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HETEROGENEOUS INTEGRATION ROADMAP

Heterogeneous Integration Roadmap

Integrated Power Electronics (IPE) Chapter 10

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Chapter 10 Outline

HETEROGENEOUS INTEGRATION ROADMAP

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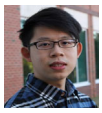
Co-Chairs



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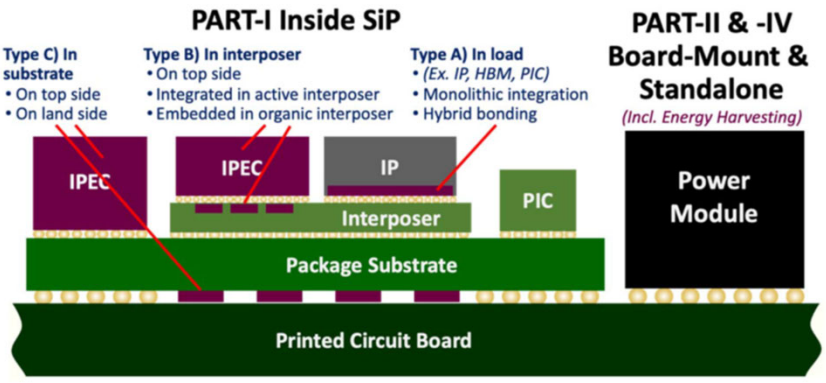
Graphic Description of Chapter Contents



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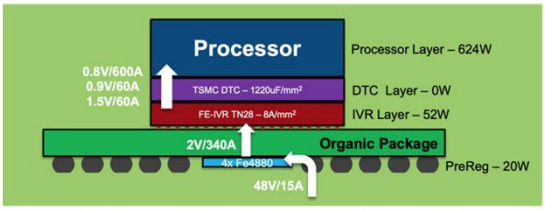
Integration with Load and/or Interposer

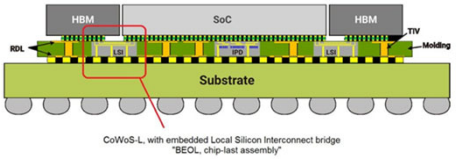
HETEROGENEOUS INTEGRATION ROADMAP

Hybrid Bonding

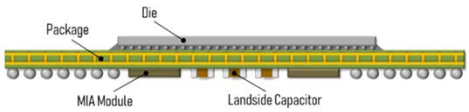
Integrate a hybrid converter topology:
1st stage: 48V-to-2V converter on landside of package
2nd stage: hybrid-bond deep trench capacitor (DTC) and integrated voltage regulator (IVR) layers to the processor dies



IEEE Power Electronics Society October 22, 2020, Integrated Power – A Virtual Panel Session



Highlights of the TSMC Technology Symposium Part 2



Magnetic Inductor Arrays for Intel® Fully Integrated Voltage Regulator (FIVR) on 10th generation Intel® Core™ SoCs

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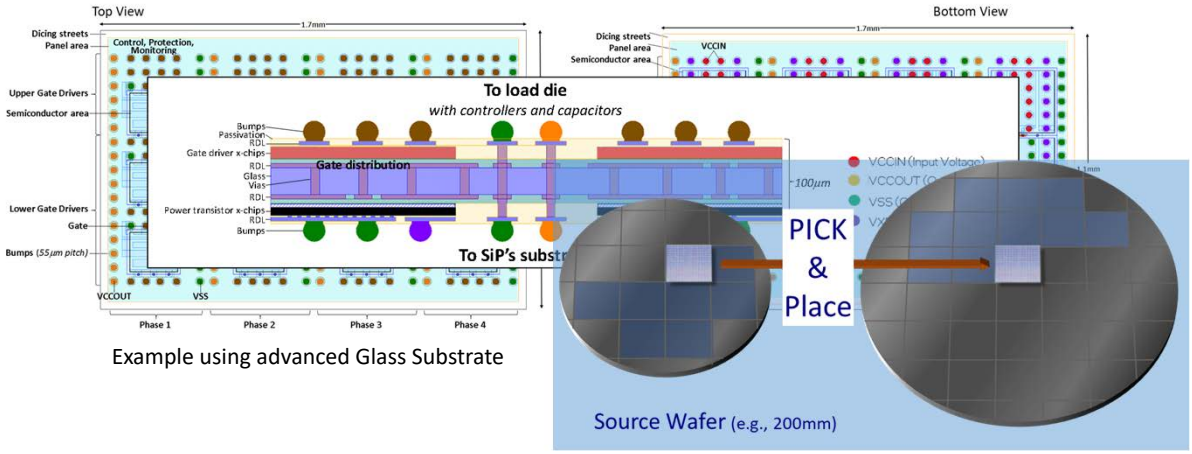
HI of III-V chips and other processes via Micro-Transfer Printing (µTP)

