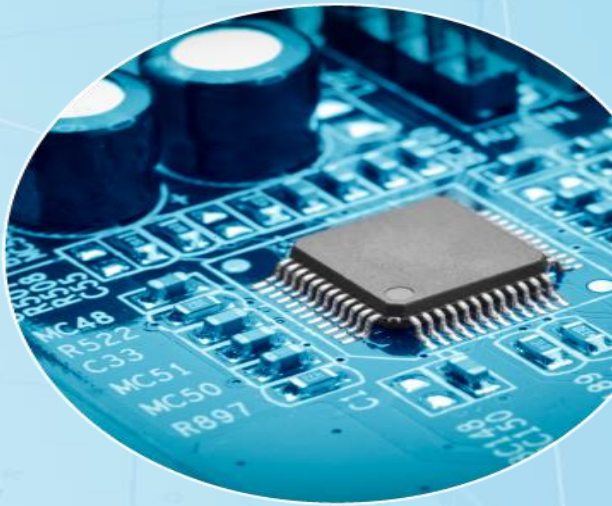
Short Introduction to the goals of HIR Modelling mission



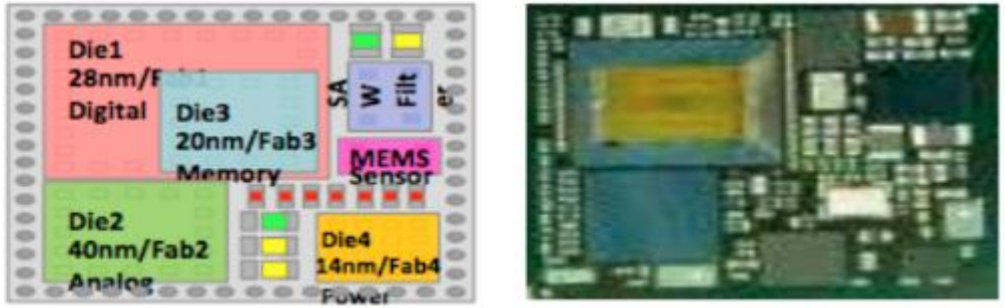
Chris Bailey
EPS, President
Co-Chair – M&S Chapter

IEEE

Heterogeneous Integration Defined

Heterogeneous Integration refers to the integration of separately manufactured components into a higher level assembly (SiP) that, in the aggregate, provides enhanced functionality and improved characteristics

Die/Package, Heterogeneous Components



System-in-Package (SiP)

- Integration: Different nodes, MEMS, Si Photonics, Power ICs, etc
- Miniaturised by Advanced Packaging (SiP Toolbox)
- Performance optimised - Signal and power integrity
- Decrease development time & Improved reliability
- Flexible, re-usable & re-configurable design

HIR
HETEROGENEOUS INTEGRATION ROADMAP

Heterogeneous Integration Roadmap

Topic Theme	Technical Working Group
Heterogeneous Integration Components	Single Chip and Multi-Chip Packaging (includes Substrates)
	Integrated Photonics (includes Plamonics)
	Integrated Power Devices
	MEMS
	RF and Analogue Mixed Signal
Cross Cuttung Topics	Emerging Research Materials
	Emerging Research Devices
	Interconnect
	Test
Integration Processes	SiP
	3D & 2.5D
	WLP (fan-in & fan-out)
Packaging for Specialised Applications	Mobile
	IoT and Wearable
	Automotive
	High Performance Computing
Design	Co-Design, Modelling and Simulation
Supply Chain	Elements of the Supply Chain Appropriate for pre-Competive Collaboration

ITRS:

1991 - 2015

- Precompetitive
- 15 years outlook & 25 years for emerging materials & devices
- Sponsored by five global semiconductor associations. Appoint IRC & approve governance
- Volunteer driven
- Free access
- CMOS "Moore's Law" node driven
- 17 Technical Working Groups

HIR:

2016 --

- Precompetitive
- 15 years outlook & 25 years for emerging materials & devices
- Sponsored by IEEE technical societies & organizations with similar outlook. Appoint IRC & approve governance
- Volunteer driven
- Free access
- Systems & application driven
- 19 Technical Working Groups

