ECO-CHIP: Estimation of Carbon Footprint of Chiplet-based Architectures for Sustainable VLSI

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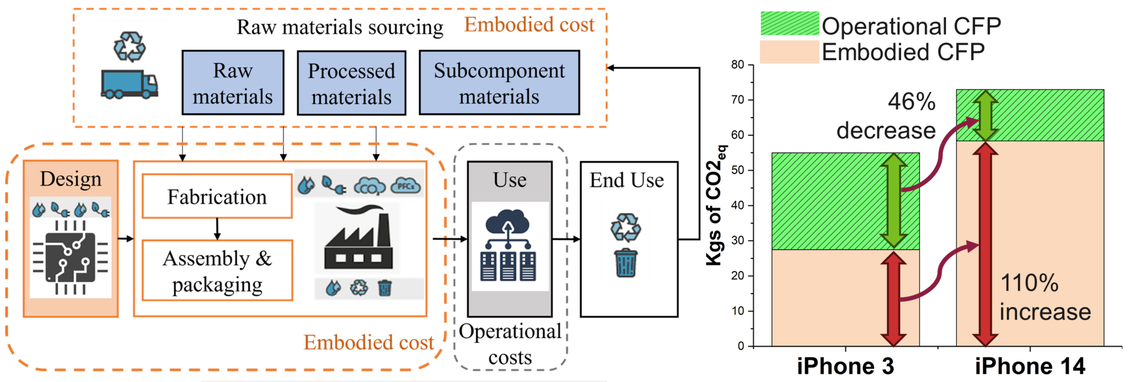
Introduction and background

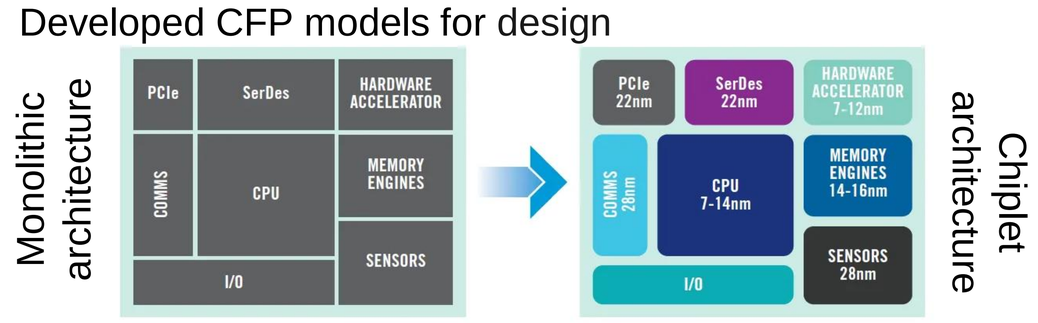
- The information and computing technology (ICT) industry contributes to 3-5% of the world's total carbon footprint (CFP)
- The industry has focused on optimizing power, performance, and area of chips but has neglected environmental impacts
- Embodied CFP has increased over time due to:
  - Lower yields in newer technology nodes
  - Increased time required for design closure



Prior work and our contributions

ACT: Architectural carbon modeling tool [Gupta et. al. ISCA 2022]
- Modeled embodied carbon
- Assumed constant packaging overheads

Our key contributions:
- Proposed heterogenous integration (HI) for sustainability
- Developed a tool for CFP analysis for heterogeneous systems
- Developed CFP models for advanced packaging technologies
- Developed CFP models for design

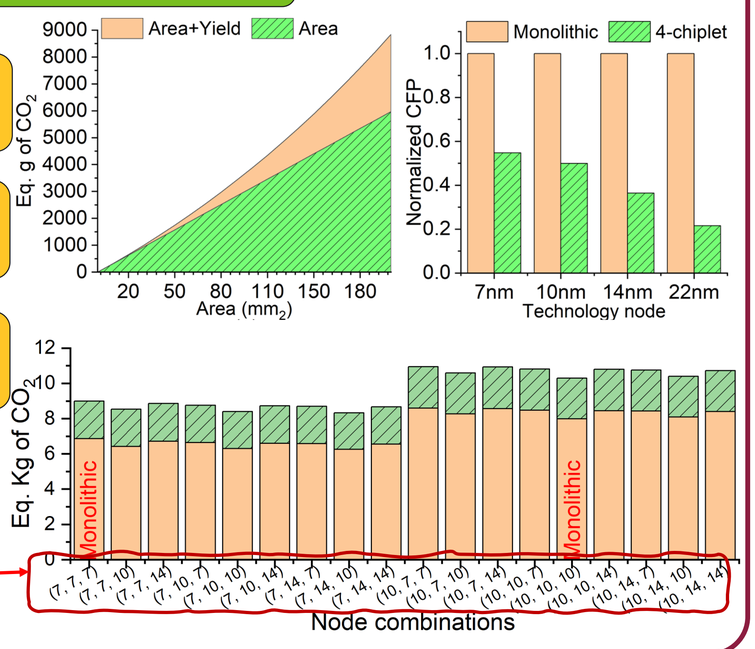


What is HI? Multiple chiplets manufactured individually and integrated into a single advanced package to sustain Moore's law

