Modelling & Simulation Chapter
Chapter 14

Chris Bailey
Arizona State University, USA

Xuejun Fan
Lamar University, USA

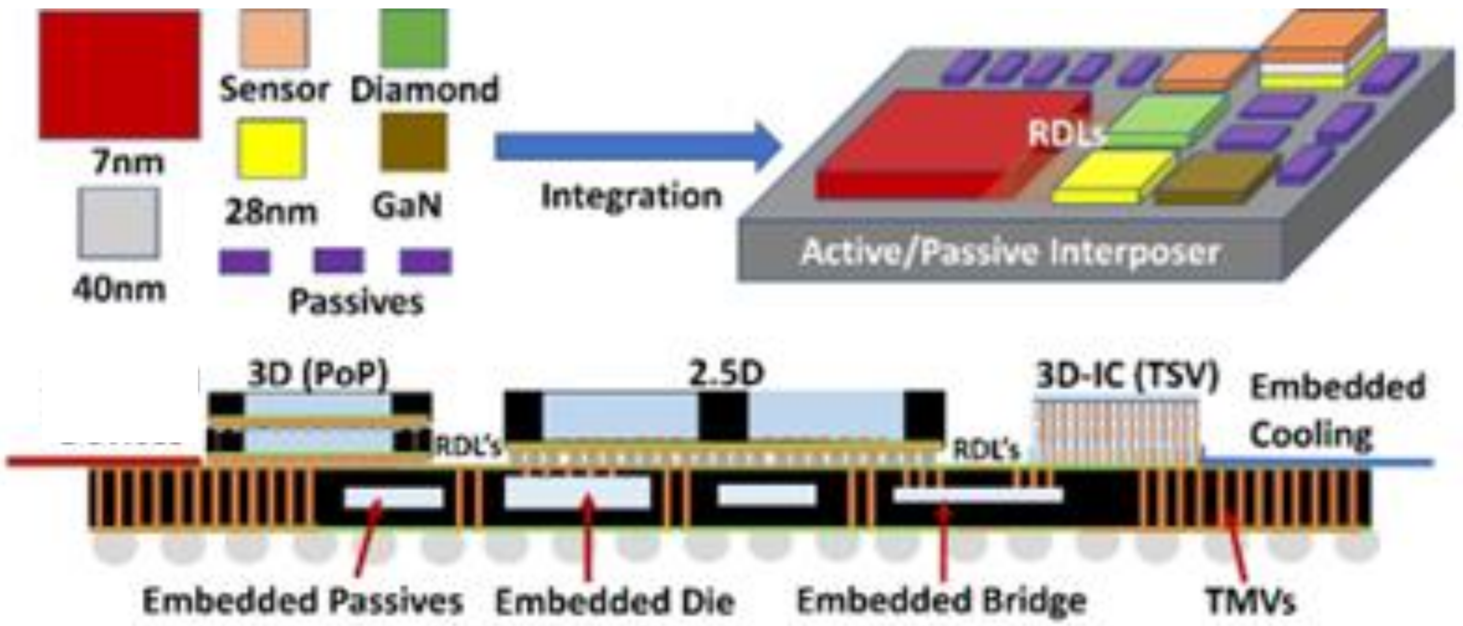
M&S supporting HI Knowledge Base

Design

Materials

Processes

Environments



Device Packaging	Bonding	Interposers	Interconnects
Wafer Level Packaging	Flip Chip	Organics	C4, Microbump's, Cu-Pillar
3D PoP, 3D-IC (Die Stack)	Thermo-Compression	Silicon	RDL's, TxVs, Optical
SiP, QFN, BGA, Hybrids...	Hybrid Direct Bonding	Ceramics	Cu-Cu (bumpless)

Electrical

Performance

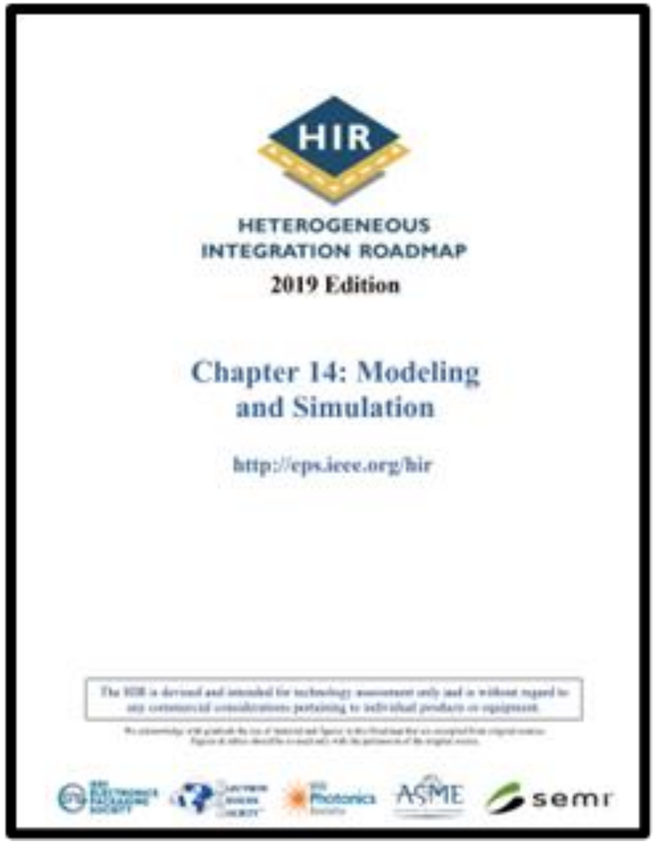
Thermal

Mechanical

Reliability

Highlights from M&S

- State of the art
  - High Fidelity Models: FEA, CFD, FDTD
  - Lower Fidelity Models: Compact models…
  - Point analysis tools
- Example of Challenges
  - Electrical – SI/PI die-die coupling, parasitics.
  - Thermal & Mechanical – Hot spots, Warpage..
  - Multi-physics – Mobility shifts, Migration
  - System-Level models – fast/accurate models
  - Reliability – Physics of Failure
  - Materials – Stochastic behavior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Chapter 14: Modeling and Simulation

