Tech Topics Series: Complex Integrated Systems

CIS — The Future of Electronics Manufacturing

Watch the webinar recording

YouTube: https://youtu.be/i0rhetlOikM

Other video:
https://thor.inemi.org/webdownload//2024/Tech_Topic/CIS/CIS_Future_Elects_Mfg.mp4

Girish Wable
Dan Gamota
September 26, & 27, 2024

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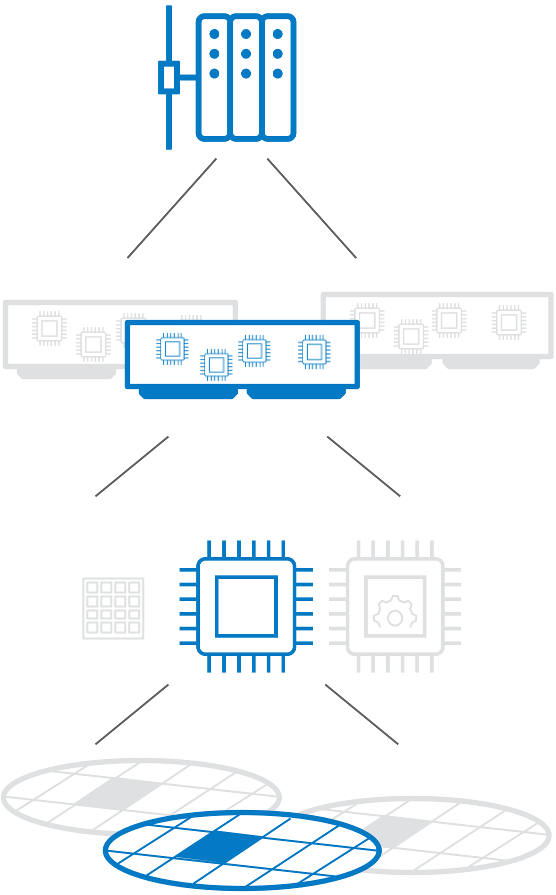
Complex Integrated Systems White Paper

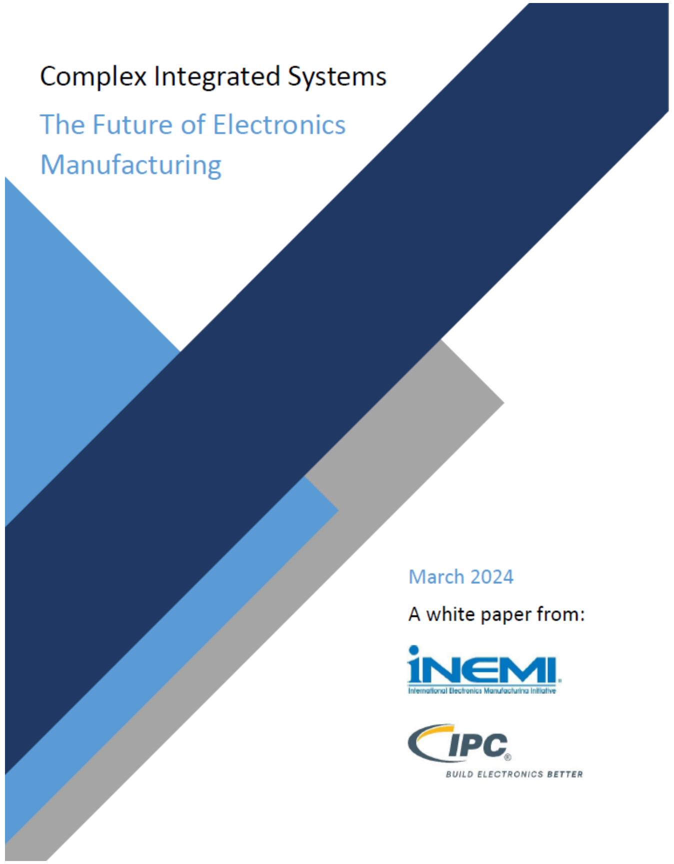
System
Level 3

Module
Level 2

Component
Level 1

Die
Level 0




Complex Integrated Systems

The Future of Electronics Manufacturing

March 2024

A white paper from:

iNEMI

IPC BUILD ELECTRONICS BETTER

25 March 2024:
Joint white paper with IPC and other interested parties

CIS Whitepaper link -- https://go.ipc.org/complexintegratedsystems

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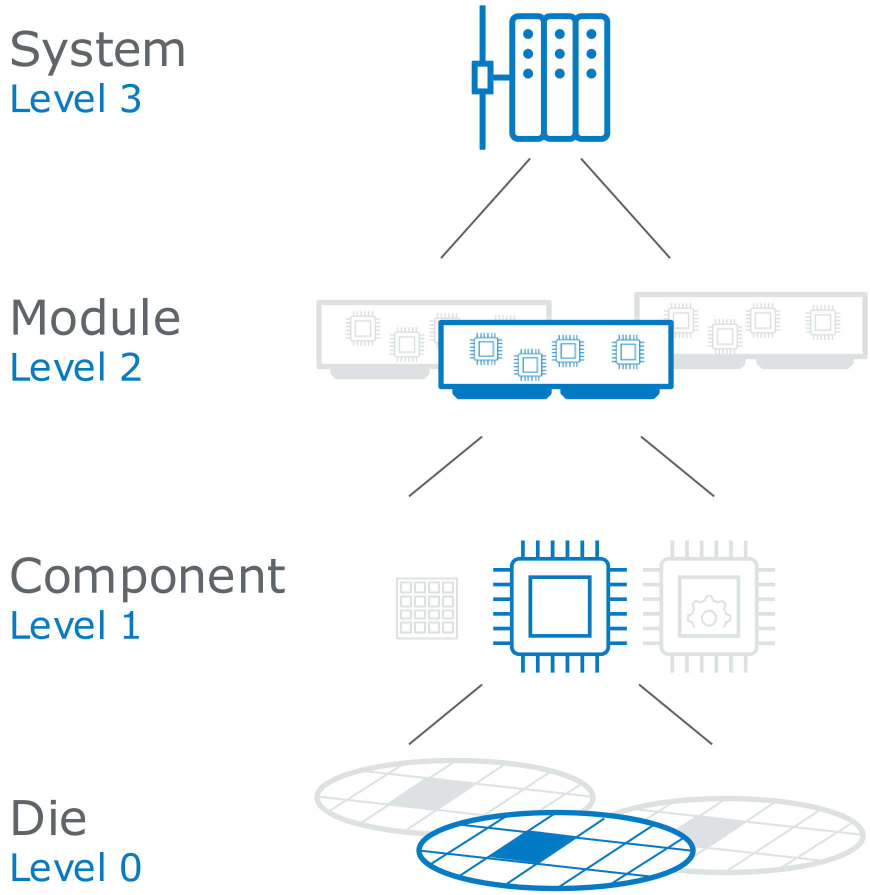
Complex Integrated Systems: Definition