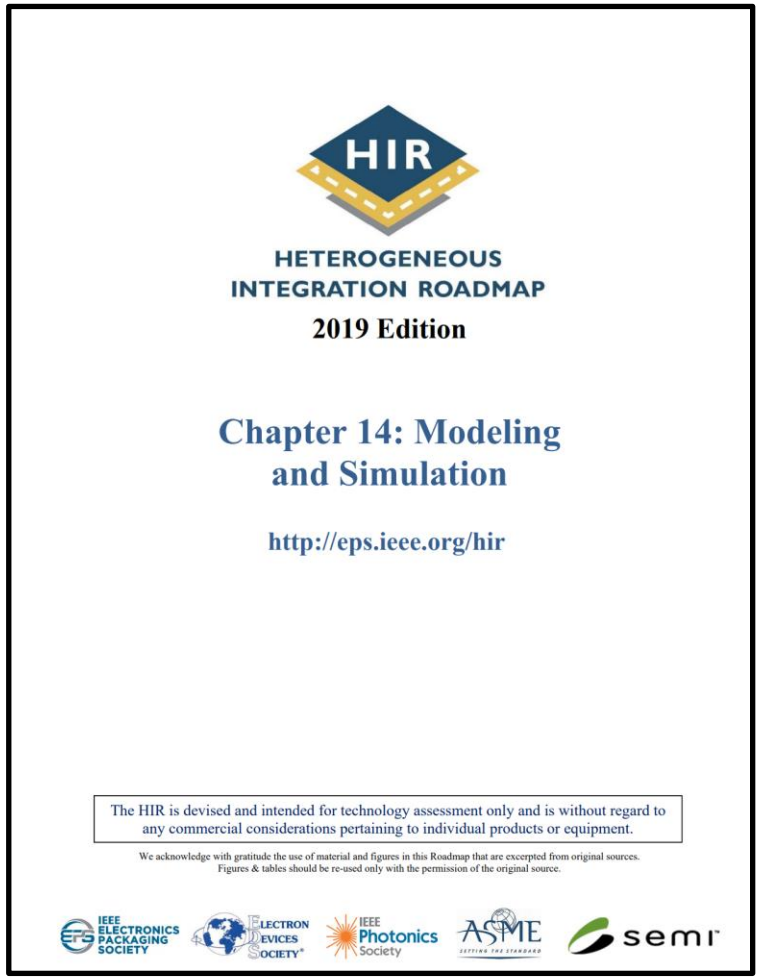
IEEE photonics Society · semi · ASME · Electron Devices Society

