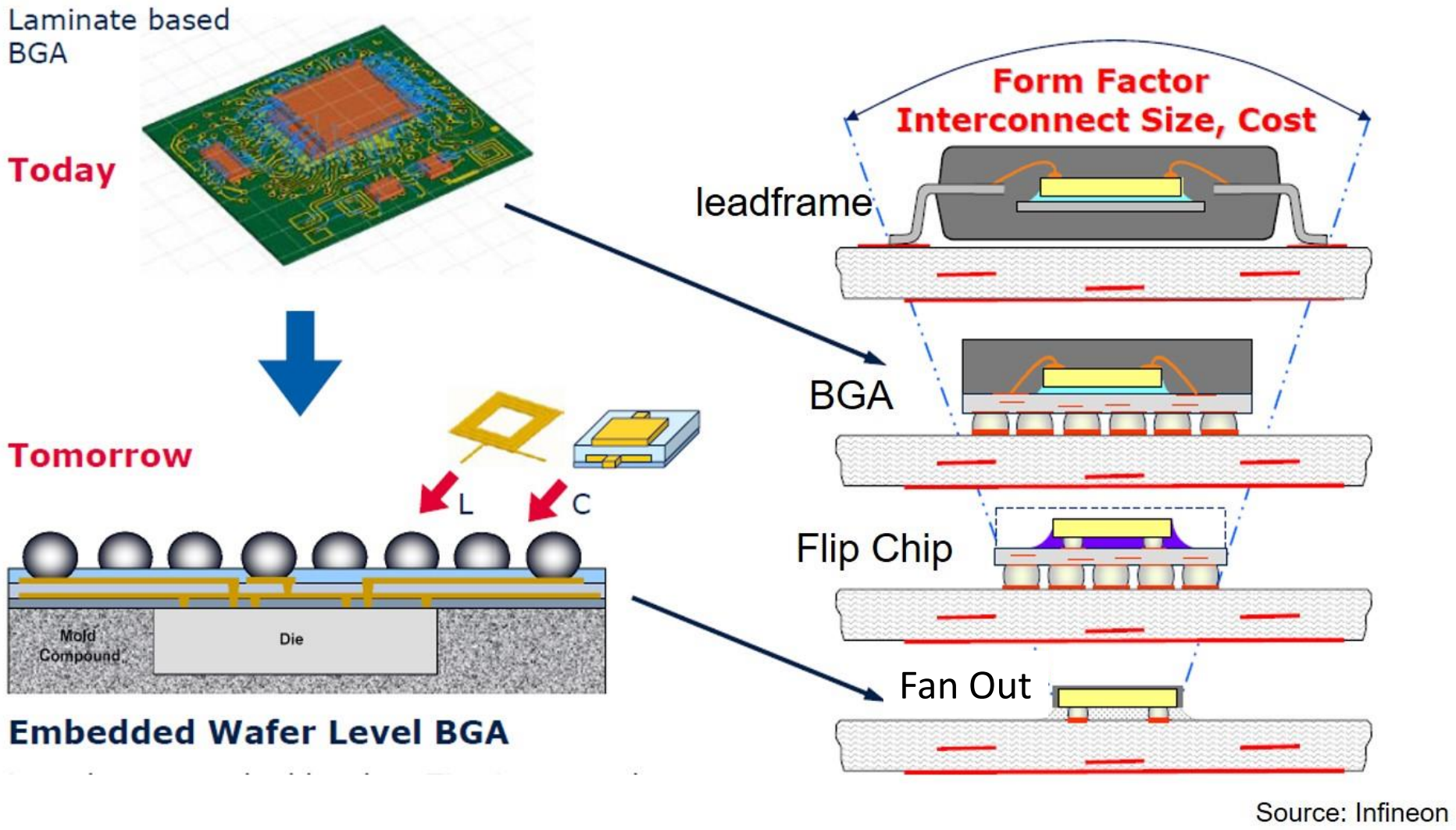


What is Fan-out



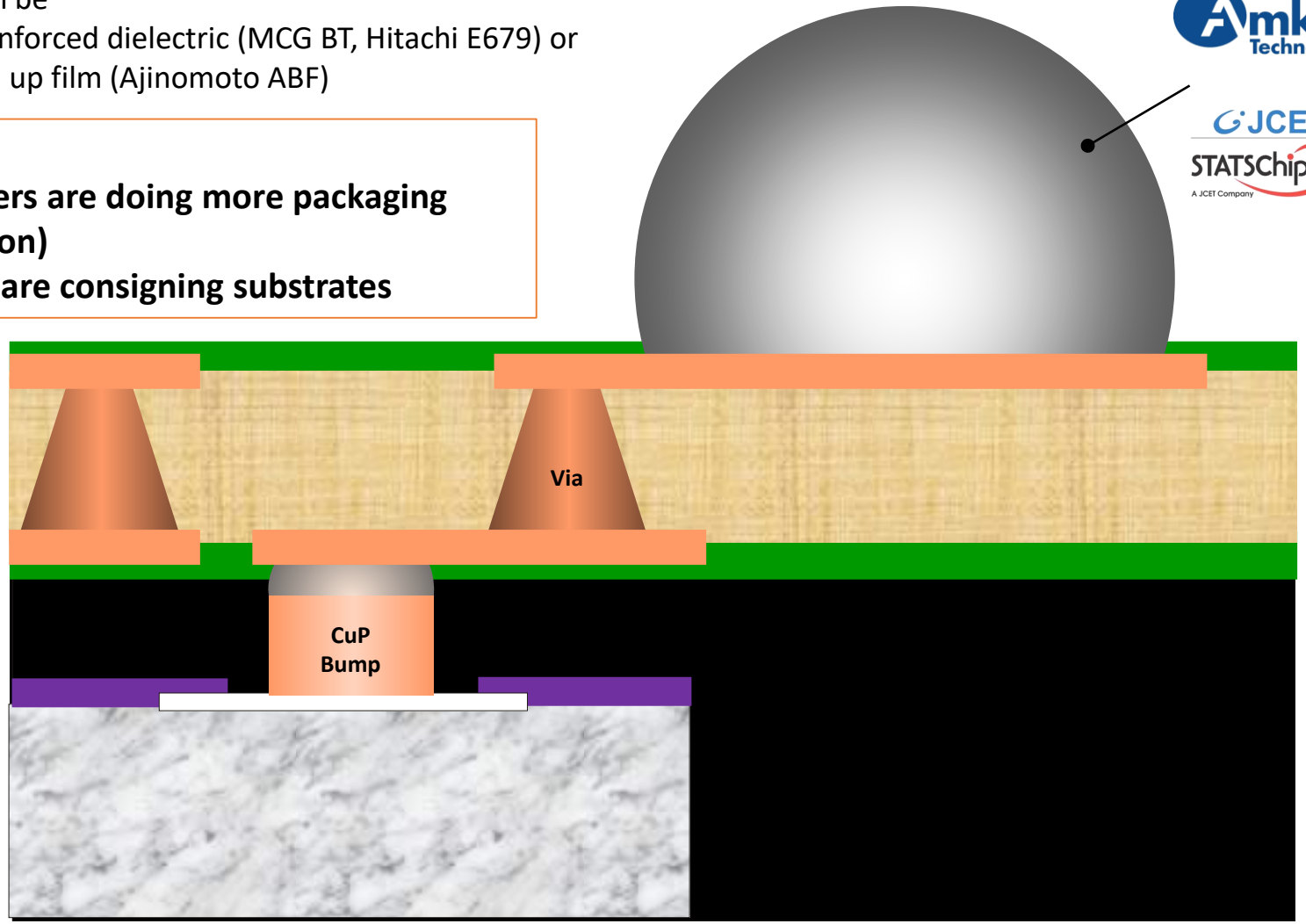
Source: Infineon

fcCSP with Substrate Structure

Substrate can be
(1) glass reinforced dielectric (MCG BT, Hitachi E679) or
(2) (2) Build up film (Ajinomoto ABF)