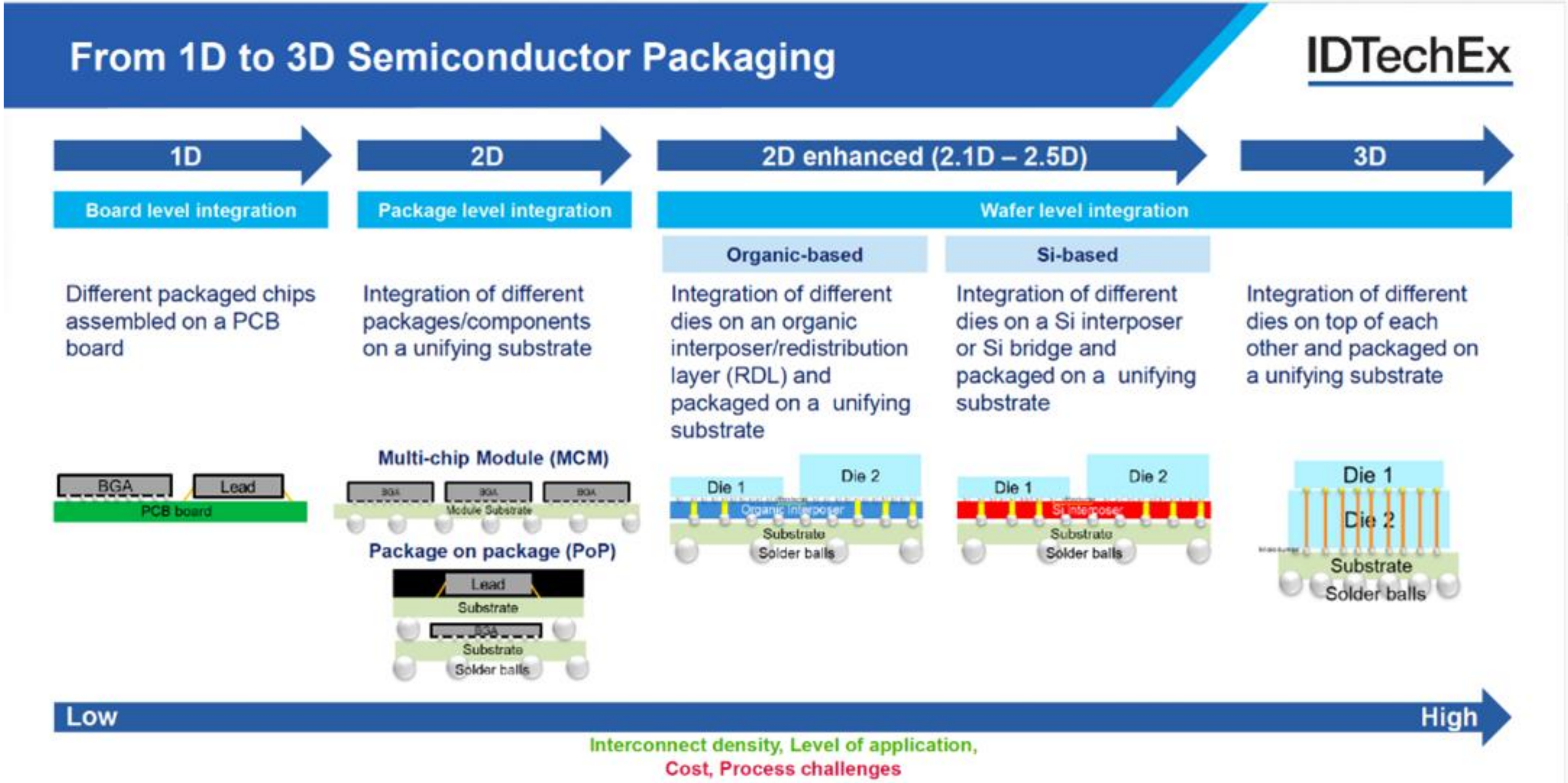


Complex integrated systems (CIS) combine different types of functions

- digital,
- analog,
- optical,
- micro-mechanical,
- power-related,
- structural

in a single system to ensure the best solution for the product and its end market.

Situation Analysis and Trends Mapping
Innovative Designs, Materials, and Processes



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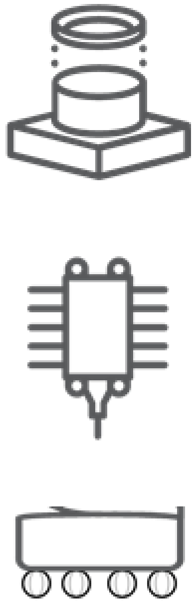
Trend – Semiconductor Assembly, Packaging, and Test
Complex Integrated System (CIS)

A Complex Integrated System (CIS) may consist of:

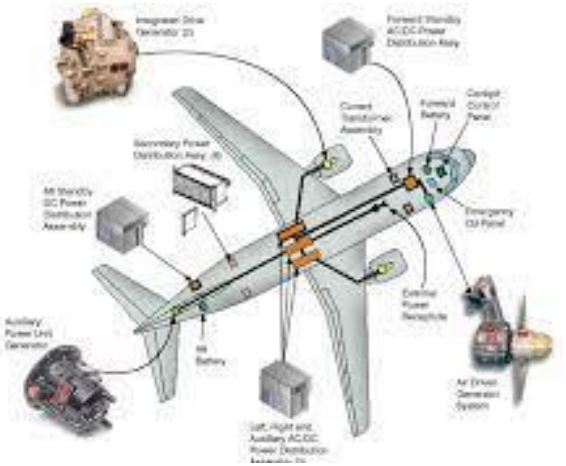
- Optics – CMOS, Lens, Mirror
- Photonics – PIC, Fiber, LED
- Electronics – EIC, Bare Die, SMT, PTH
- Mechanics – Enclosures, Motors, Servos, Micropumps
- Substrates – Organic, Inorganic, Rigid, Flexible, Stretchable
- Materials – Electrical, Thermal, Optical, Mechanical



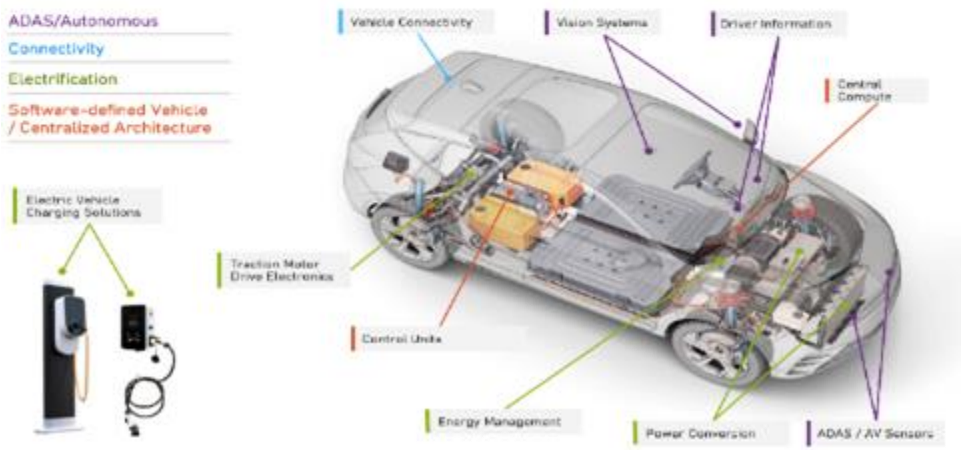
Manufacturing and test solutions for complex integrated systems (CIS) require a resilient and efficient supply chain that offers end-to-end services providers leveraging capabilities from 1st Level (Foundries), 2nd Level (Semiconductor Assembly, Packaging, & Test), and 3rd Level (Electronics Assembly and Product Integration).