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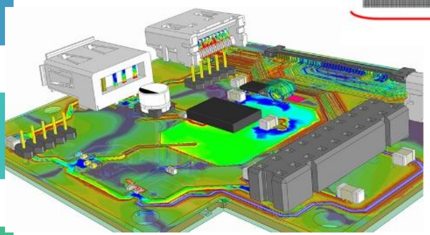
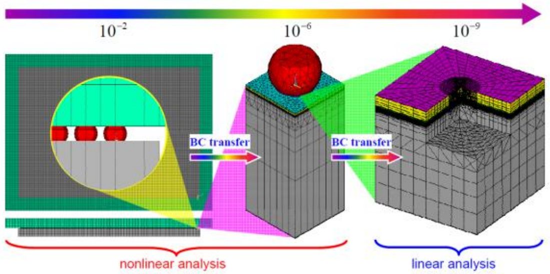
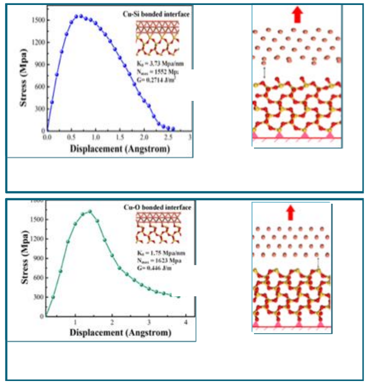
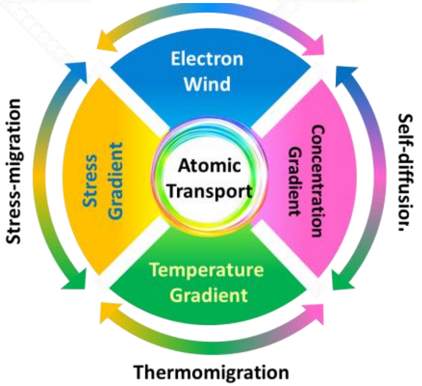
Modelling and Simulation Techniques

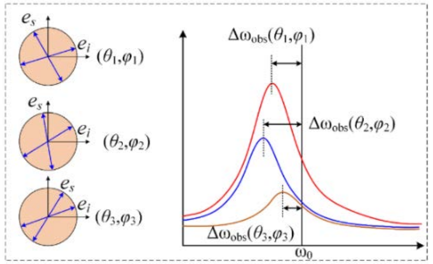
- Electrical analysis
- Thermal & thermomechanical
- Mechanics & multiphysics modeling
- Multi-scale modeling
- Machine learning/AI
- System-level modeling
- Material characterization











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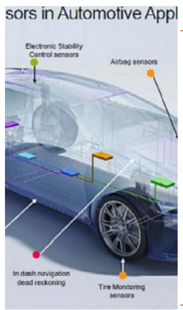
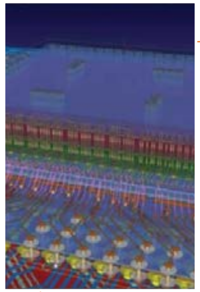
Applications