Changing Dynamics
- **Substrate suppliers are doing more packaging (embedding silicon)**
- **OSAT customers are consigning substrates**

- **Mat'l: 60-75%**
  - **Subs: 50-70%**
- Labor: 10-15%
- Depr: 15-30%



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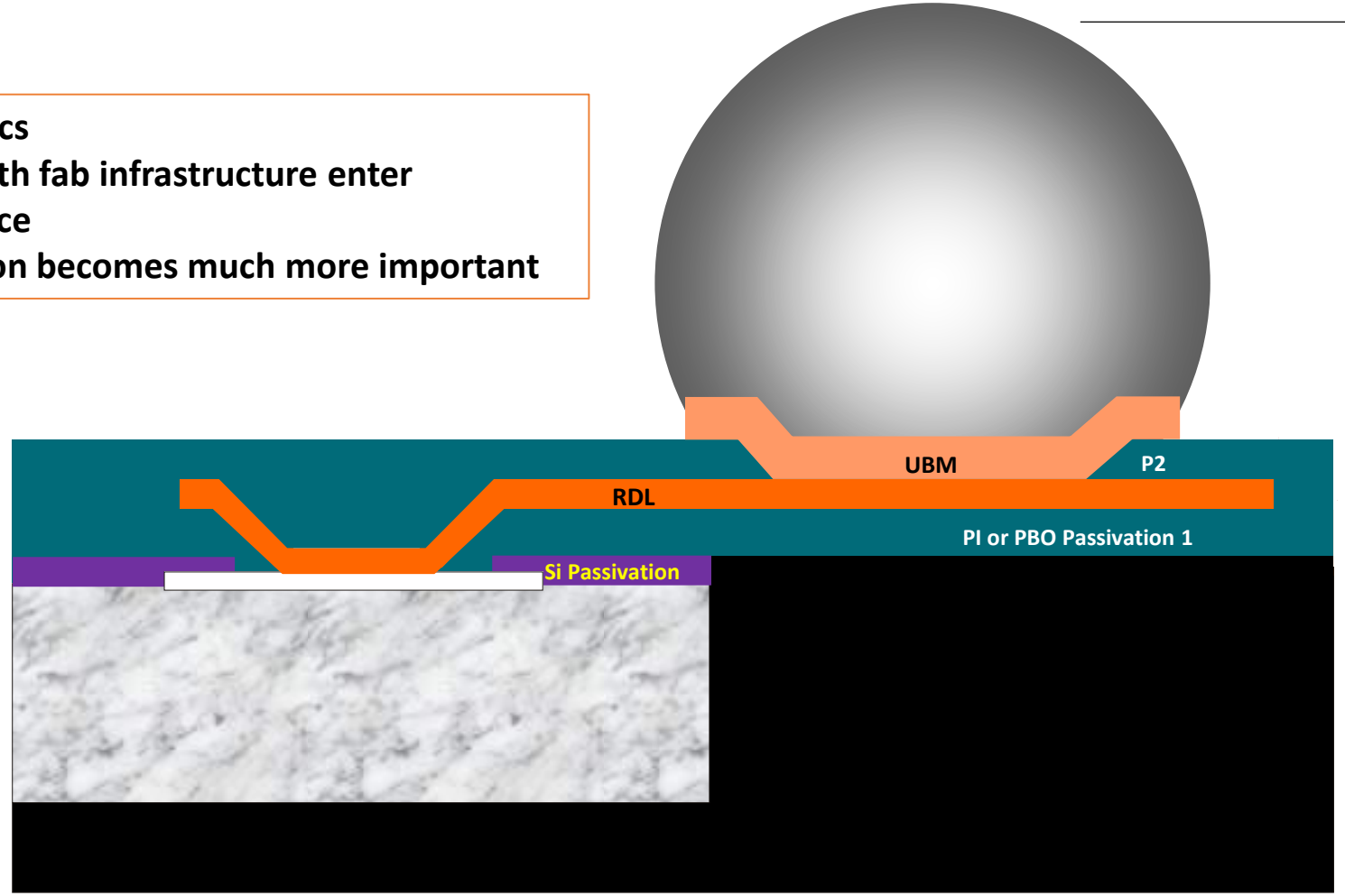
Fan-out Build Up Structure

Changing Dynamics
- **Companies with fab infrastructure enter packaging space**
- **Asset utilization becomes much more important**



- Mat'l: 20-25%
- Labor: 15-20%
- **Depr: 40-65%**

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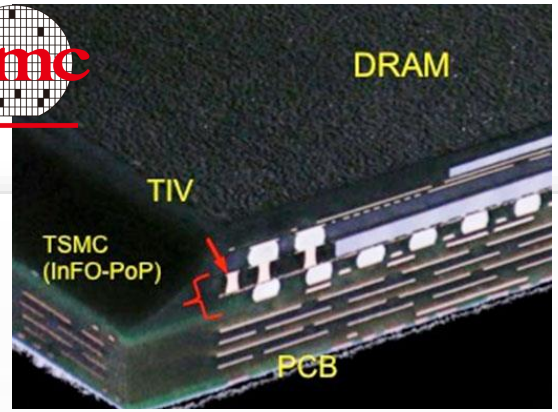
Cost per Transistor is Rising