Complex Integrated Systems and Platforms

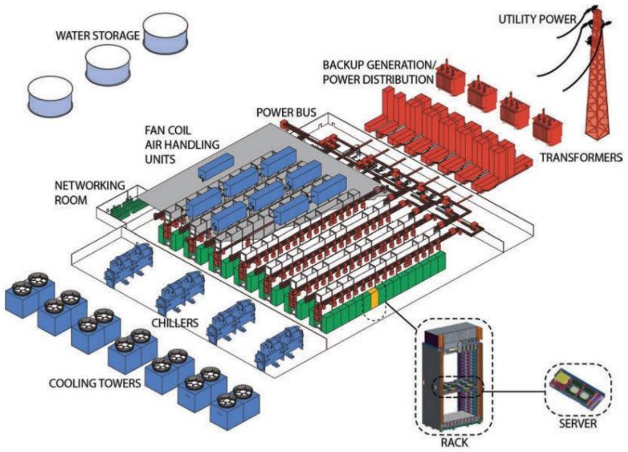
Aerospace



Automotive



Data Center



*https://s27.q4cdn.com/276975351/files/doc_financials/2023/q4/Q4-FY23-Investor-Briefing-Presentation-All-Slides-Final.pdf

Several platforms are demanding robust design, manufacturing, and test solutions for complex integrated systems (CIS) to enable feature rich options to improve customer experience, safety, and sustainability.

CIS Manufacturing Ecosystem: Blending Manufacturing Verticals

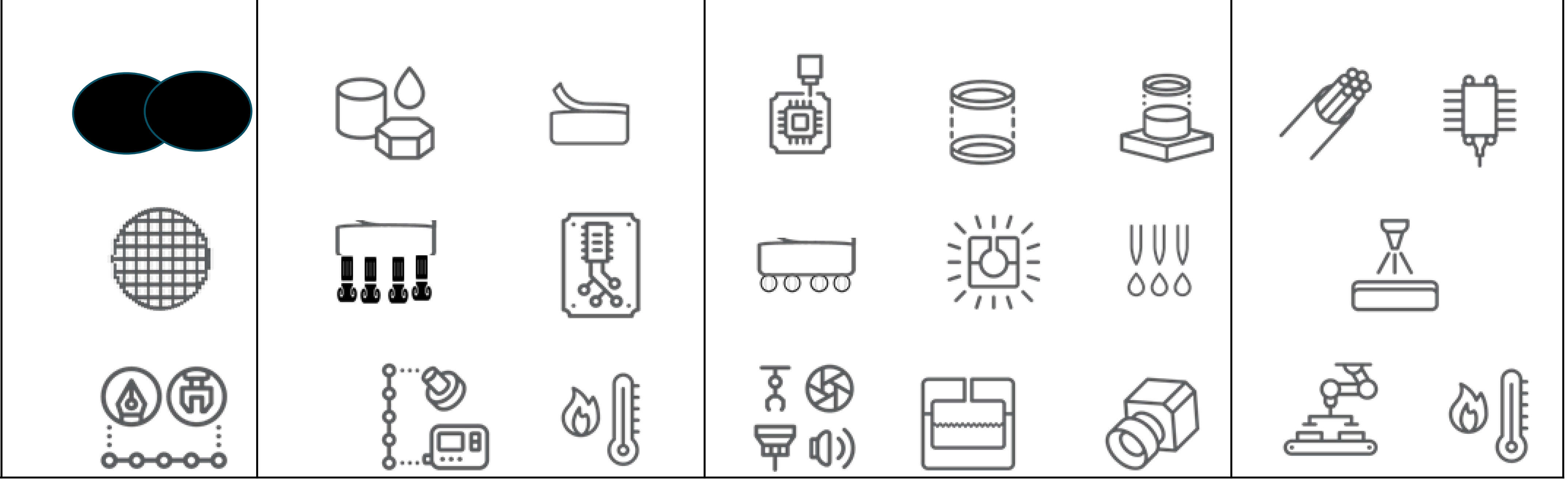
- **Innovation and integration**
  - This growth will foster advancements in wafers, components, modules, and systems through the integration of smart manufacturing, sustainability, and skilled workforce.