HETEROGENEOUS INTEGRATION ROADMAP



Example using advanced Glass Substrate

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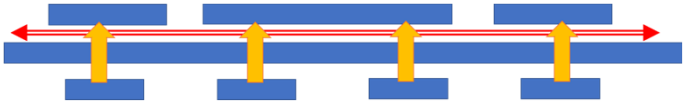
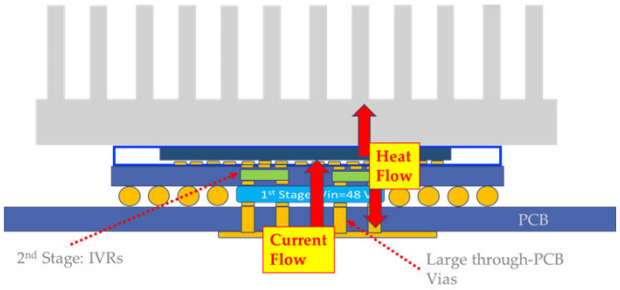
In HPC, Signal Interconnect Requirements Are at Odds with Power Integrity

- In the substrate, Signal and Power paths are orthogonal both in direction and requirements





Power can only travel in the Z direction to minimize losses → two different interconnect paradigms

IVR Requirements

Metric	Target	
Input Voltage	>5 V	Reduce routing loss
Output Voltage	0.6 – 1.2 V	
Current Density	>10 A/sqmm	
Target Efficiency	>90 %	Minimize power loss
Switching Freq	10-25 MHz	Shrink passives Increase transient response

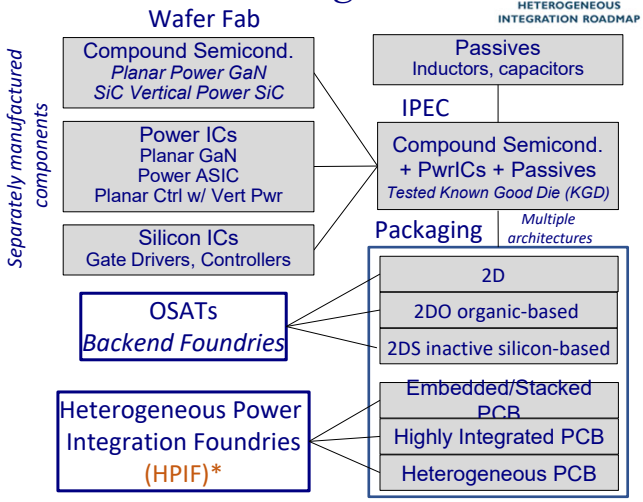
Source: K. Radhakrishnan

Additional requirements

Facilitates use in SiPs & SAP

- Modular building blocks
- Minimal z-height
- Known good "die" (KGD)
  Tested / binned prior to integration in SiP
- Low cost
- High reliability
- Ultra low thermal resistance

IPEC Integration



* HPIF Concept: National network of flexible-packaging foundries with Pwr Pkg PDKs (P^3DKs)

Source: K. Radhakrishnan, Challenges and Innovations in Microprocessor Power Delivery, IEEE Electronics Packaging Society Silicon Valley Area Chapter webinar, June 22, 2002.

SAP: Stand Alone Power

A sub-group of HIR Chapter 10 has engaged in projects funded by CHIPS Act

- DARPA NGMM Phase 0 Proposal has bee accepted:
  - "Requirements for a 3DHI Power Microsystem (3DHIP) and Manufacturing Center"
- Participation to Manufacturing USA "Semiconductor Institute" RFI

Focus on Section IV for 2023 update: Energy Harvesting

- Challenges:
  - Multi-science simulation requirements (electrical, packaging, etc.)
  - Flexible, conformal components, substrates and packaging
  - Materials for Biodegradable Sensors

Potential for Cross TWGs Collaborations

- Energy efficiency is job one for all products, both to improve performance and to satisfy the sustainability objectives.
- Power management is a critical aspects of all applications, thus relevant collaboration can be established with many HIR Chapters.
- Closer integration with the IEEE EPS Power and Energy Technical Committee is ongoing.