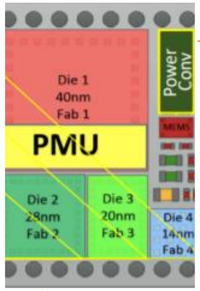


MEMS

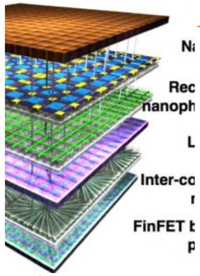
Reliability



Manufacturing Process

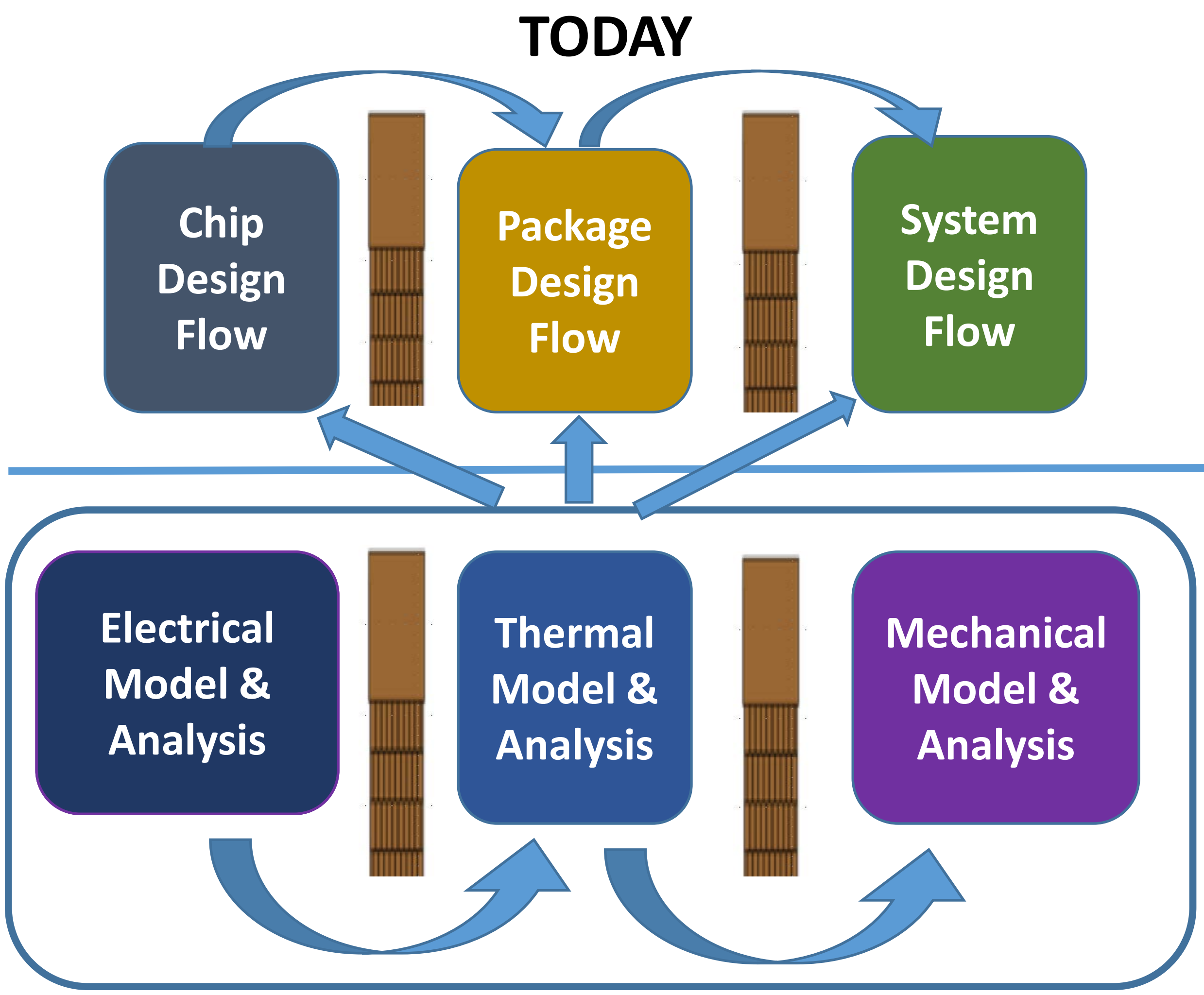


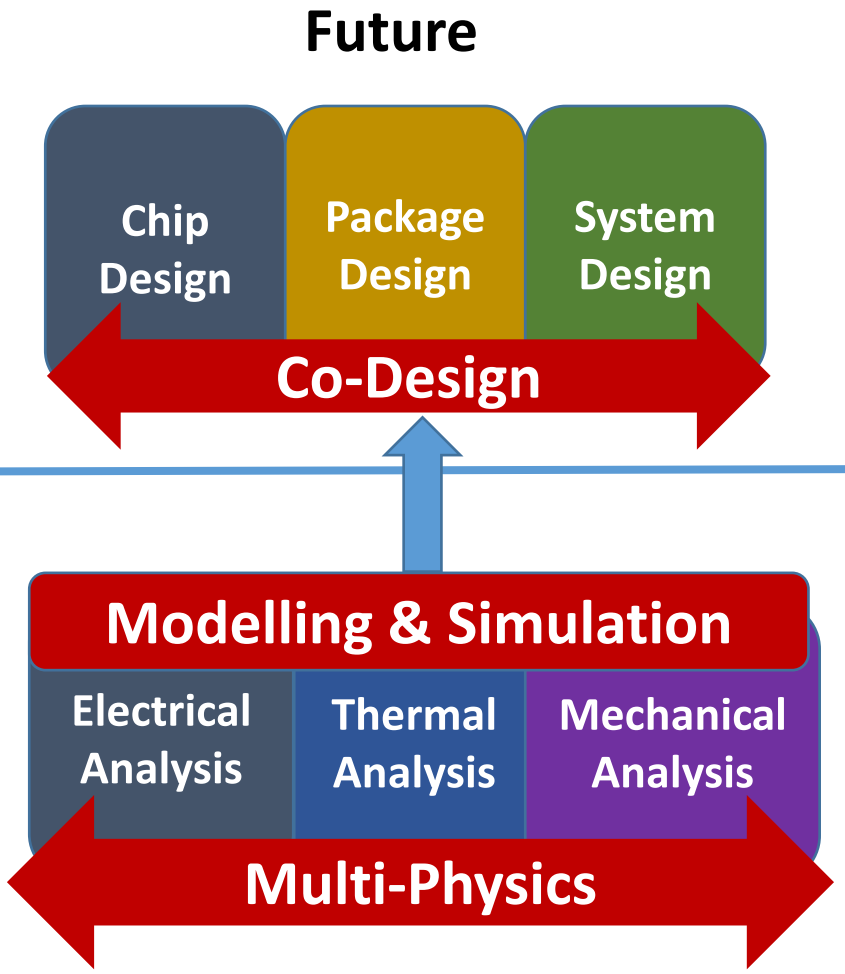
Composite Materials

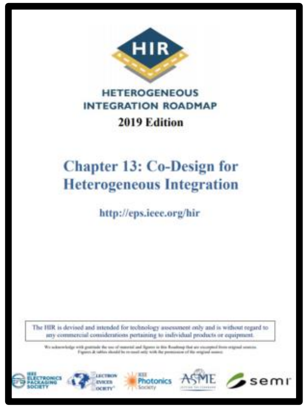


Digital Twin

Moving towards a New Paradigm



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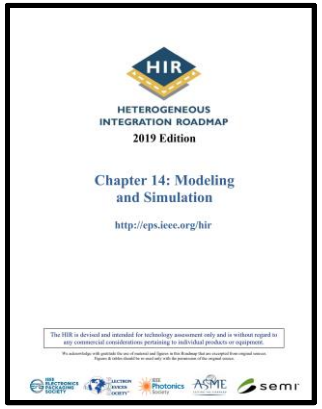
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Modeling & Simulation

Scale: Devices (nm) | Packages(um-mm) | Boards (mm-cm) | Systems (cm-m)

Data:
Materials
Manufacturing
Characterization;
Mission Profiles,
etc

Electrical & Optical
- Signal/Power Integrity
- EMI/Crosstalk
- Parasitics/Signal delays
- Optical attenuation
- Power Maps

Electro-thermal interactions

Electro-mechanical/chemical interactions

Design for Manufacture, Performance, Reliability & Robustness

Thermal
- Joule Heating
- Passive/Active cooling
- Hot spots
- Thermal resistance
- Thermal runaway