https://eps.ieee.org/technology/heterogeneous-integration-roadmap.html

HIR HETEROGENEOUS INTEGRATION ROADMAP

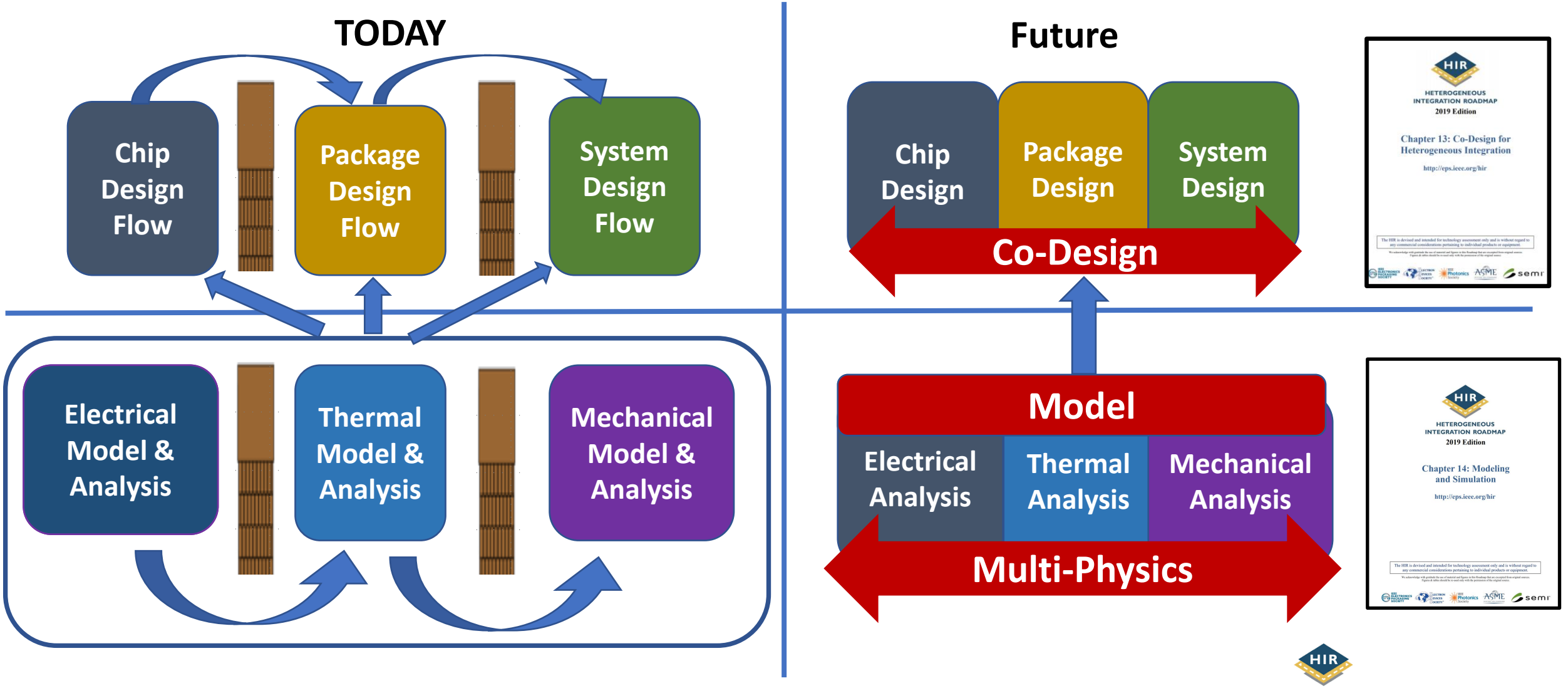
Scope

- Five sections
  - Electrical Analysis
  - Thermal Analysis
  - Materials Modelling & Process Models
  - Mechanical & Multi-Physics Analysis
  - Reliability and Prognostics
- Chapter details
  - State of the Art & Challenges
  - Potential solutions