- **Diverse product design**
  - Product designers are seeking innovative designs, materials, and assembly processes to manufacture CIS-enabled products.

- **CIS manufacturing challenges**
  - The assembly of CIS-enabled products requires a combination of different processes, tools, and equipment from various manufacturing verticals.

- **Accelerated growth**
  - The electronics manufacturing ecosystem is poised for accelerated growth driven by increased demand for various applications.

Trend - Convergence of Capabilities Across Electronics Manufacturing Level 1, Level 2, and Level 3

	1st Level (Foundry)					2nd Level (Semiconductor Assembly, Packaging & Test)															3rd Level (Electronics Assembly and Product Integration)				
	Design	Wafer Processing				Wafer Level Packaging							Component Packaging/ Module Assembly								Board Level Assembly			System Integration	
Capabilities (Example)	IC Design	Film Dep	Litho-graphy	Etch	Probe/ Test	Thru-Si Via	Back-grinding	RDL	Die Bumping	D2W W2W	Test (KGD)	Dicing/ Clean	Die Stacking	Die Bond Wire Bond Flipchip	Encap-sulation	Final Test	Trim & Form	Balling	Optics Attach	EOL Test	SMT	PTH	Singulation/ Test	Final Assembly	Functional Test
Example Topics for Best Practices, Guidelines, & Standards	EDA, Tool Flow Interoperability																								

Sample Use-Case Applications Enabled By Complex Integrated Systems (CIS)

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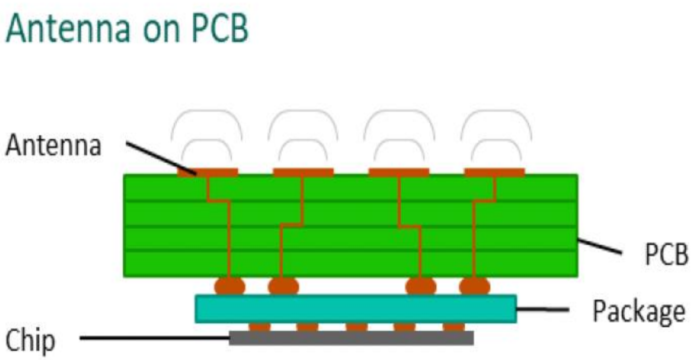
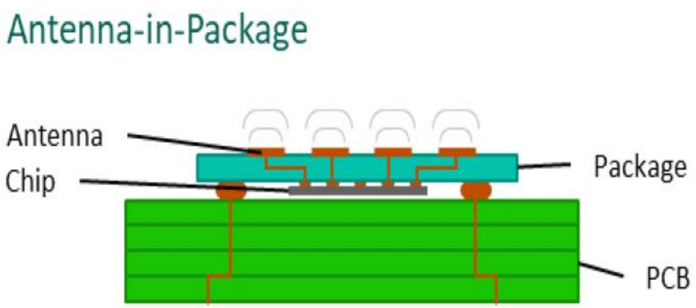
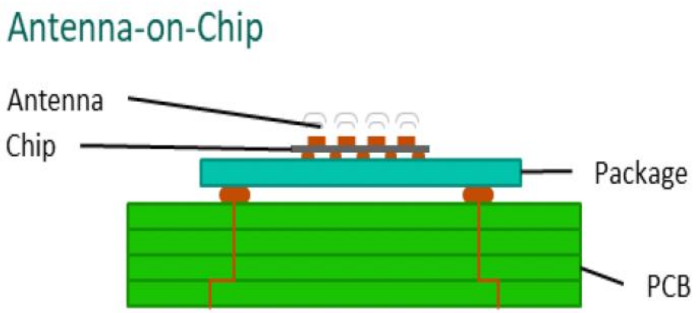
Massive Wireless Broadband with 5G mmWave Systems

- Integrated RF front-ends are needed for high-speed mmWave communication.
- Smaller analog components are required for higher frequencies.
- RF system-on-chip is crucial for mmWave applications.
- Advanced materials and substrates are essential for efficient thermal management and low-loss signal transmission.





Suitable for 20-100GHz
Incompatible with sub-6GHz



Suitable for >100GHz

High Performance Computing

- **Power-efficient machine learning:** Specialized computing cores with multiple processing nodes and distributed embedded memory caches are essential for power-efficient machine learning.
- **Computational density and power efficiency:** In traditional high-performance computing applications like data centers and self-driving vehicles, chiplet-based designs are driven by the need for computational density and power efficiency, while addressing power delivery and thermal management challenges.
- **Machine learning in non-stationary equipment:** Non-stationary electronics will increasingly rely on machine learning for adaptability, with applications in drones, medical instrumentation, and factory robots to deliver on demand efficient edge computing.
- **Heterogeneous chiplet integration:** Flexible designs aiming at high-yield manufacturing will implement a heterogeneous mix of computing architectures using chiplets integrated into a single package.