Fan-out Process Flow Fab Polymer & RDL Wafer-based

Wafer Tape to Carrier

Die (Active side down) to Wafer Tape

Compression Molding of Mold Compound over Die

Wafer Tape Separation and Removal

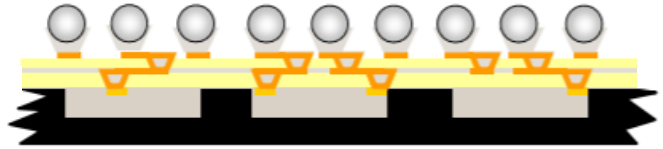
Rotate 180º

Apply
Polymer 1

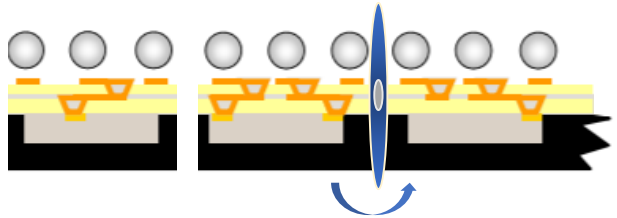
Photo Define Vias and
Build Up RDL 1

Apply Polymer 2 and Photo
Define UBM vias

Plate UBM
Pads

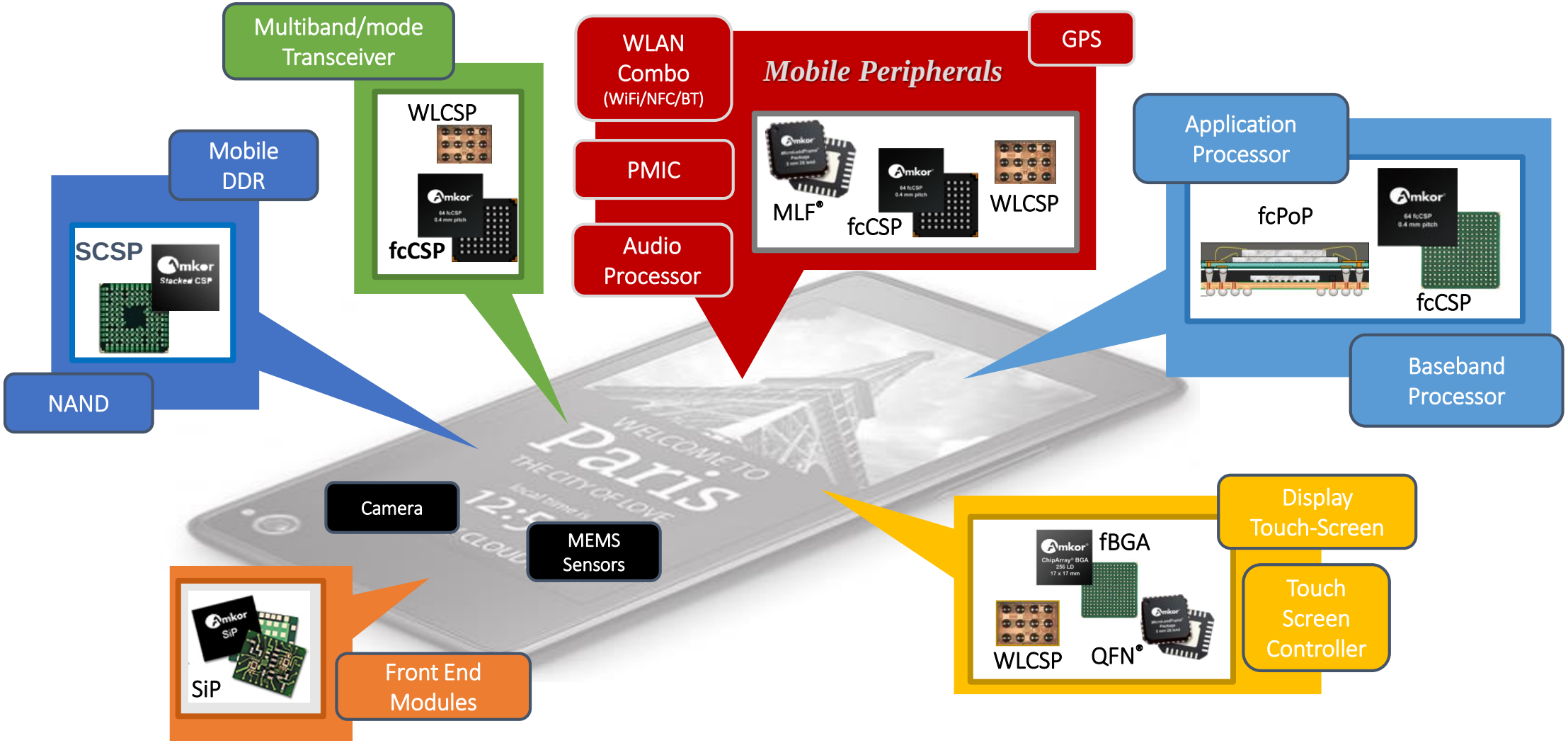


Place
Solder balls

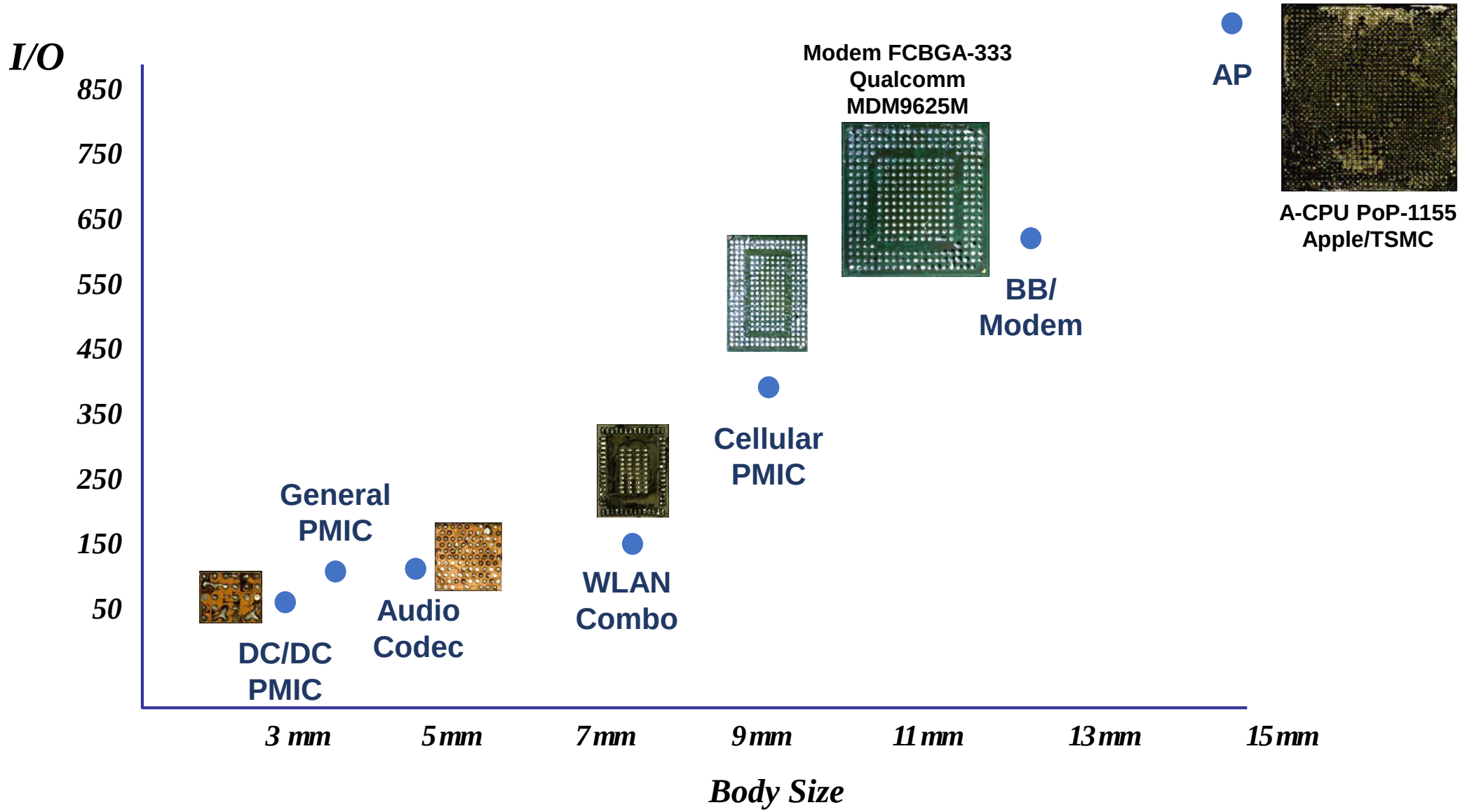


Package
Singulation

Smartphone Platform Package Adoption



Package Trends & Positioning



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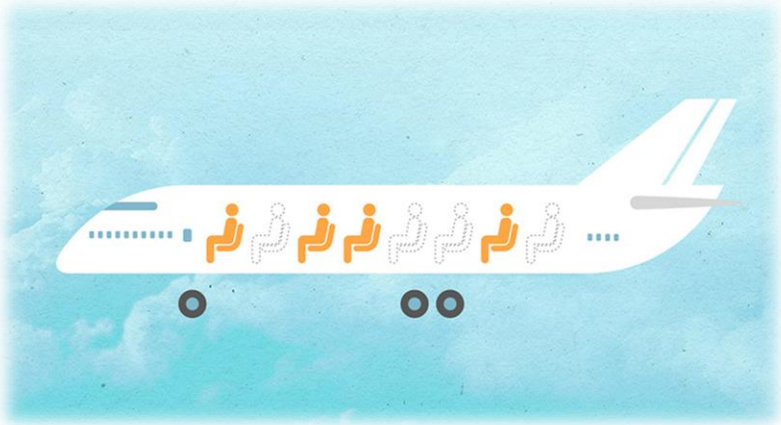
Asset Intensive Operations