HIR
HETEROGENEOUS
INTEGRATION ROADMAP

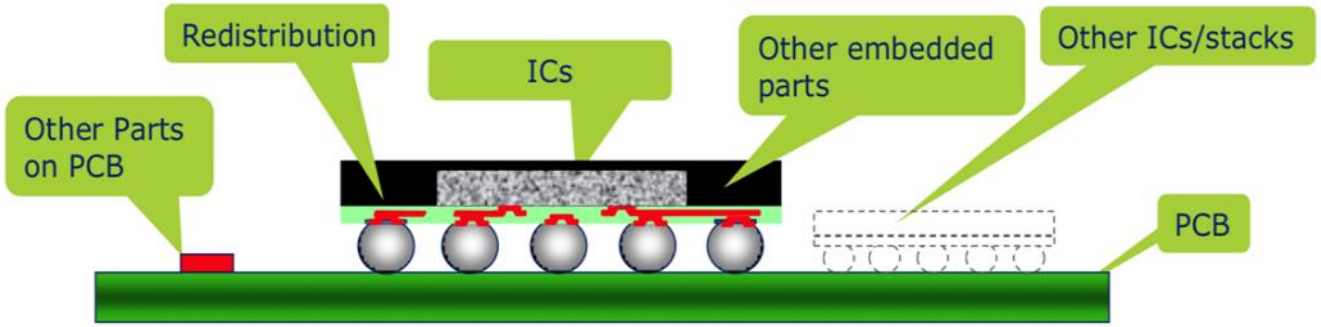
Moving towards a new paradigm



HETEROGENEOUS INTEGRATION ROADMAP

Co-Design Requirements

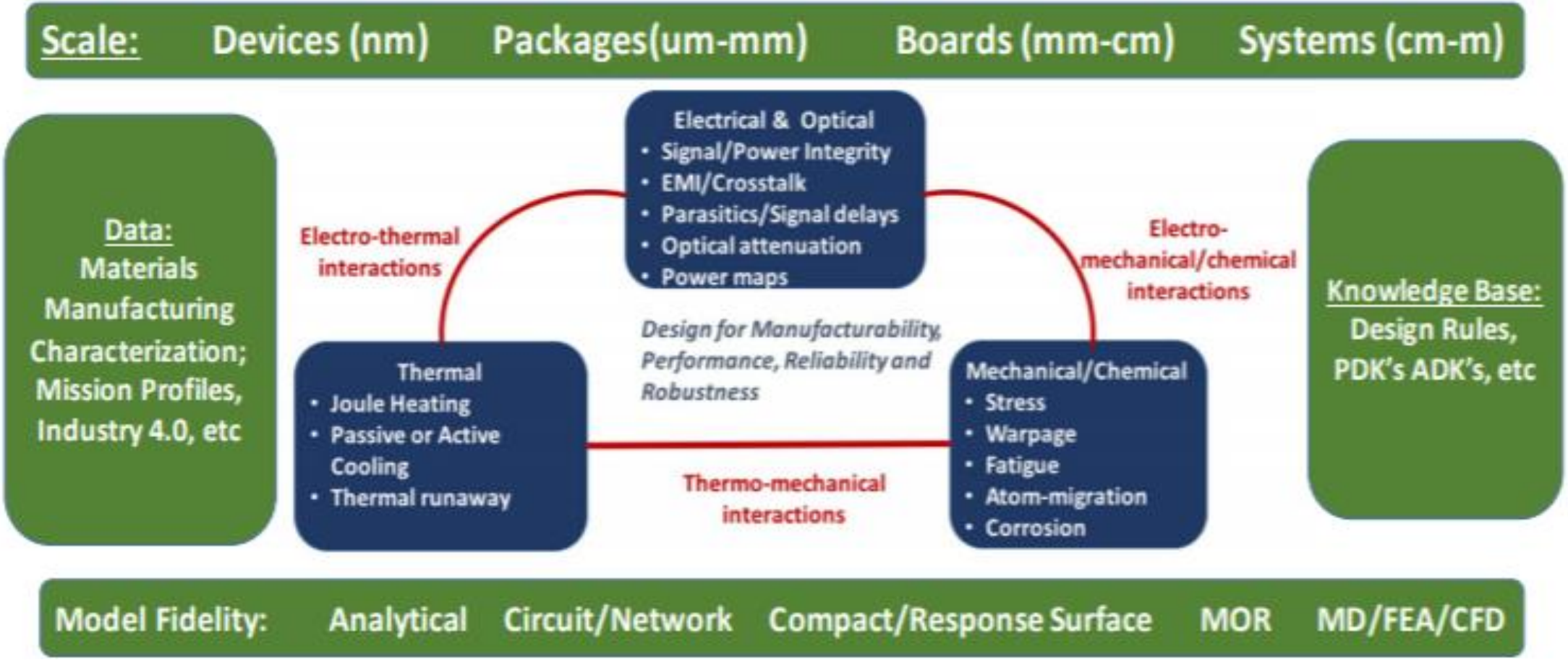
- Design Challenges:



- Many technologies within one project
  - Different Si tech's – substrate/RDL – PCB – other components
  - Multiple length scales
  - Interdependencies: dies, package, test, and board
  - Independent optimization at different levels does not lead to optimize system
- Need global optimization (chip – package – board/system)
  - Higher performance, reduced cost, better quality and reliability

HETEROGENEOUS INTEGRATION ROADMAP

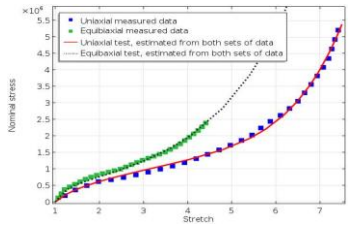
Modelling & Simulation



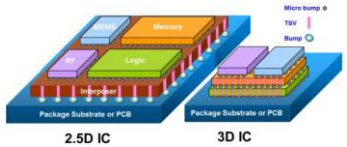
HETEROGENEOUS INTEGRATION ROADMAP

Physics of Failure (PoF) Based Reliability Modeling

Material Properties



Design Information



Application Conditions

Stochastic Process Modelling

Physics of Failure

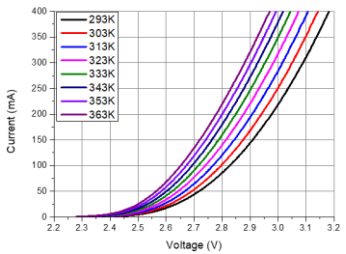
Electronic Simulation ⟷ **Optical Simulation**