Thermo-mechanical interactions

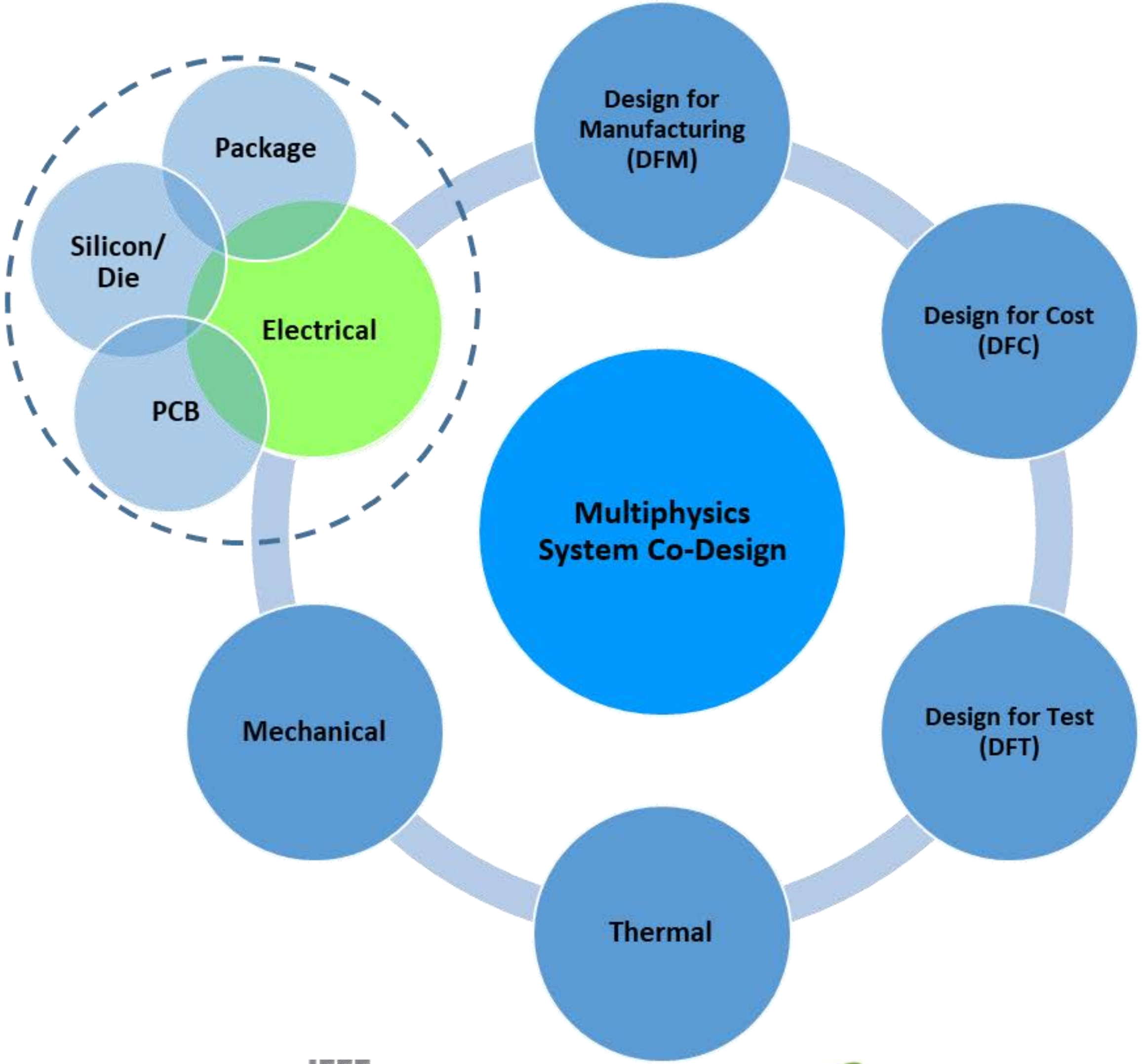
Mechanical
- Stresses
- Fatigue
- Warpage
- Metal-migration
- Corrosion

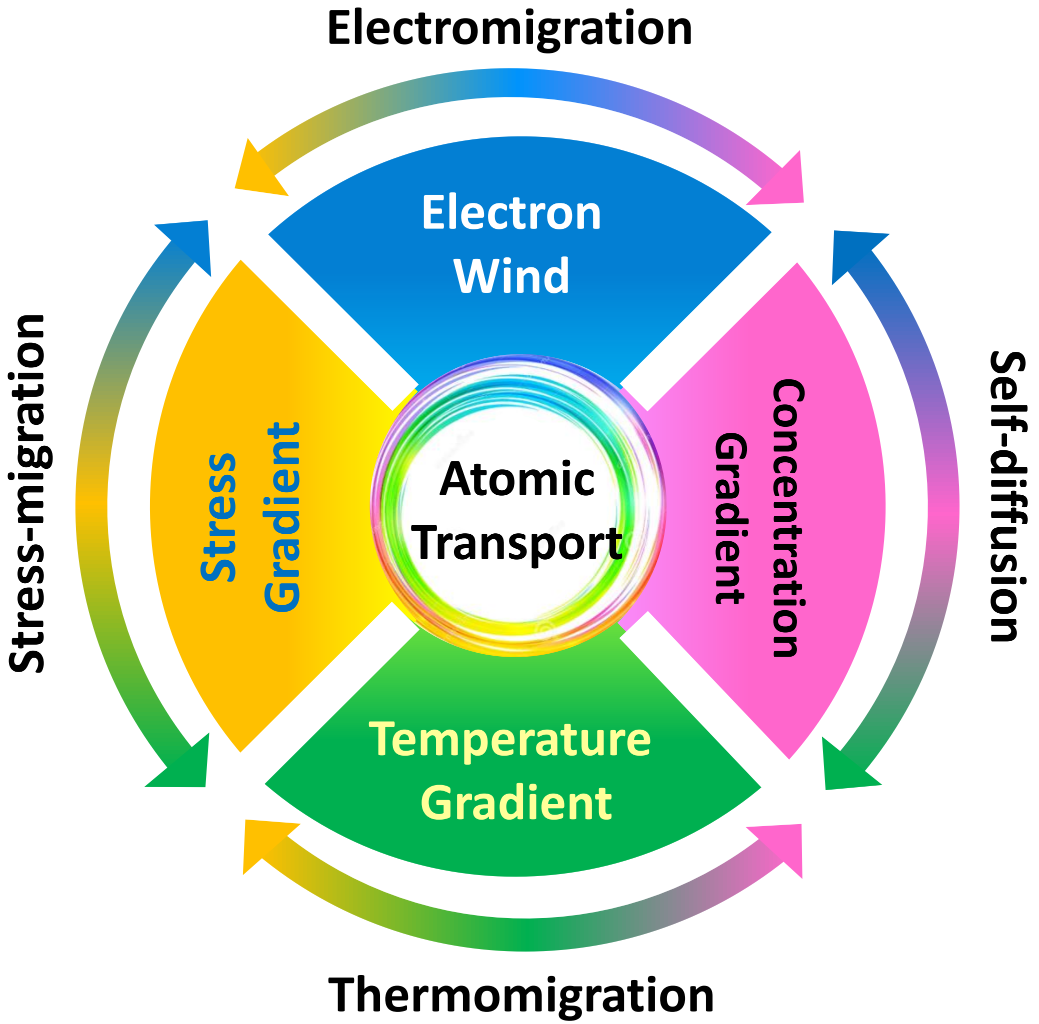
Knowledge Base:
Design Rules,
PDK's ADK's, etc