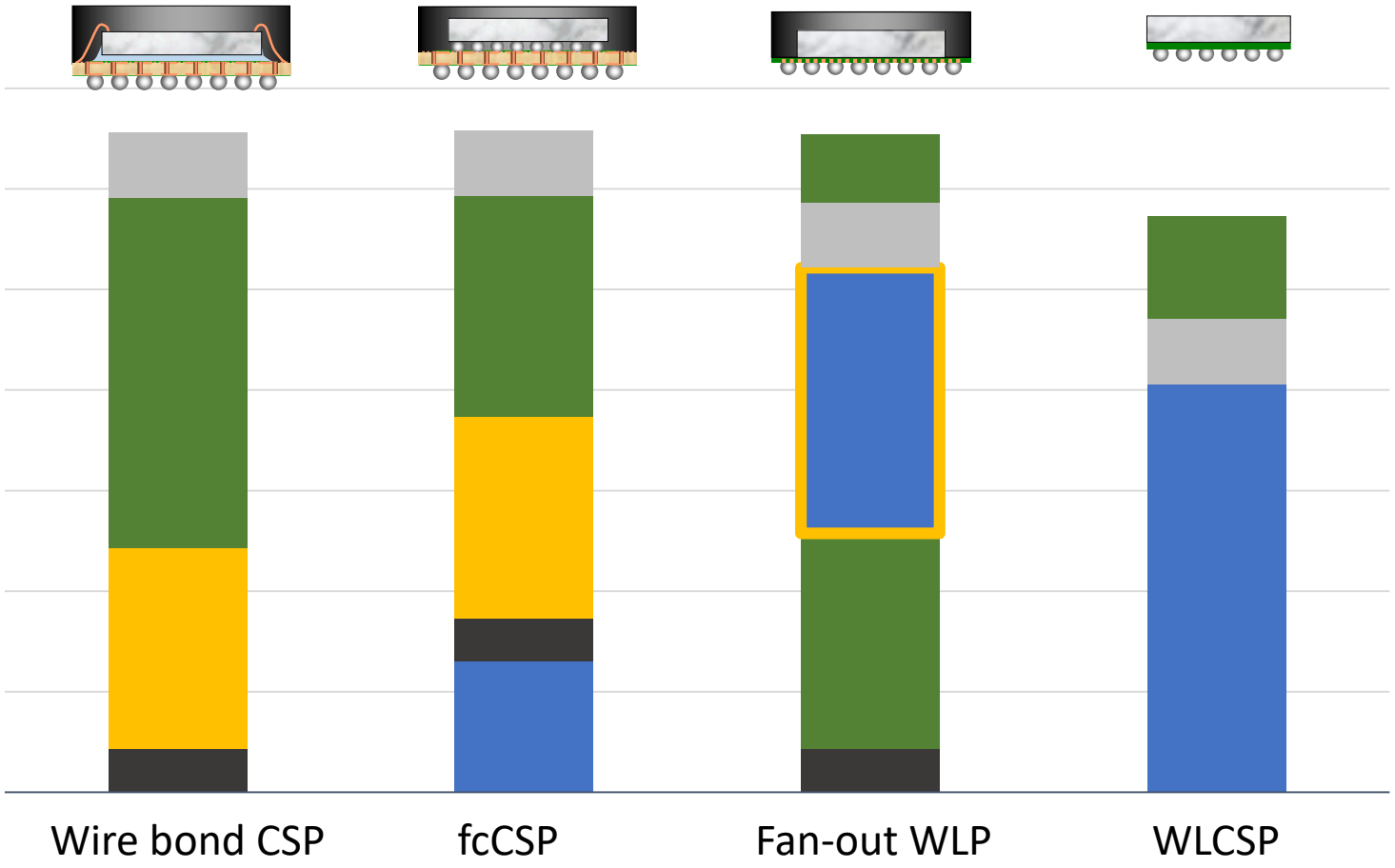


- Wire bonders and chip attach machines generate $$ the moment they are plugged in
  - Like planes in the air
- Platform commonality makes operations, maintenance and planning easy

- What fuels their economic engine now?
  - Profit per X | Jim Collins, *Good to Great*
  - **Profit per Seat or Profit per Asset**

Cost Influencers by Major Process

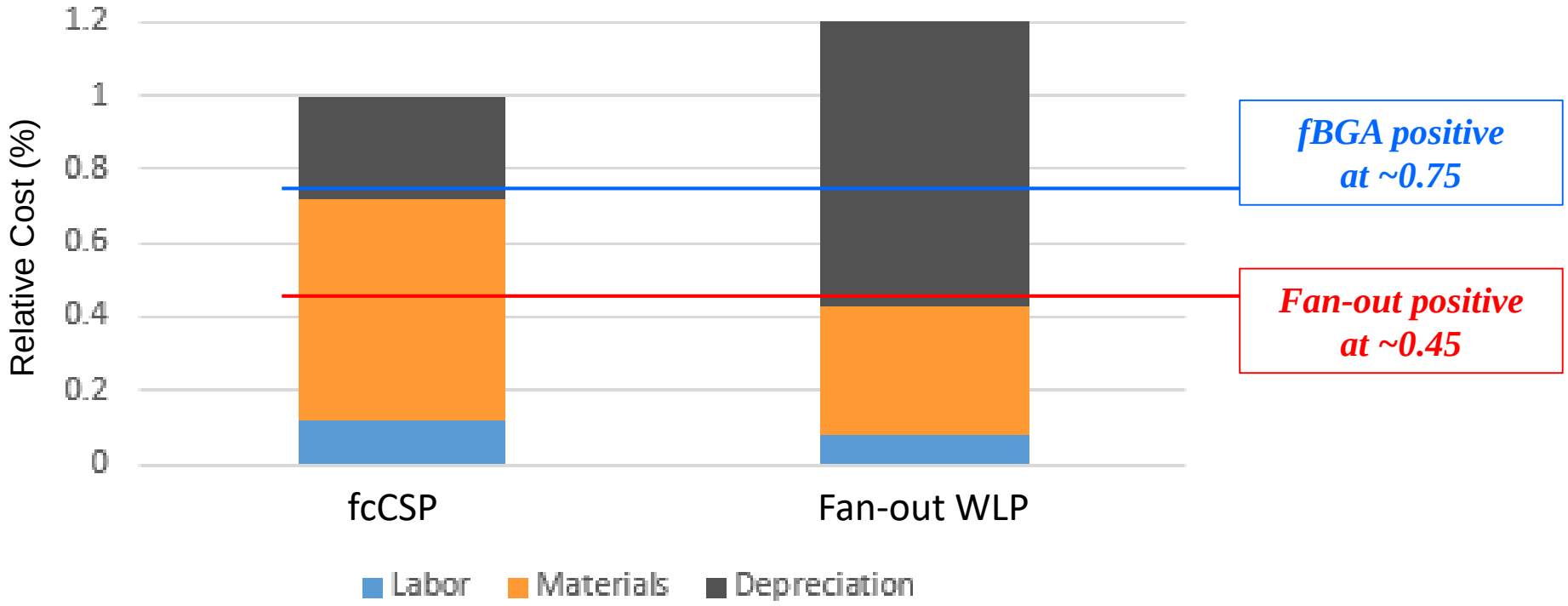
- Substrate margins at risk as end customers begin consigning
- FanOut competitiveness also impacted