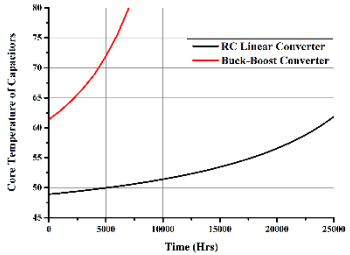
Thermal Simulation

Failure or Degradation
Temperature/time dependent Failure or Degradation

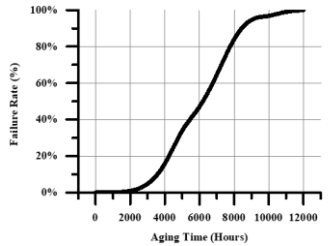
Monte Carlo Simulation

History of Electronic-Thermal Behavior

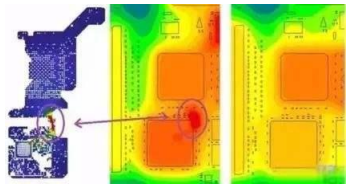




Reliability/ Lifetime/ MTTF



Critical Component & Material

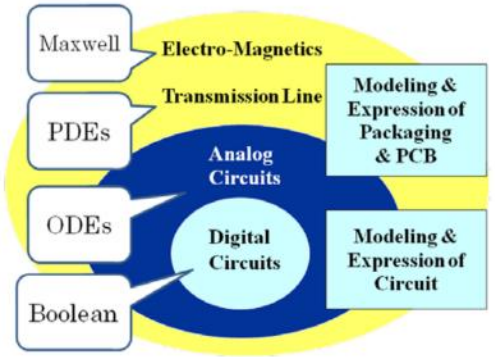


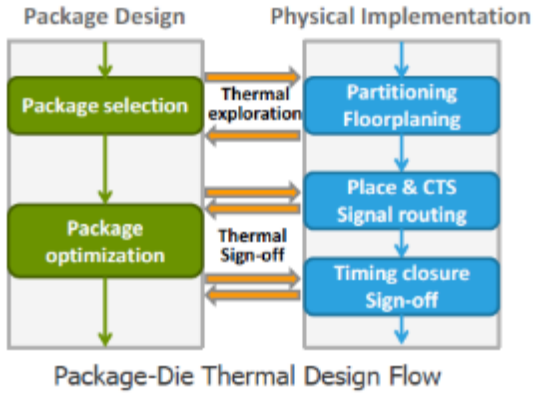
B. Sun, X.J. Fan, et al., RELIABILITY ENGINEERING & SYSTEM, 2017;
B. Sun, X.J. Fan, et al., IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, 2016;

HETEROGENEOUS INTEGRATION ROADMAP

Highlights from 2019 Edition of HIR

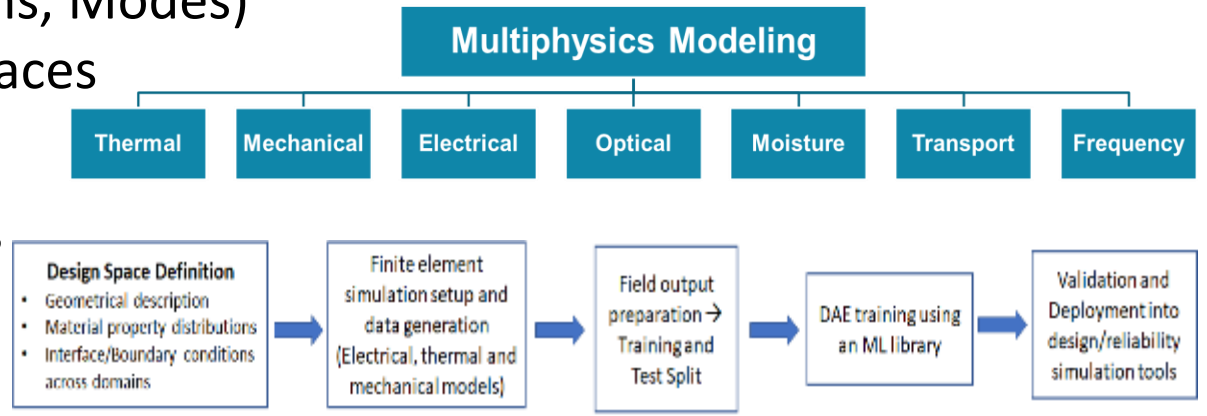
- State of the art
  - FEA, CFD, FDTD … Compact Models, Spice
  - EDA Tools … Spreadsheets
- Examples of Challenges
  - Electrical - Simulate across features (within die and die-die coupling)
  - Electro-Thermal – Predicting hot spots (Joule Heating, Thermal Runaway)
  - Electro-Thermal-Mechanical – Stress on transistors (Mobility shifts)
  - Reliability – Physics of failure (Mechanisms, Modes)
  - Materials – Stochastic behaviour & interfaces
- Potential solutions
  - Multi-physics/scale modelling techniques
  - Model order reduction techniques
  - Machine Learning & AI