Model Fidelity: Analytical | Circuit/Network | Compact/Response Surface | MOR | MD/FEA/CFD

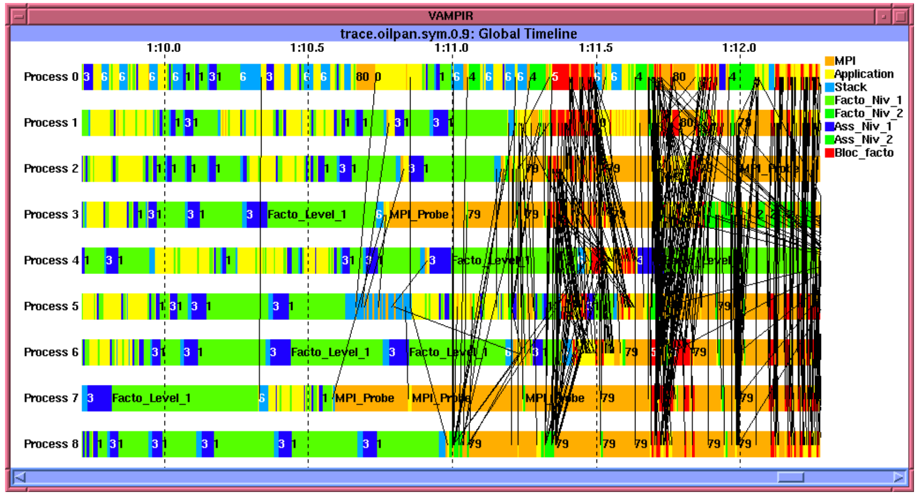
Model based Optimization; Big Data Analytics; Physics of Failure Models; Prognostics; etc.