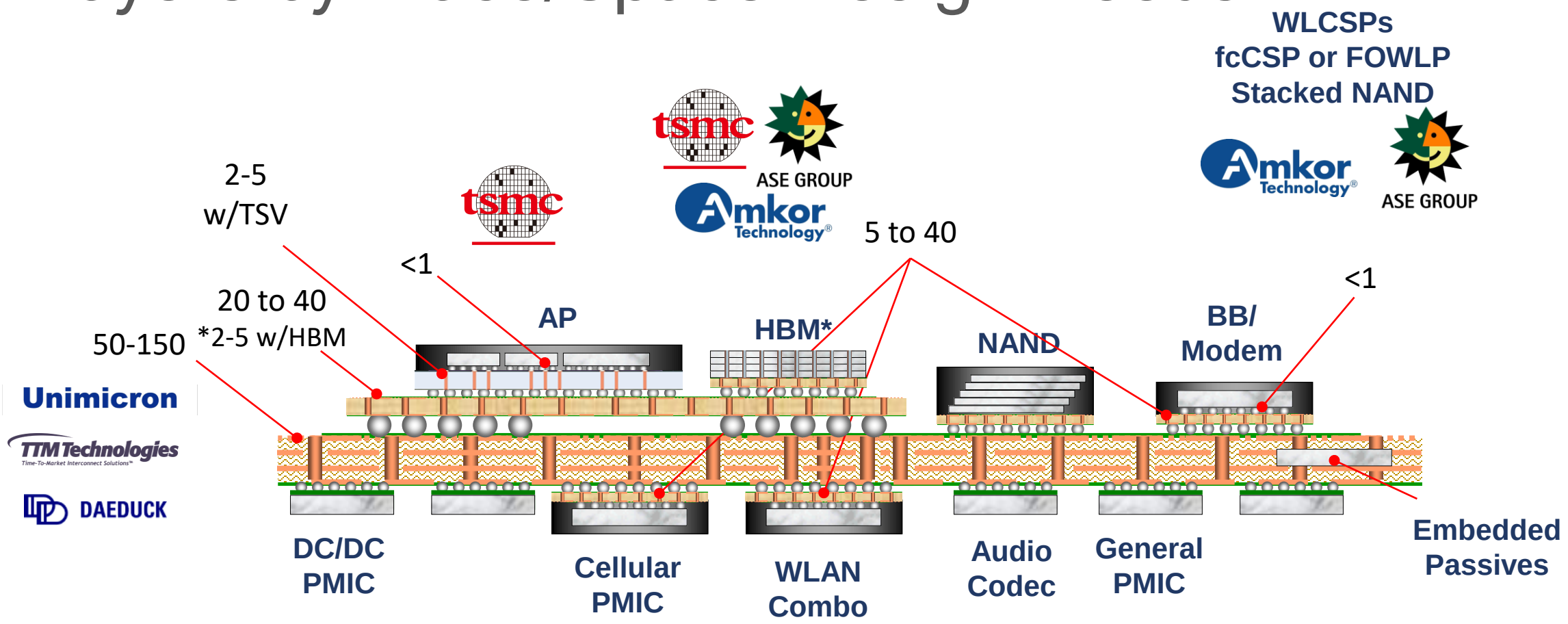
Acronyms

DP: Die Prep (back grind, saw)
BG: Back grind
Saw: Package Singulation
mS: Mechanical saw
LS: Laser saw
DA: Die Attach
WB: Wire bond
M: Over mold
P&P: Pick & Place
T&R: P&P+Tape & Reel

Discounting Depreciation Can Give Positive Cash Flow

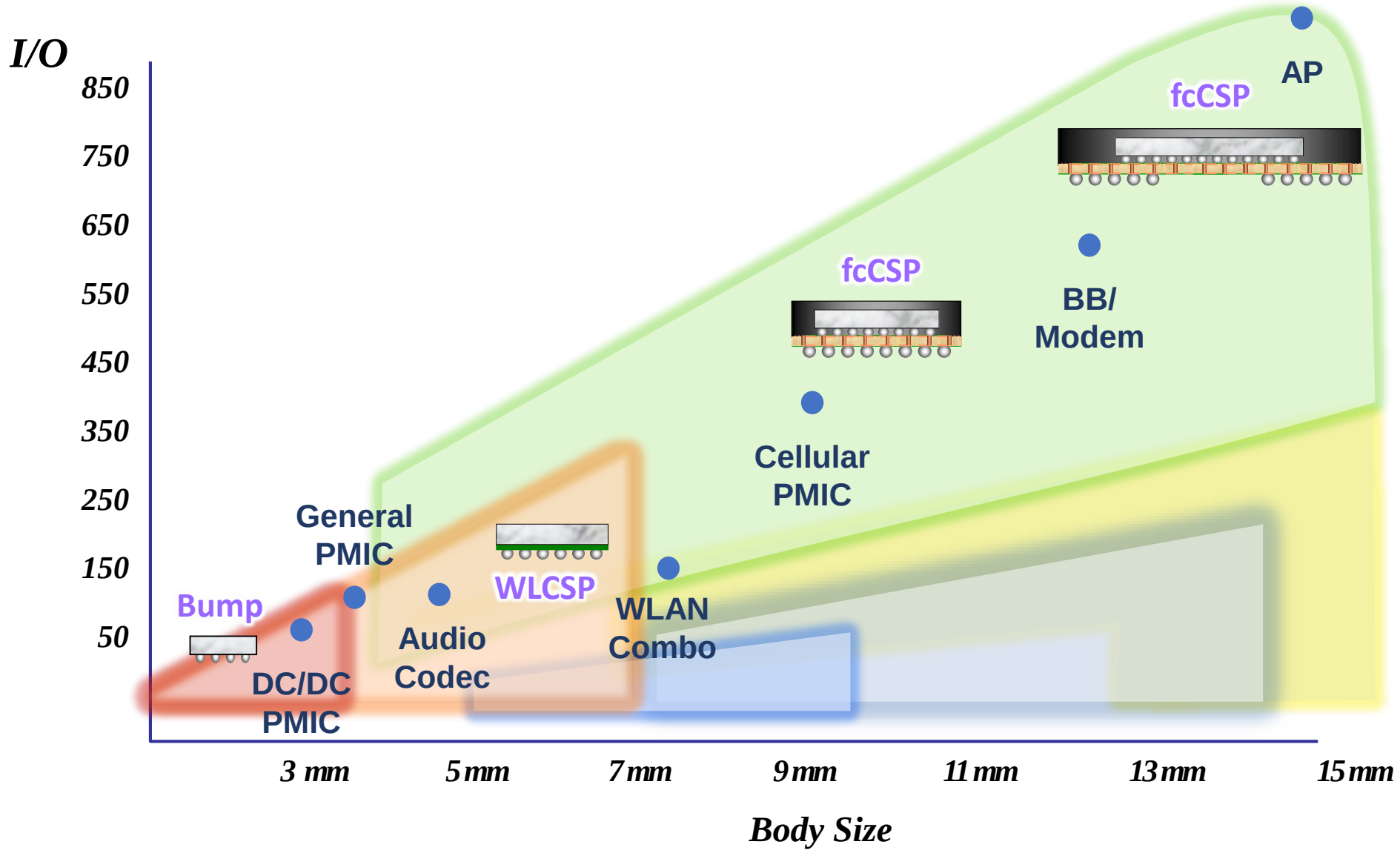


Players by Trace/Space Design Needs



* Could drive need for 2.1D Substrates or alternative interposer packaging method