AR/VR/MR Devices

- **Wafer-level components in XR:** Wafer-level components enable transformative commercialization in XR applications by enhancing performance and miniaturizing devices like glasses and goggles.
- **Top-down assembly for light engines:** A preferred approach for developing an economical, high-output process for miniaturized light engines is top-down assembly.
- **Architectural process design:** Architectural process design focuses on component attachment, passive alignment, and wafer-level package placement to broaden the process window without compromising cost, yield, or performance.
- **Component evaluation and equipment assessment:** During design, evaluation of physical connections between components, such as anisotropic conductive adhesive, is essential. Additionally, high-precision automated equipment for wafer-level die placement must be assessed to ensure single-digit µm precision, repeatability, and throughput.

Advanced Driver Assistance Systems–Passenger Vehicles

- ADAS sensor subsystems market is projected to reach $12 billion by 2030 providing immense subsystem integration opportunities.
- ADAS subsystems include radar, cameras, and LiDAR, providing various functionalities.
- Manufacturing ADAS subsystems requires addressing precision placement, controlled processing, and packaging challenges.
- Precise placement of components is critical for ADAS subsystem performance.
- Controlled processing parameters are essential for reliable ADAS subsystem operation.

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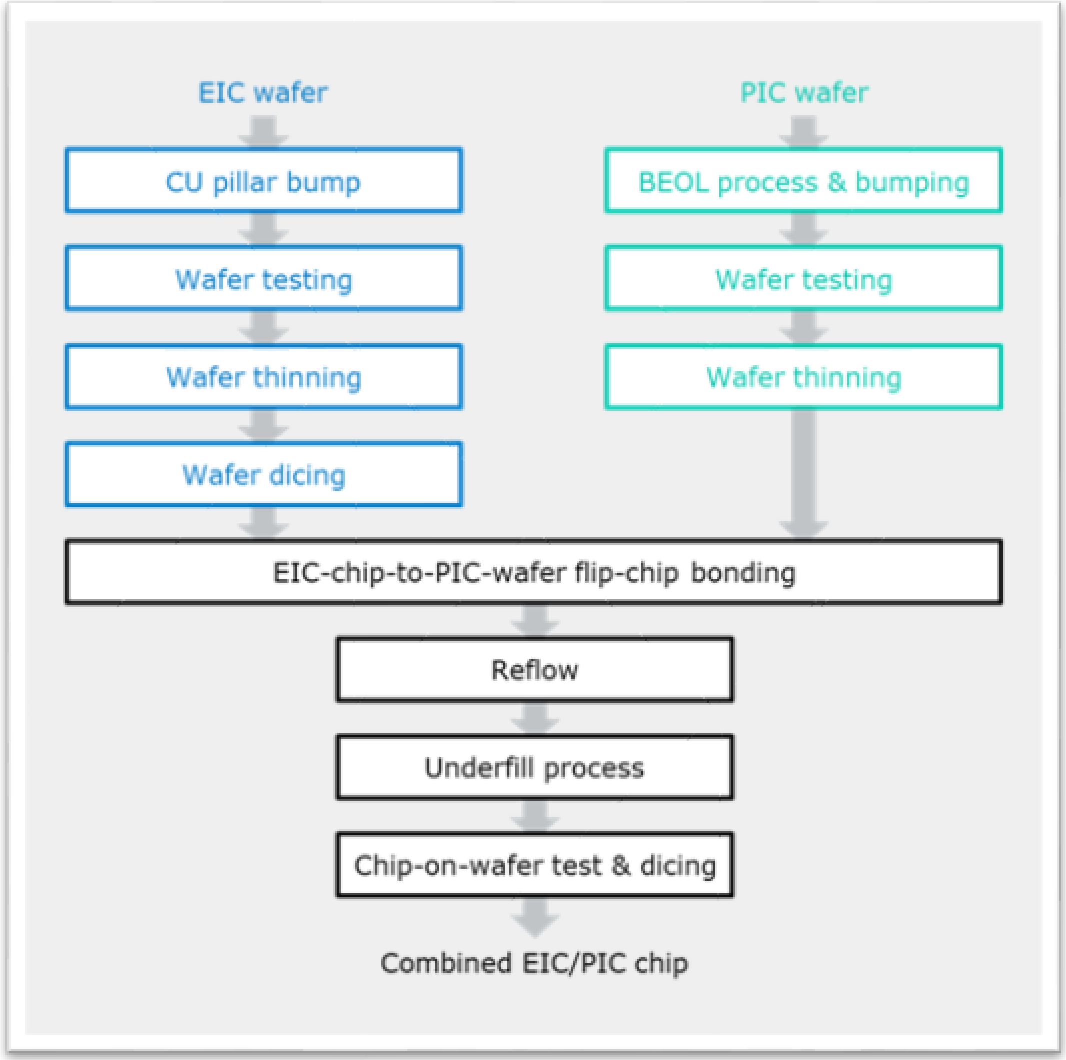
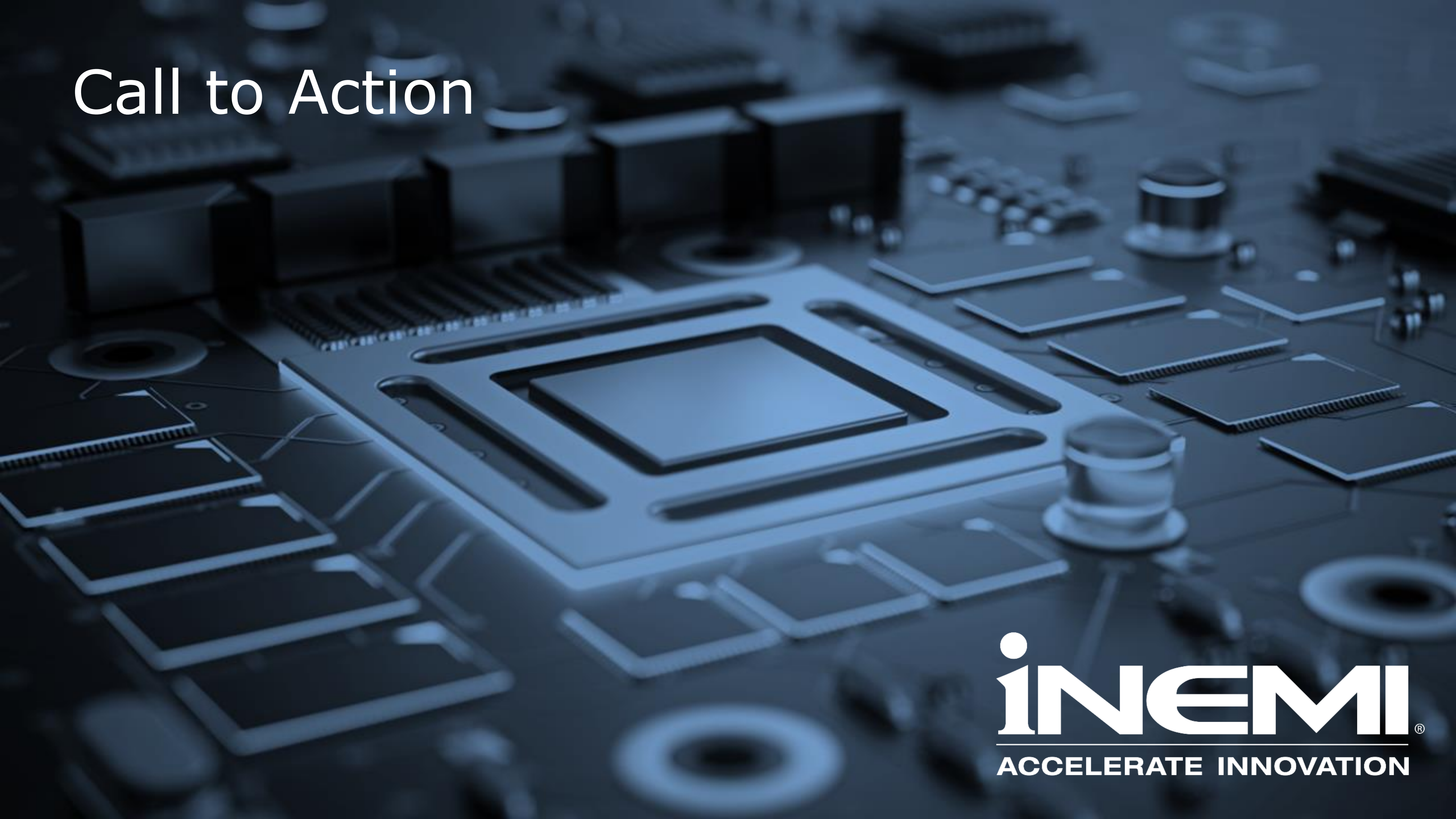
Integrated Photonics

- Demand for highly integrated photonics solutions is growing due to various applications.
- Fiber optics hardware will evolve from pluggable transceivers to optical I/O.
- CIS toolbox addresses challenges in optics product design and manufacturing.
- CIS manufacturing site offers post-CMOS processes, wafer-level assembly and test, and module assembly.