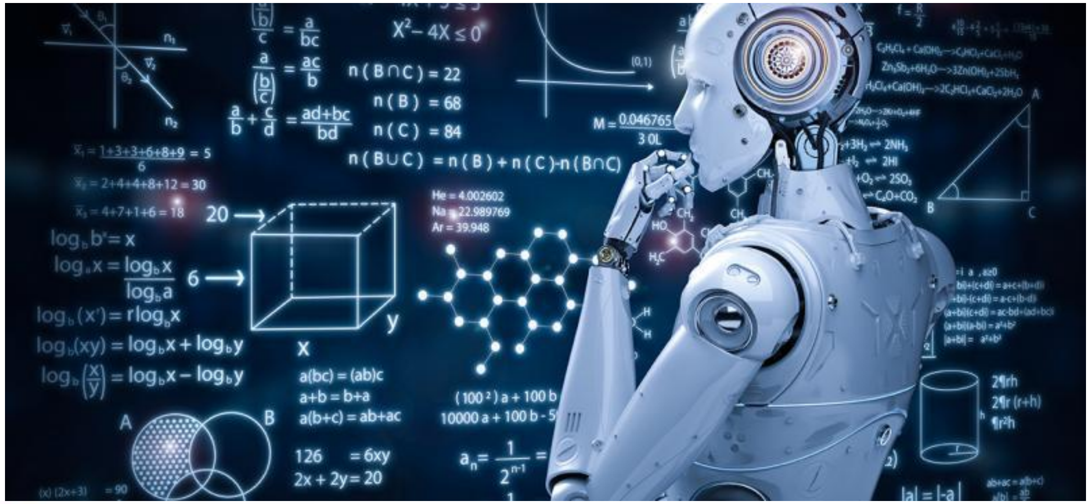
Multi-Physics/Scale





Potential Solutions

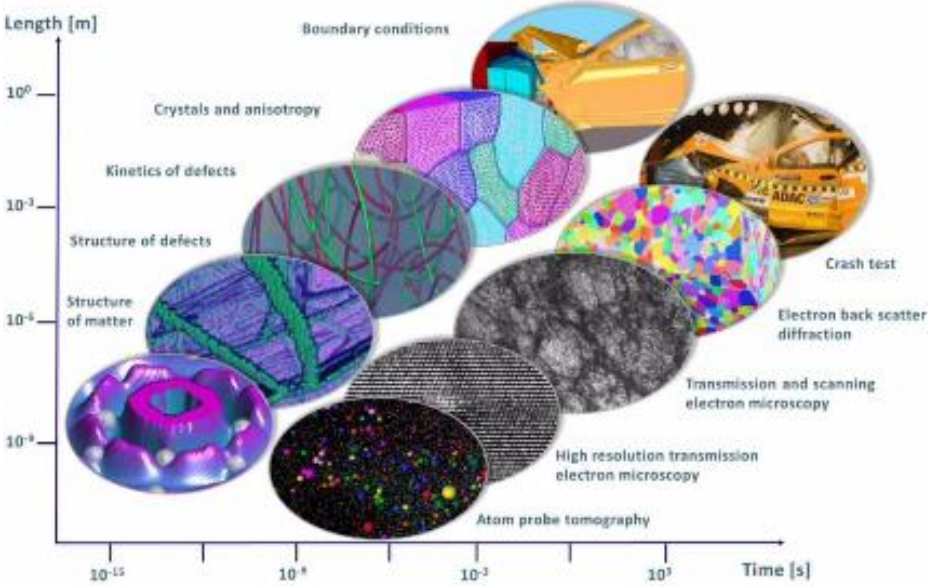


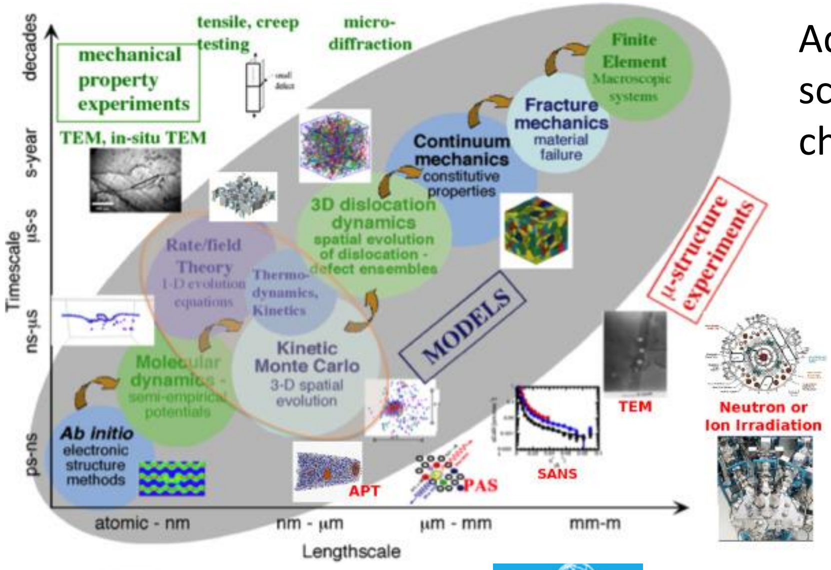


AI/ML applications

Advanced solvers (CPU, CPU-GPU, Cloud AWS, and DSA).

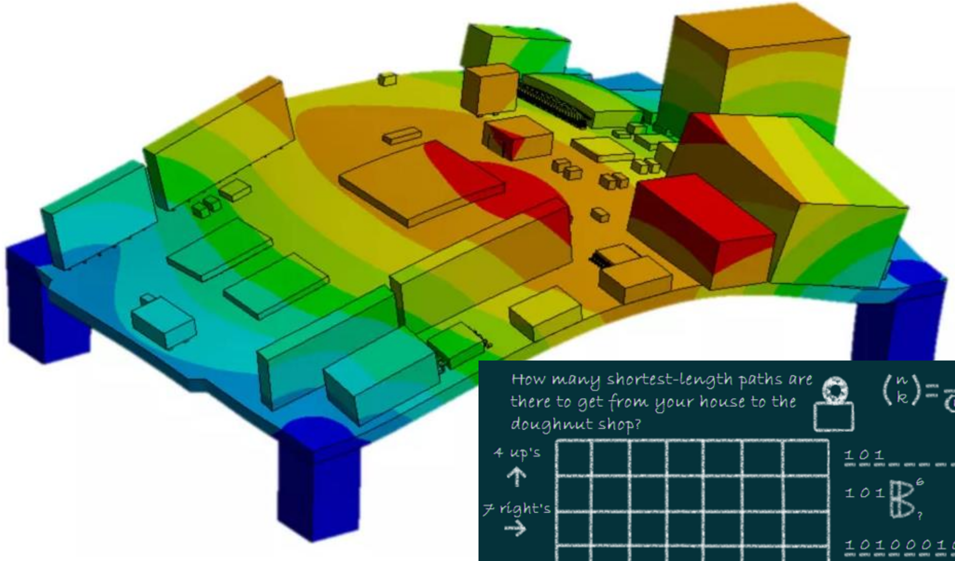
Multi-scale modeling



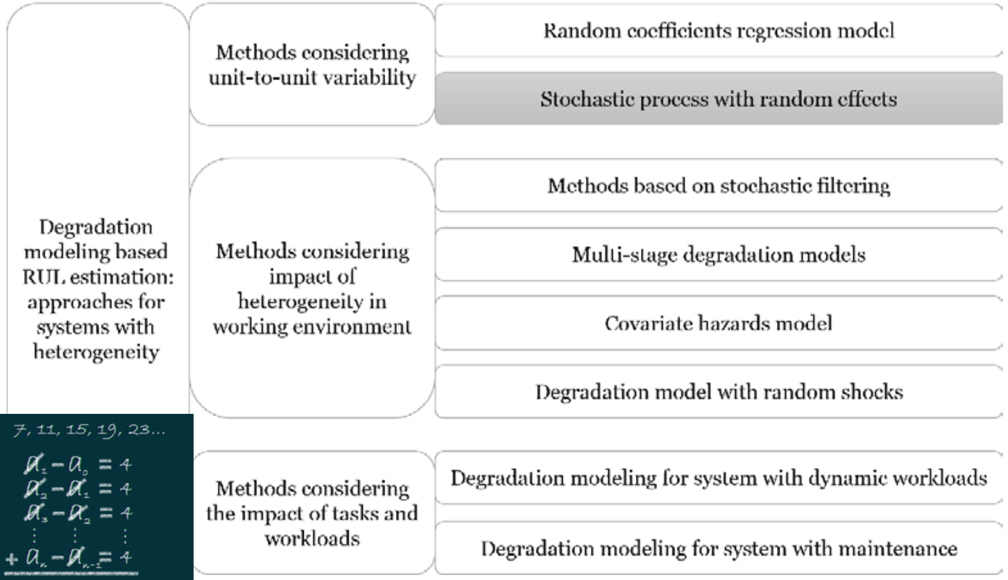


Advanced multi-scale material characterization.