Package Trends & Positioning



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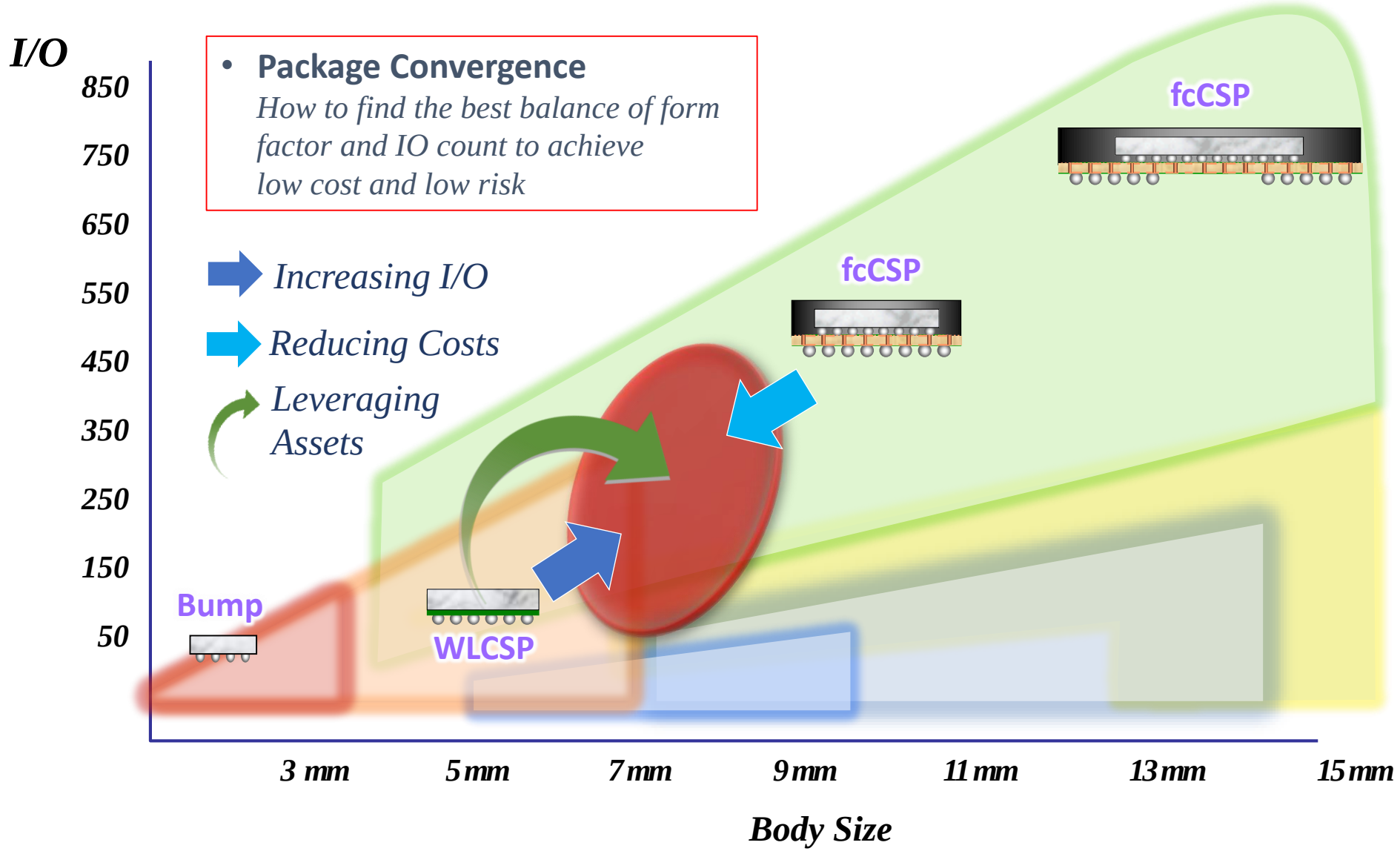

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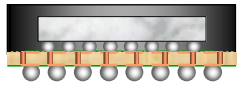
- How can the equipment supply chain enable a shift
  - Lower cost processing (i.e., faster throughput, lower equipment costs, equipment longevity, panel and circle)
  - Faster Payback
  - Fungability

What Can Change to Drive Agents

- Equipment Providers
  - Faster equipment throughput
  - Lower cost clean room environmental requirements
  - Longer equipment life
  - Lower cost Equipment
- OSATs
  - Seasonal pricing strategies (for managing capital intensive businesses)
- IC Suppliers
  - Greater ownership over Laminate Substrate supply chain and elimination of GM stacking

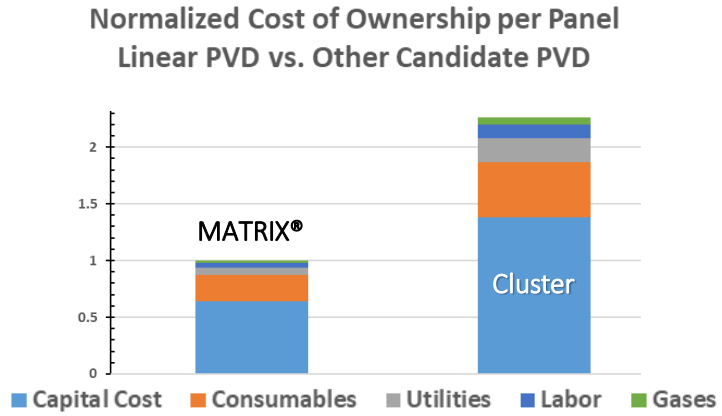
Risks – An OSAT Perspective

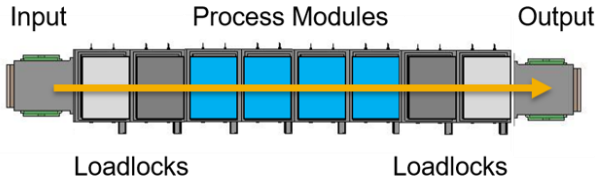


	Characteristic	Laminate Substrate Interposer	Typical IC Packaging	Fab-based Processing
OSAT Cares	Depreciation	Low	Mid	High?
	Fungibility (i.e., Control Risk)	High	Mid	Low?
	Payback Period	1-3 months	< 2 Years	< 3 Years
	GM Markup	0-15%	17-25%	25-35%
IC Supplier Cares	Lead-times	Long	-	Short
	Material obsolescence risk	High	-	Low
	GM Markup on Substrate	0-15%	17-25%	25-35%

Intevac's MATRIX® PVD – Advanced Packaging

- Lowest Cost of Ownership
  - Highest Throughput
    - 240 300mm UPH
    - No robot or queue constraints
    - Capable of 90% UE
  - Smaller factory footprint
  - Lower material waste
  - Improved yield from reduced ESD on die-first products
  - Convert sputter material type or product form factor in under 2-hours
  - Proven 30-year time in the field





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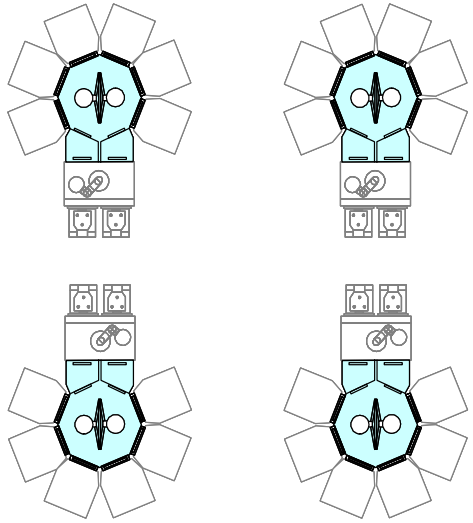
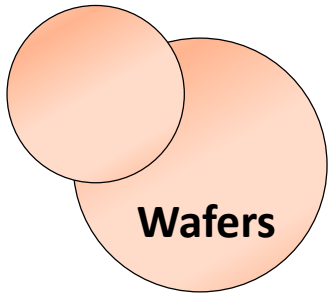
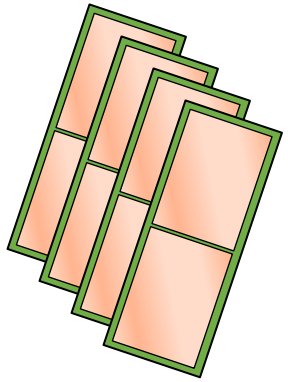


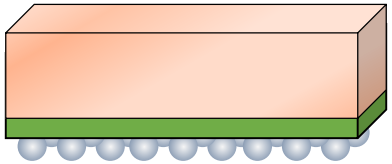
Intevac's MATRIX® PVD

- Ability to sputter on anything provides greater fungibility and unique competitive solutions