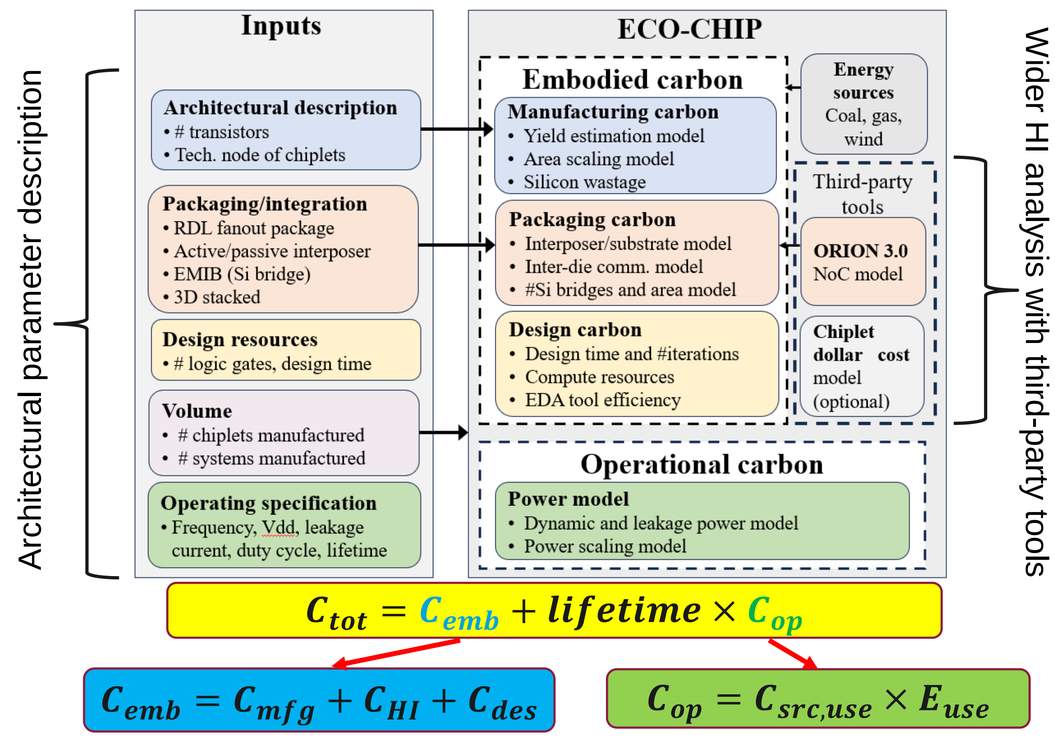
HI as a path towards sustainability

Sustainable computing via HI

- Better yield with smaller chiplets
- "Mix and match" technology nodes
- Chiplet reuse across systems



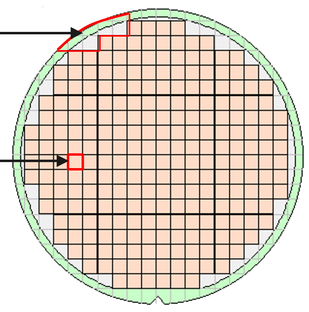
ECO-CHIP framework: Total CFP model



ECO-CHIP: Embodied CFP models

Manufacturing CFP:

$$C_{mfg} = CFPA\ (Die\ area + Wasted\ area)$$

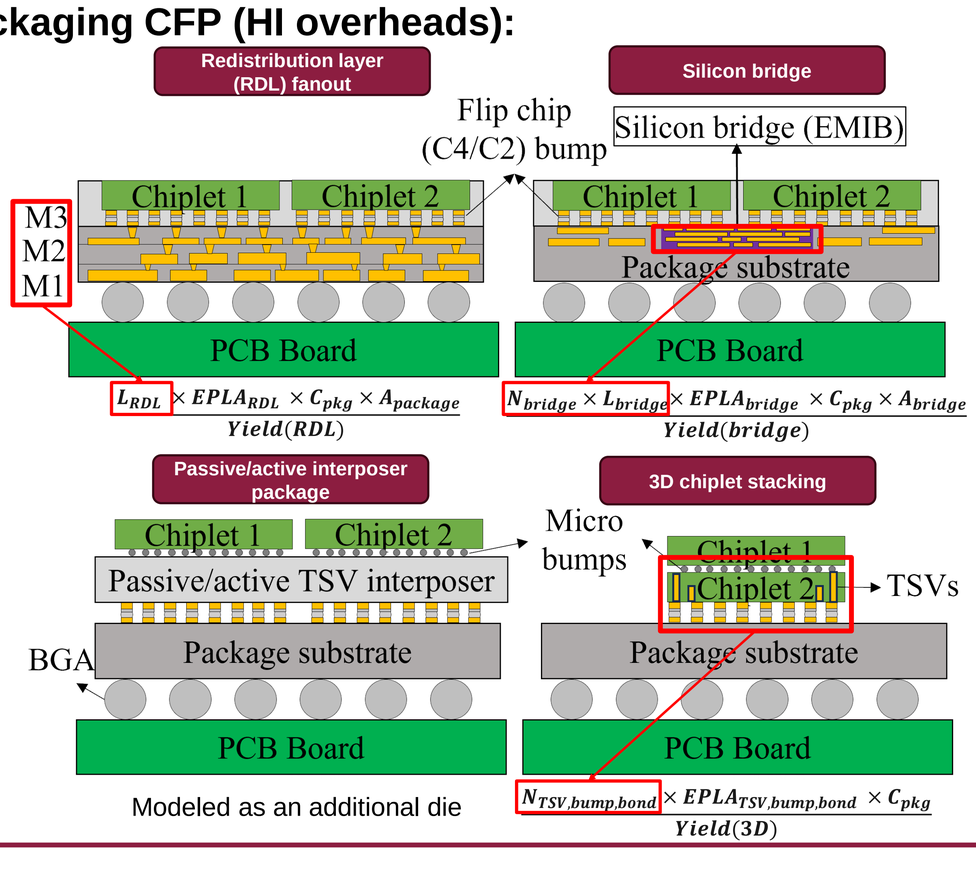


Design CFP:

$$C_{des} = t_{des} \times P_{des} \times C_{src}$$

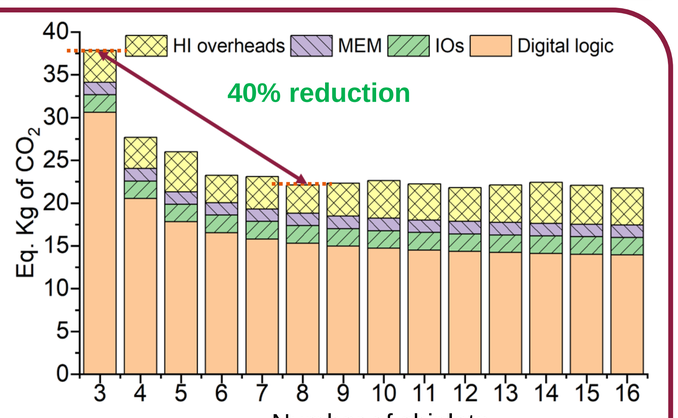
$$t_{des} = \frac{t_{verif} + (t_{SP\&R} + t_{analyze}) \times N_{des}}{\eta_{EDA}}$$

Packaging CFP (HI overheads):

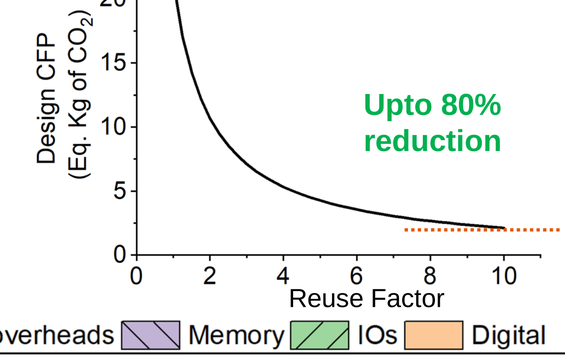


Key results and conclusion

- **40%** CFP reduction with chiplet disaggregation
- **36%** CFP reduction with mix and match of technology nodes
- Up to **80%** design CFP reduction with increased chiplet reuse



- ECO-CHIP analyzes CFP of heterogeneous system
- Advanced heterogeneous packaging architecture CFP overheads modeled
- Design CFP modeled



SCAN ME: ECO-CHIP

Open-source code