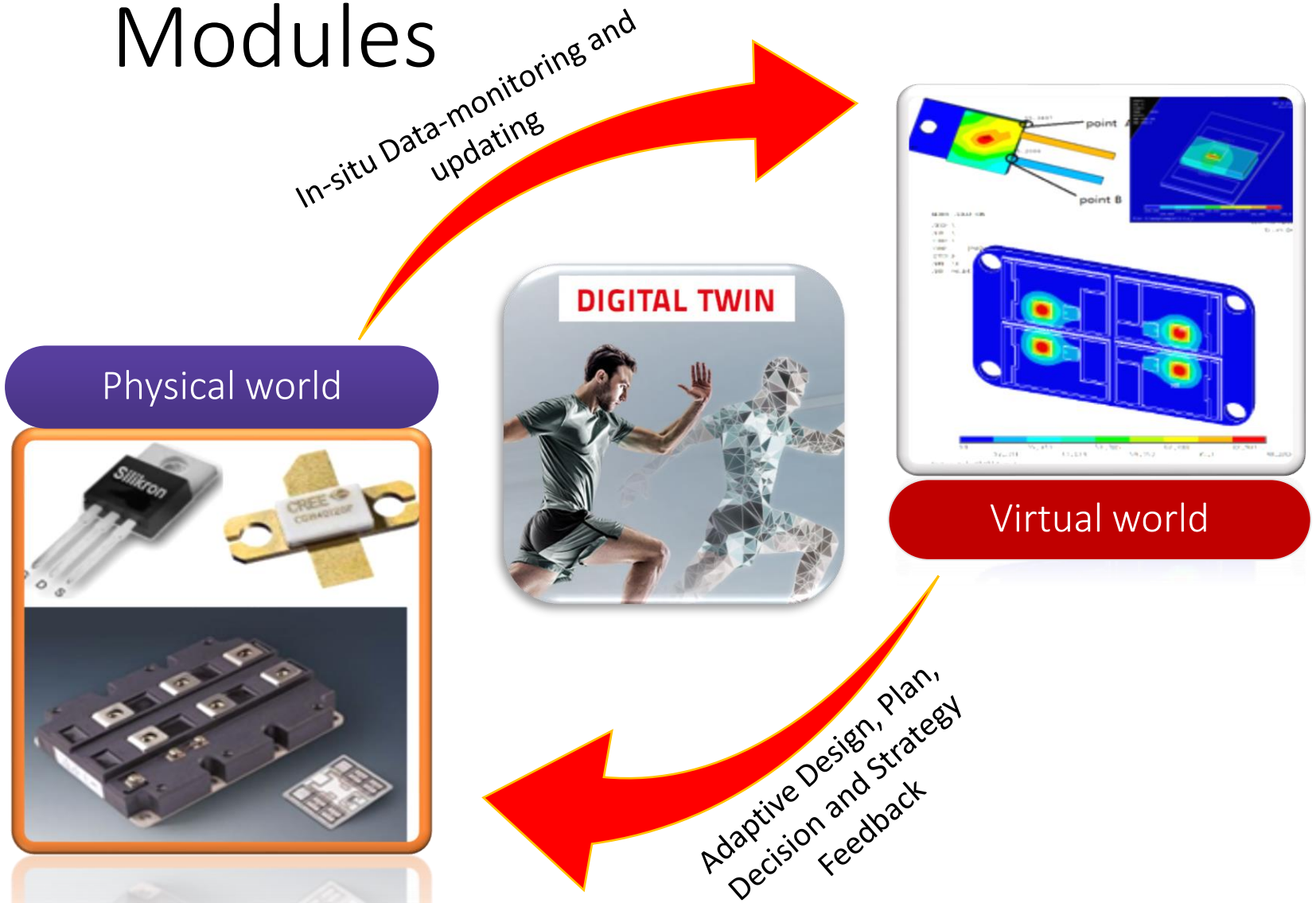
Package-Die Thermal Design Flow

DAC Designer Track 2017 | ***Pascal Vivet***



HIR
HETEROGENEOUS INTEGRATION ROADMAP

Digital Twin for Electronic Components and Modules

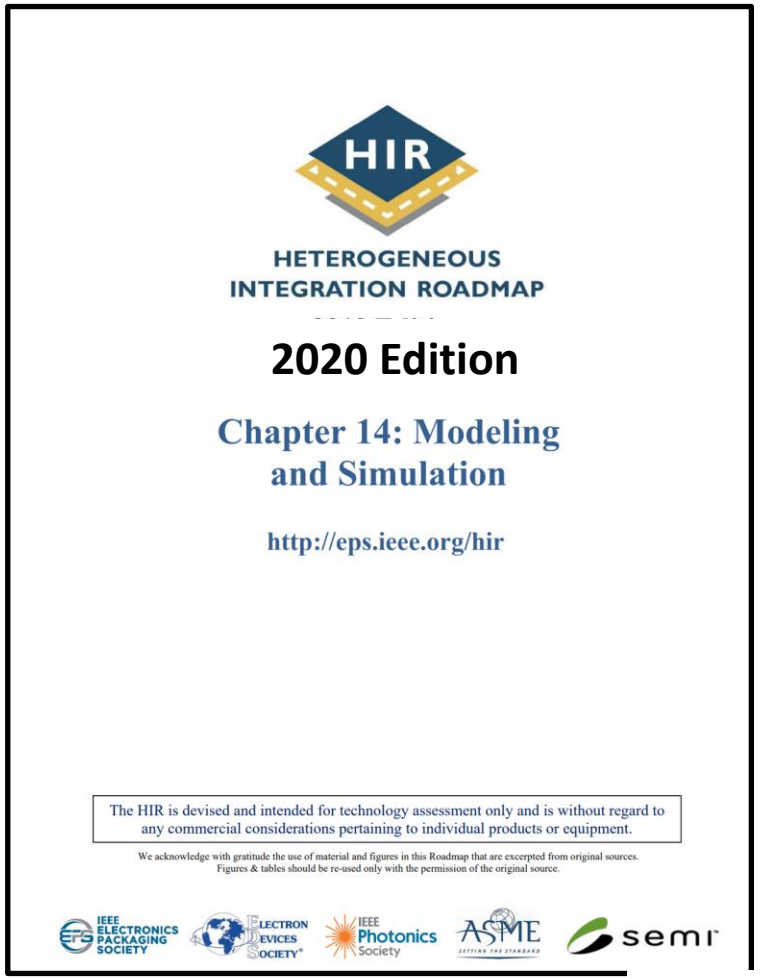


- Digital Twin is the ultimate aim of product design, reliability and lifetime management.