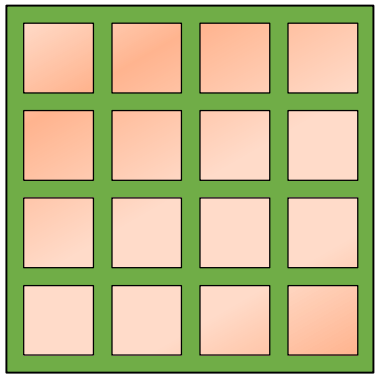




Strips for fcCSP



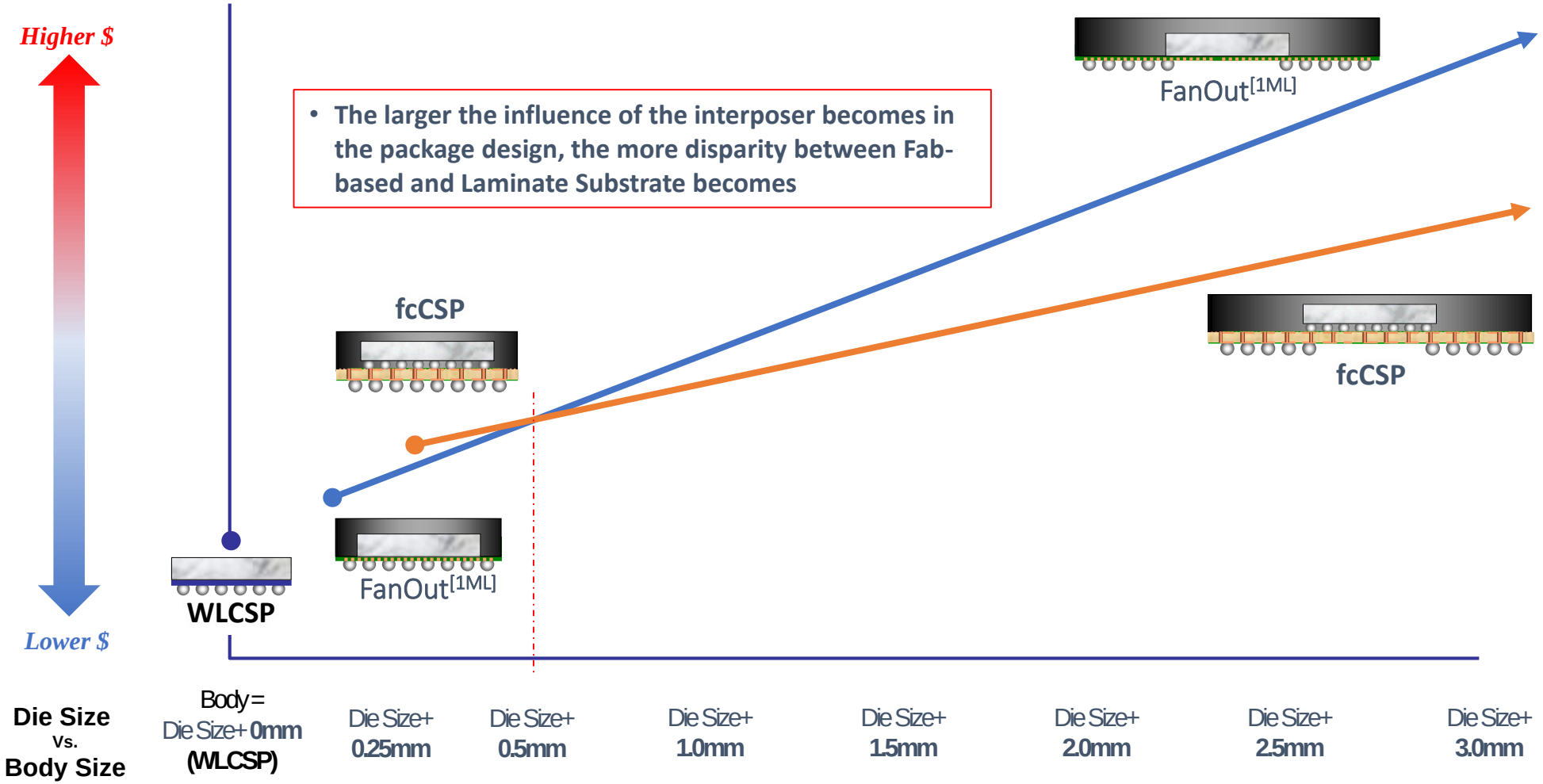
IC Packaged Units For RF shielding



PCBs & Substrates for 2.1D Products

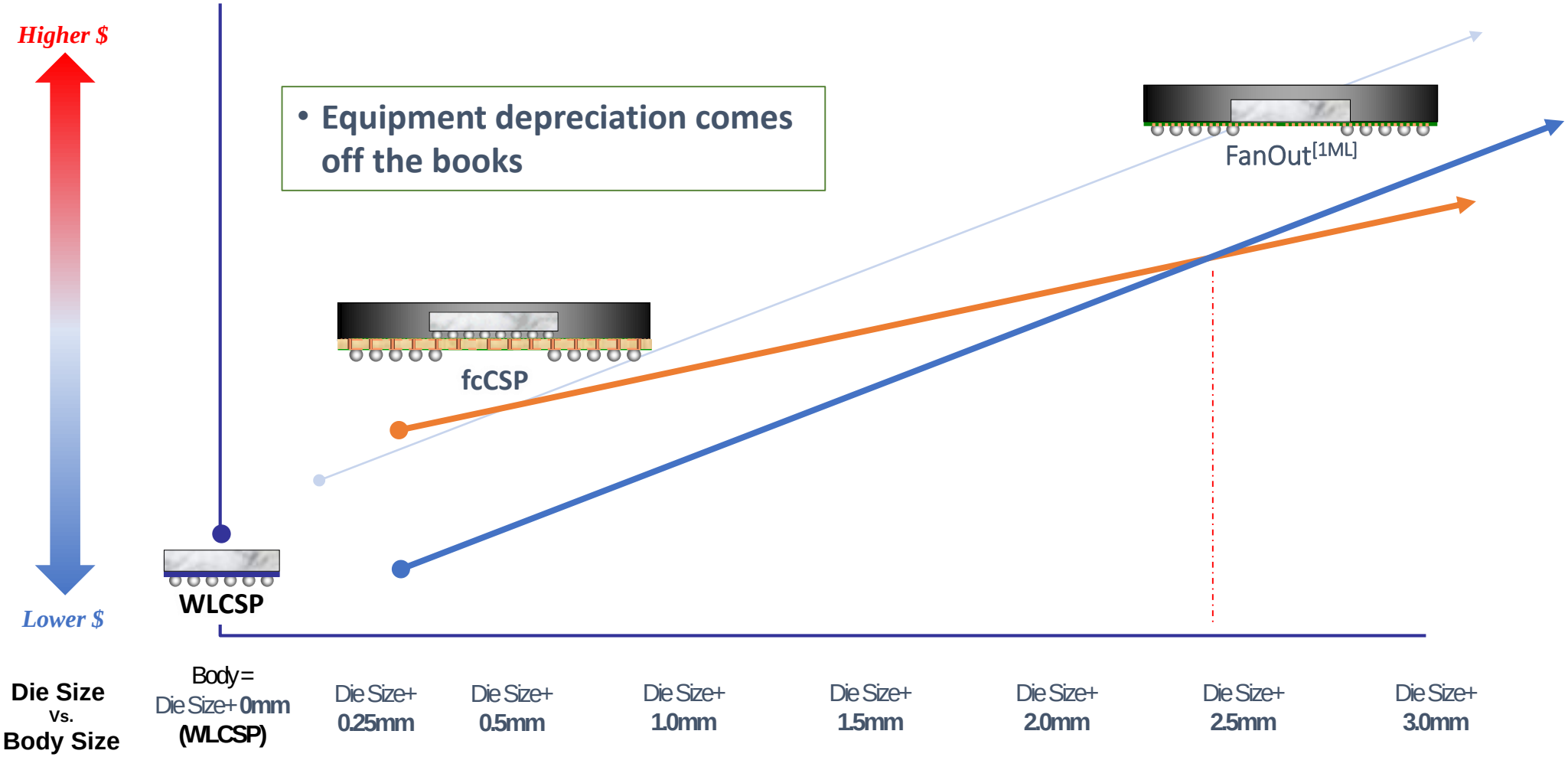
- Challenges: Getting OSATs to understand the 'squeeze' and need for new mindset
  - Need an alternative infrastructure to compete against TSMC and more 'substrate/pcb' like
  - Find a way to qualify faster with no risk of downtime
  - Providing the end market with dual sourcing