Reliability & Prognostics

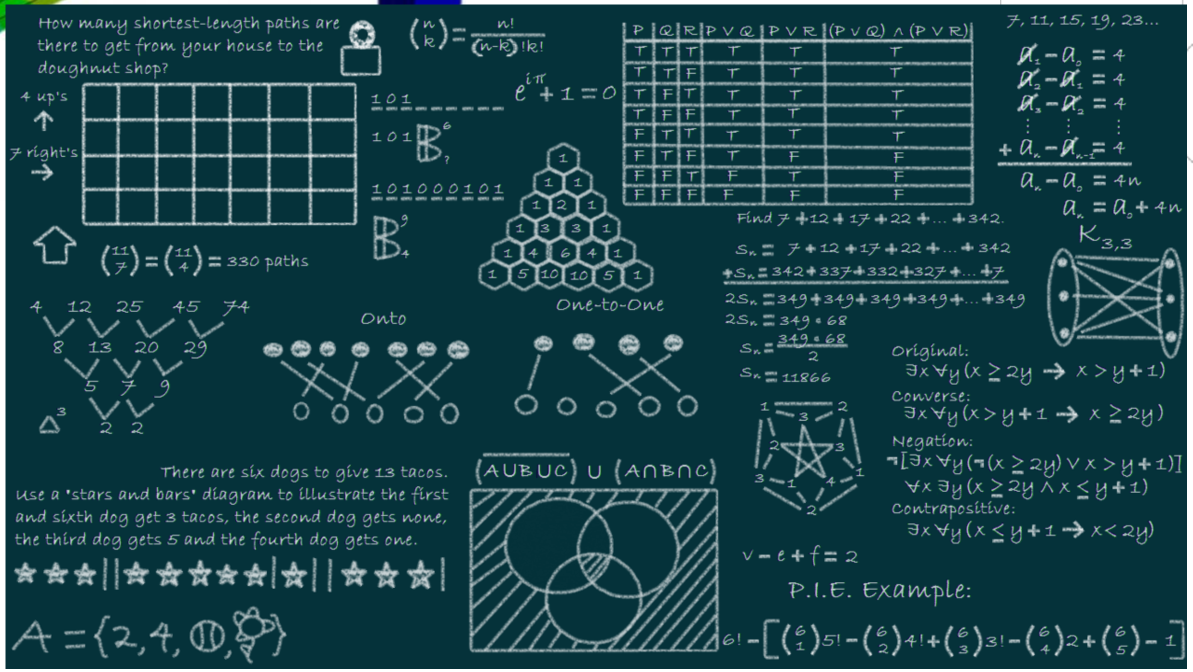


Multi-Physics Modeling

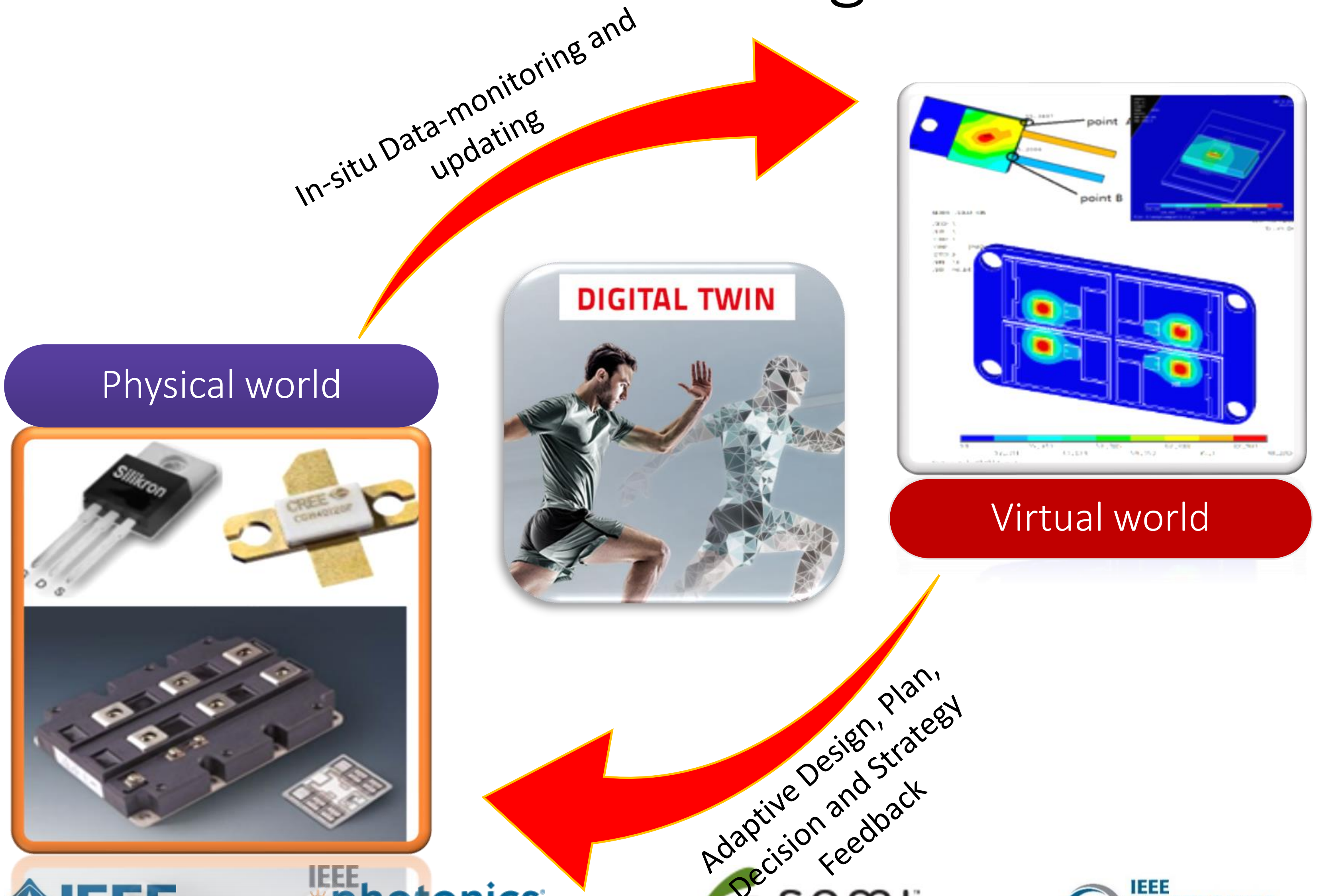


Degradation Modeling

Machine learning algorithms



Digital Twin



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

Potential Solutions - Tools

EDA suppliers are enabling multiphysics and system co-design solutions through on-going developments:

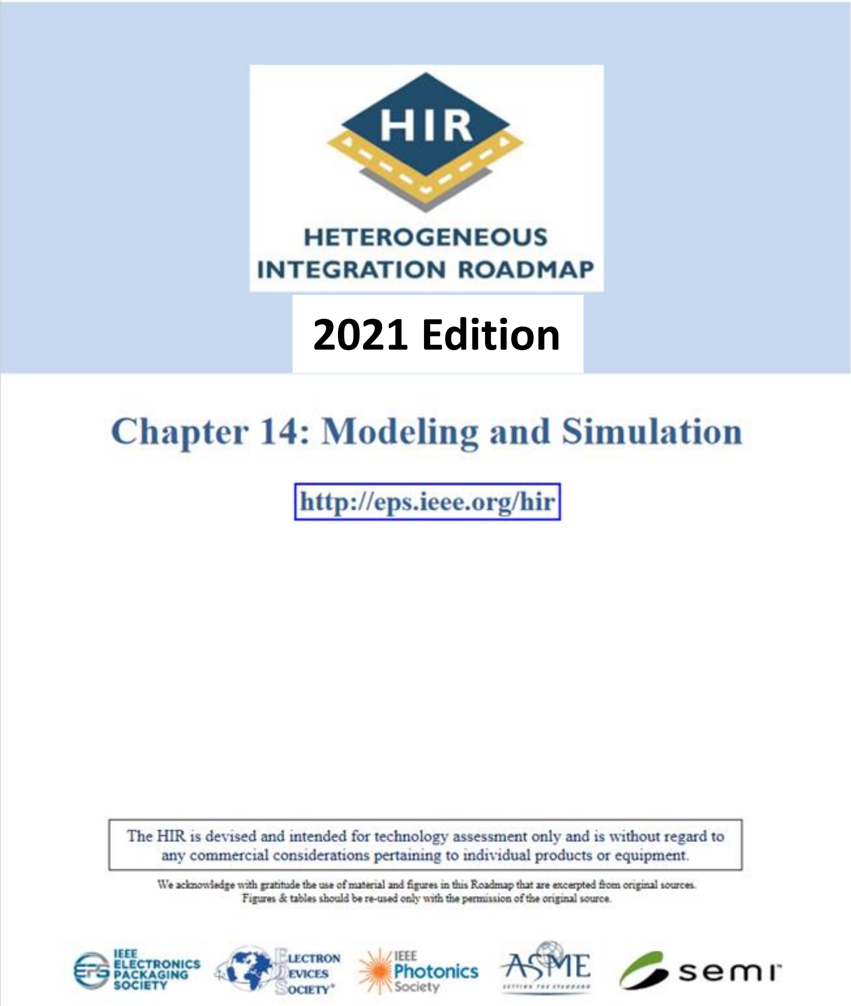
Rajen Murugan (Texas Instruments, EuroSimE 2021, HIR Panel

Metrics

Metric	5 years	10 years	15 years
Development Time from Concept to Product	5 years	3 years	18 months
Accuracy of Material Model/Property	>50%	>75%	>90%
Accuracy of Modeling	>50%	>75%	>90%
Effectiveness of Modeling & Simulation	Validated modeling for known failure modes with multi-physics modeling at different levels	Accurate modeling for comprehensive failure modes/mechanisms, with combined multiphysics modeling with multiscale modeling	Accurate and predictive modeling for unknown failure modes/mechanisms, with comprehensive multiphysics modeling combined with multiscale modeling and stochastic modeling
Efficiency of Modeling & Simulation	Simulation tool capable of multiphysics modeling across different domains (chip/package/board/system) mainly based on linear analysis	Simulation tool capable of multiphysics and multiscale modeling across different domains with mixed linear/nonlinear analysis	Simulation tool capable of multiphysics and multiscale modeling across different domains with fully nonlinear analysis

Plans for next edition

- Plans for 2022/3
  - Expand/revise current sections
  - New section on photonics
  - New Section on Process Modelling
- Current linkages with TWG's
  - Co-Design
  - Single and Multi-Chip
  - Automotive
  - Mems and Sensors
  - Reliability
  - Thermal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Thank You

TWG Members & Contributors

- Chris Bailey (University of Greenwich)
- Dale Becker (IBM)
- Xuejun Fan (Lamar University)
- Dhruv Singh (Apple Inc)
- Rajen Murugan (Texas Instruments)
- Nancy Iwamoto (Honeywell)
- Willem van Driel (Signify & TU Delft)
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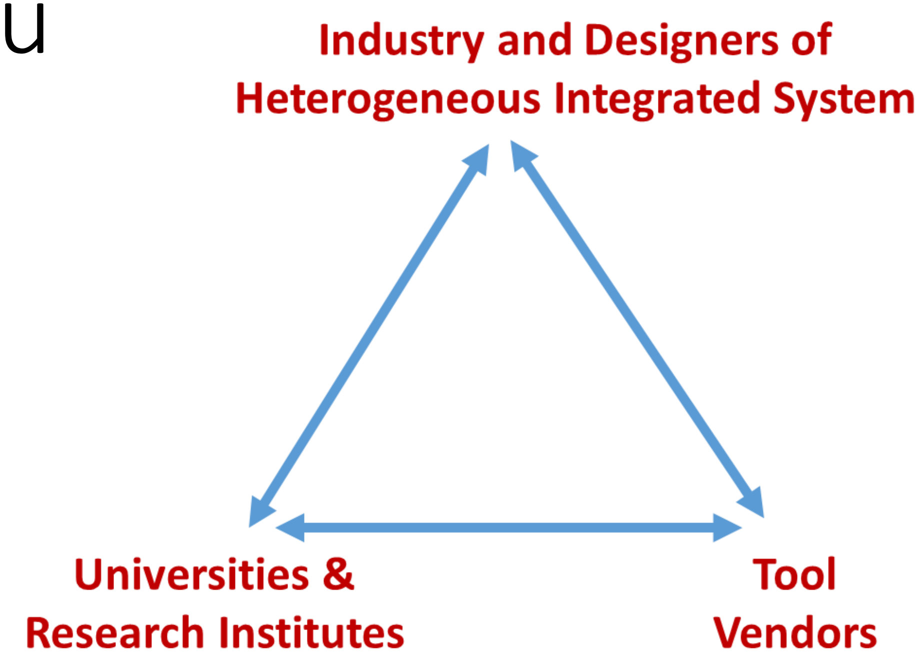
- Kouchi Zhang (TU Delft)



We welcome new participants

Contact:
Chris Bailey: Christopher.j.bailey@asu.edu
Xuejun Fan: xfan@lamar.edu

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