- Modeling and Simulation plays a vital role in digital twin realization.

HETEROGENEOUS INTEGRATION ROADMAP

2020 Edition

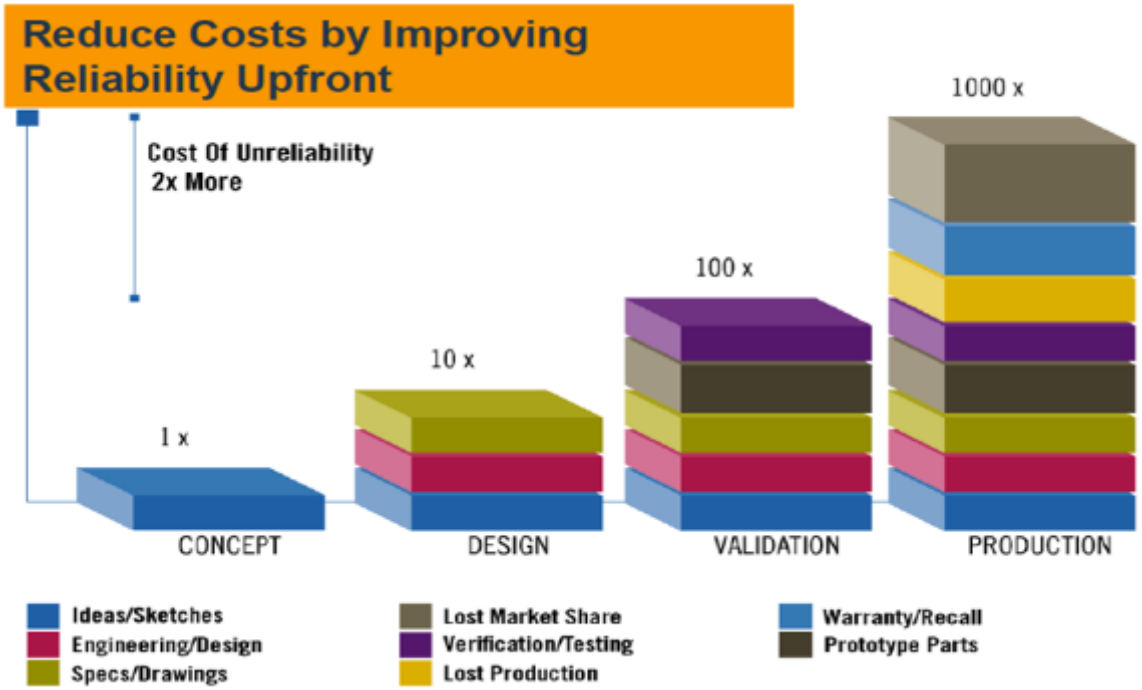
- Minor revisions on current sections
- Sections on
  - Materials Characterisation Techniques
  - System level modelling
- Alignment with other chapters
- Review metrics