Relative Cost – Flip Chip vs Fan-out



Source: Amkor Technology
Creator: Jon Woodyard

Change Agents – Throughput and Longevity



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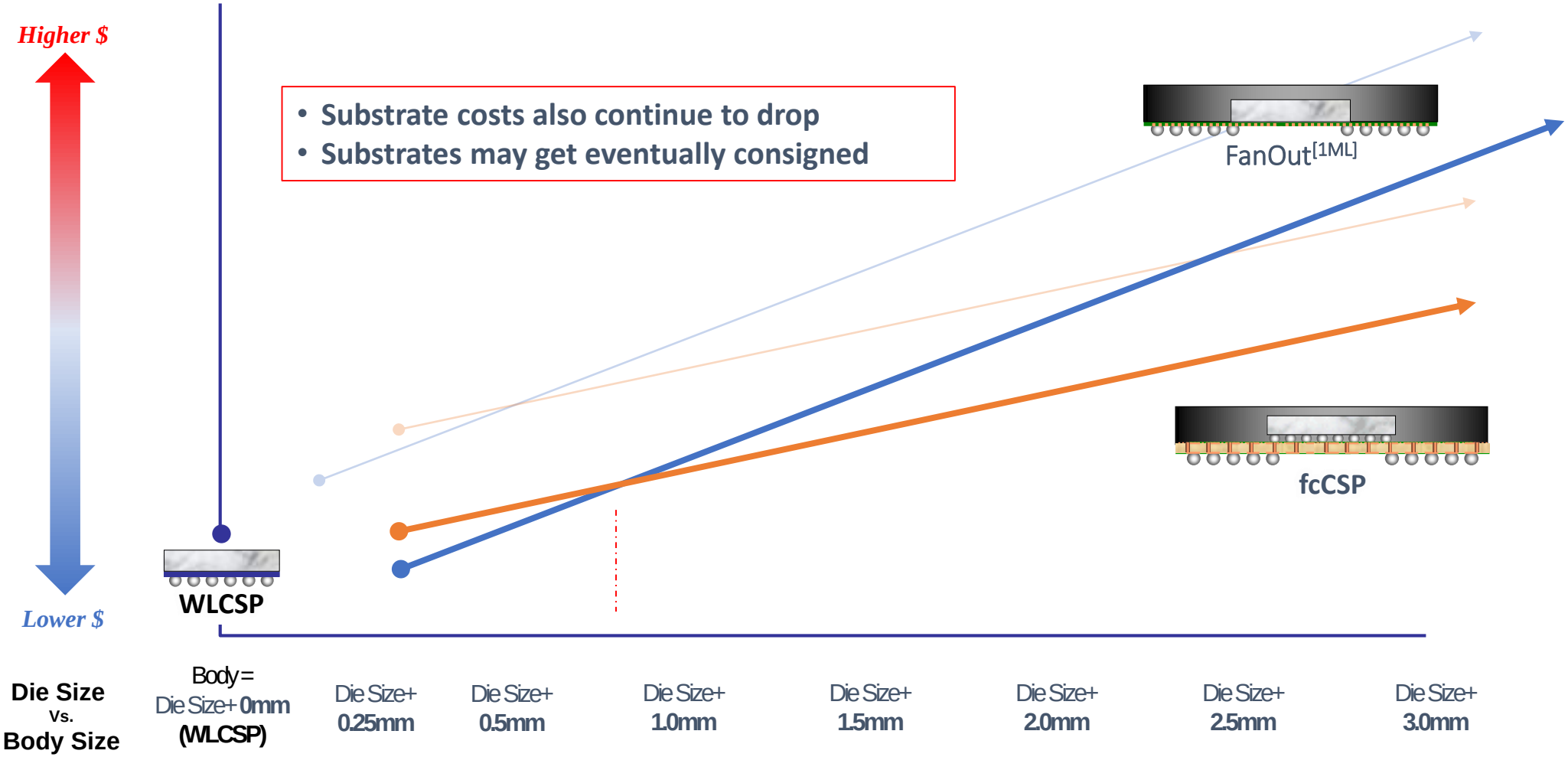

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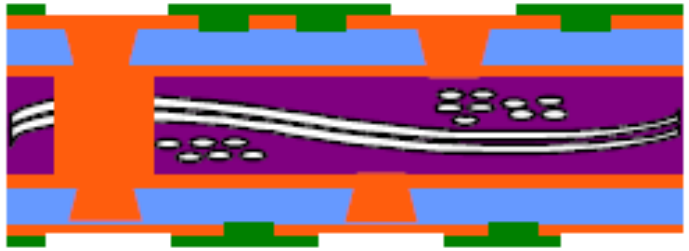
Substrate Costs Continue to Drop

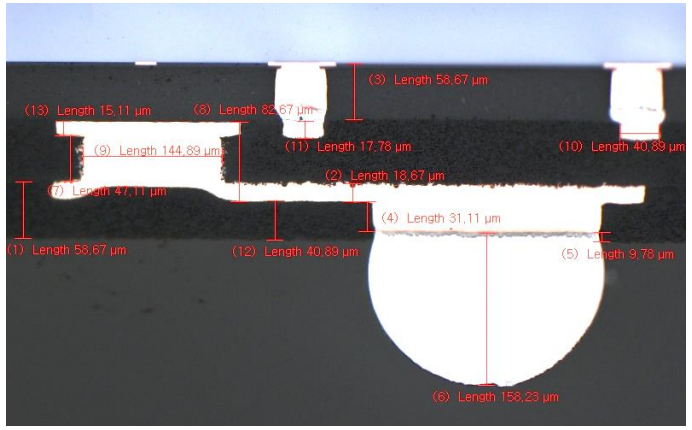
4 ML Core + ABF Build-up



2ML Embedded Trace

Molded substrate (1+ layer)

- Aggressive pricing
- Lower layer counts (1 ML)
- Less encumbered by change control restrictions

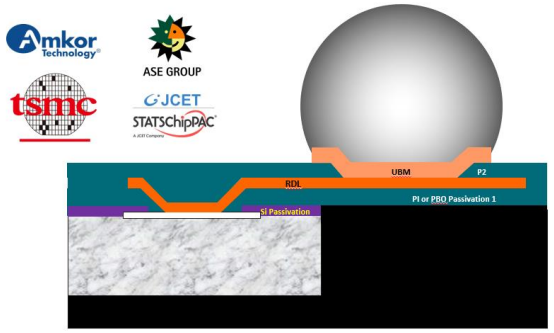


Financials & Resulting Influencers

Characteristic	Laminate Substrate Supplier	OSAT	Foundry
Revenue	2-3 Billion	4-6 Billion	>30 Billion
Capital Expenditures	13-17%	15-20%	>30%
SG&A % of Rev	4-7%	5-7%	3%
R&D % of Rev	2.5-3.5%	4%	8-9% ($3B)
Gross Margin	9-16%	17-22%	50%
Op Margin	5-10%	5-10%	40%

What is Fan Out

Fan-out Build Up Structure



- A Semiconductor package with a Fab-based substrate platform
- An Asset rather than Material-based substrate platform
- OSATs gain revenue streams but asset management risk

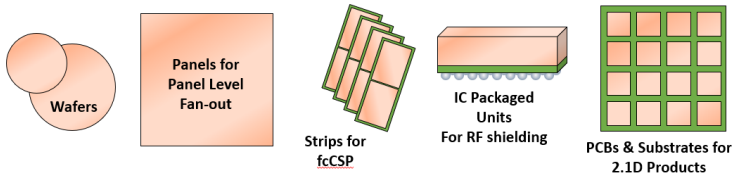
Obstacles, Risks and Concerns

Asset Intensive Operations

- Laminate solutions take revenue streams and get more cost competitive
- Depreciation costs escalate
- Profit per Asset becomes most significant KPI

Enabling a Transformation

New Infrastructure Ideas



- Understand customers Business as well as Technical concerns
- New Infrastructure is great but obstacles must be overcome
- Understand change control restrictions

Thank you