Call to Action



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Call to Action

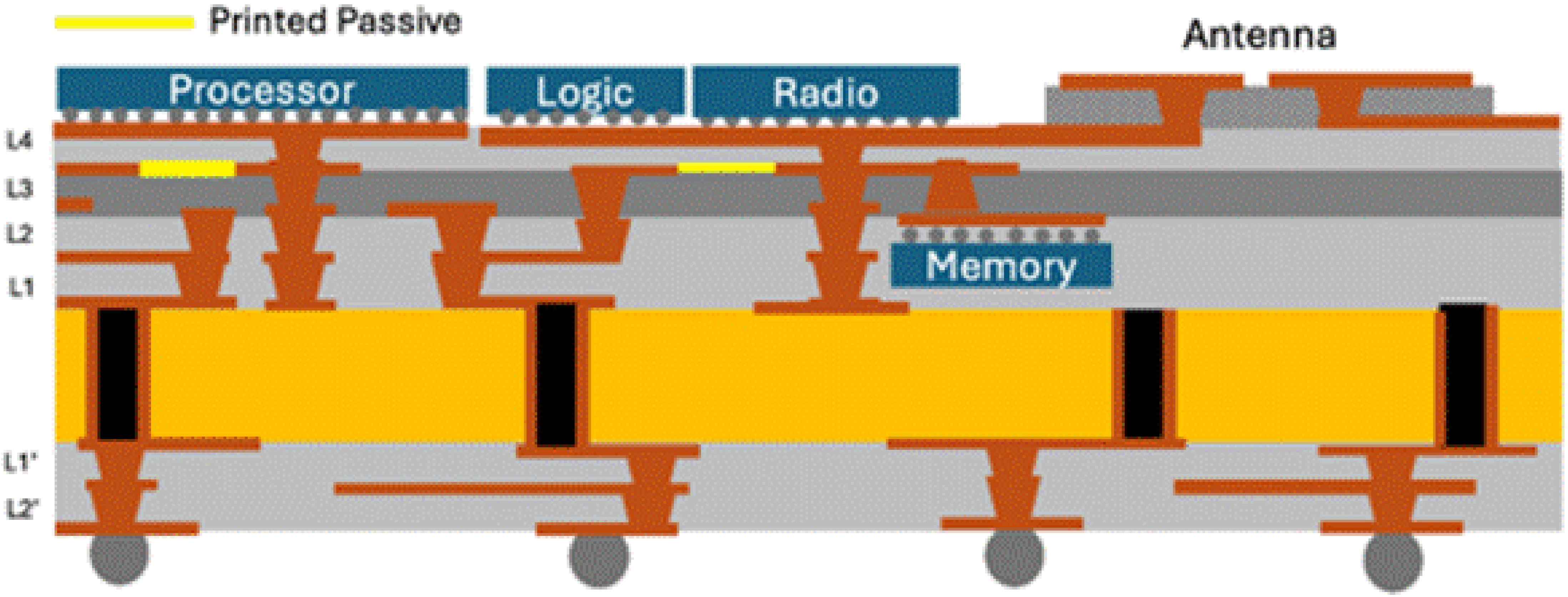
- **Technology development** focused on miniaturization.
- **Adoption of system design tools** that determine the trade-offs between different technologies and integration architectures.
- **Adoption of design for test, for manufacturing, and for sustainability** as core design principles.
- **Investment in new process and manufacturing capabilities**, opening up new integration possibilities within a single facility.
- **Modular and interoperable facility equipment and processes** that accommodate both cleanroom environments of back-end of line packaging and the flexibility of board assembly capabilities.

Call to Action

- **CIS situation awareness** and a concerted effort to build a CIS community focused on collaborative, cross-industry initiatives are needed for realizing:
  - **Standards, guidelines and frameworks** to support cross-supply chain traceability of materials, components, and their associated test data for CIS, building on existing standards such as IPC-1782.
  - **Standardization** of data exchange formats within CIS electronic design automation (EDA) flows.
  - **Standardization** of physical form factors and physical interfaces for chiplets.
  - **Standardized** assembly techniques to ease materials extraction for recycling and (in the longer term) component extraction for reuse.
- The immediate cross-industry task is to define technical issues and develop solutions in a precompetitive space, followed by tailored learning programs, standardization, and collaboration.
  - Designers, manufacturing engineers, and technicians need increased multi-disciplinary thinking and system design in undergraduate-level technical courses to address the growing complexity of cross-technology products.

CIS is Driving the Future! What's Next?

Advanced Microelectronics Architectures



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What do you want to see covered?

- What Complex Integrated System Topic(s) do you want to see covered?
- Are you interested in presenting the CIS work of your organization?

Sessions are being planned for October, November/December, January and forward….

CIS Whitepaper link -- https://go.ipc.org/complexintegratedsystems

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