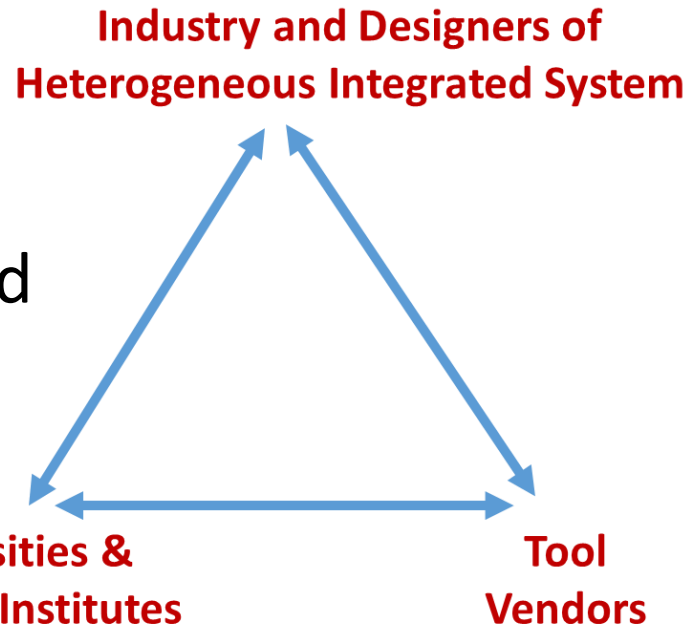


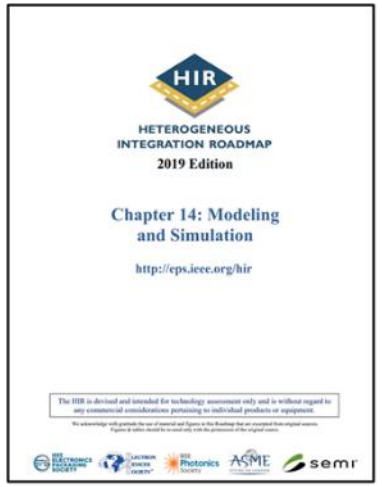
HETEROGENEOUS
INTEGRATION ROADMAP

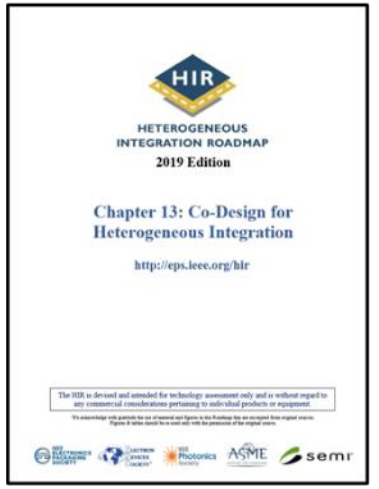
Importance of Forums like TIE/SIITME

- Economics of Moore's Law Scaling has ended
- Future Scaling through Heterogeneous Integration
- Co-Design and Multi-Physics Modelling Tools Required
  - Die – Package - System









HETEROGENEOUS INTEGRATION ROADMAP

Industrial Panel: Introduction to HIR Modelling Goals & Application Challenges

- Session Chairs
  - Chair: Chris Bailey, University of Greenwich, UK
  - Co-Chair: Pop Ovidiu Aurel, Technical University of Cluj Napoca, Romania
- Introduction Session (14:00 – 14:15)
  - *14:00 – 14:15: Short Introduction to the goals of HIR Modelling Mission* - Chris Bailey, Co-Chair of HIR Modelling and Simulation Chapter.
- Presentations (14:15 – 15:15)
  - *14:15-14:30: Simulation driven design flow of high-speed data links in the automotive industry* – Catalin Negrea, Continental Automotive, Romania
  - *14:30 – 15:00: Electromagnetic Simulation for EMC/EMI* – Irina Munteanu, Dassault Systemes SIMULIA, TU Darmstadt
  - *15:00 – 15:15: Finite element analysis in electronics* – Marius Tarnovetchi, Vitesco.
- Q&A Session: Moderated online session (15:15 – 15:30)