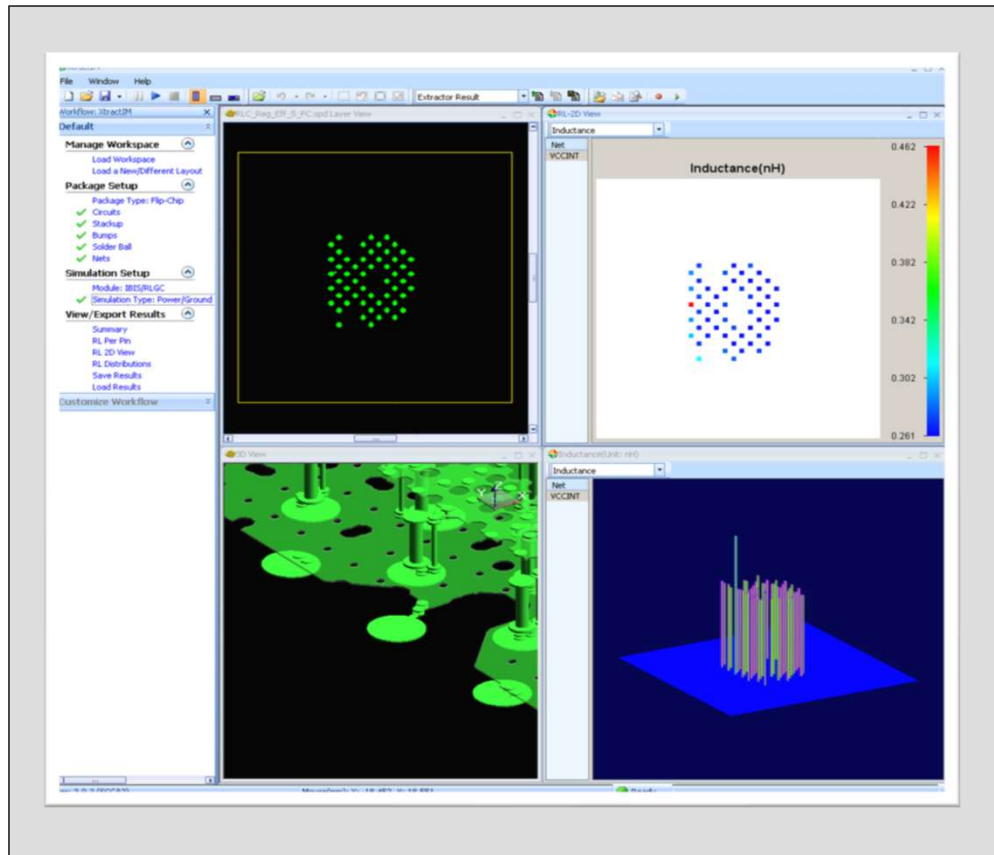Cadence Sigrity XtractIM/PowerDC (DC solver)/
PowerSI (2.5Dsolver)/OptimizePI/SystemSI/Clarity (3D finite element solver),
Celsius (3D Finite element solver) - short overview

Srdjan Djordjevic
Senior Sales Technical Leader
srdjand@cadence.com
09.10. 2024

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XtractIM

XtractIM is a fast IC package RLC extraction and assessment solution with an option to generate highly accurate broadband models. Supports a broad range of package types including BGA, SiP and leadframe designs.

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XtractIM Primary Advantages

- ✓ Built in package assessment rapidly identifies potential package defects

- ✓ Unsurpassed extraction speed and ease of use

- ✓ Able to address the broadest range of packages (single die & multi-die; flip chip, wirebond & leadframe)

- ✓ Users control model extraction precision (RLCG to broadband accurate)

- ✓ Easy to learn for occasional users and layout designers

- ✓ HTML reports that can be readily shared with partners
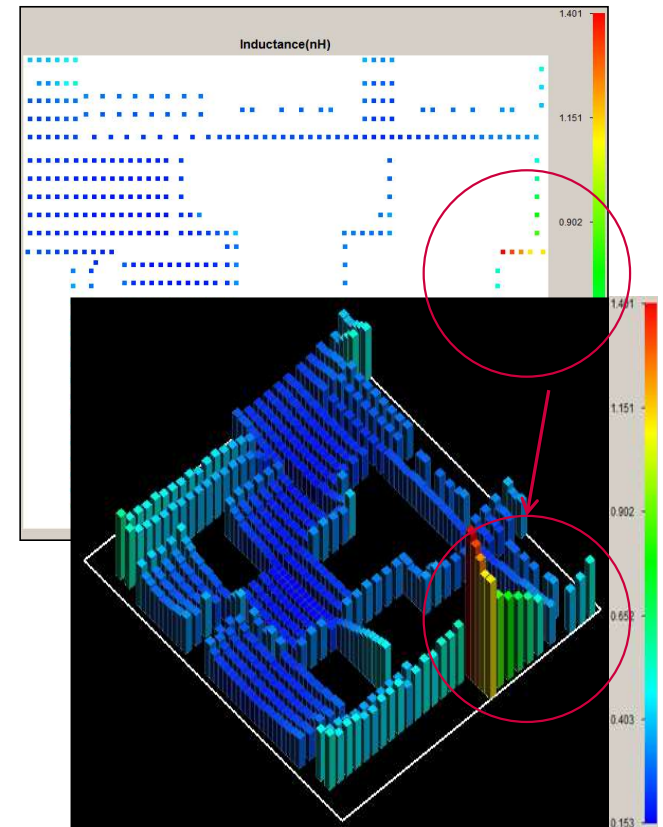
Red shows impact off
*Per-pin self loop inductance*

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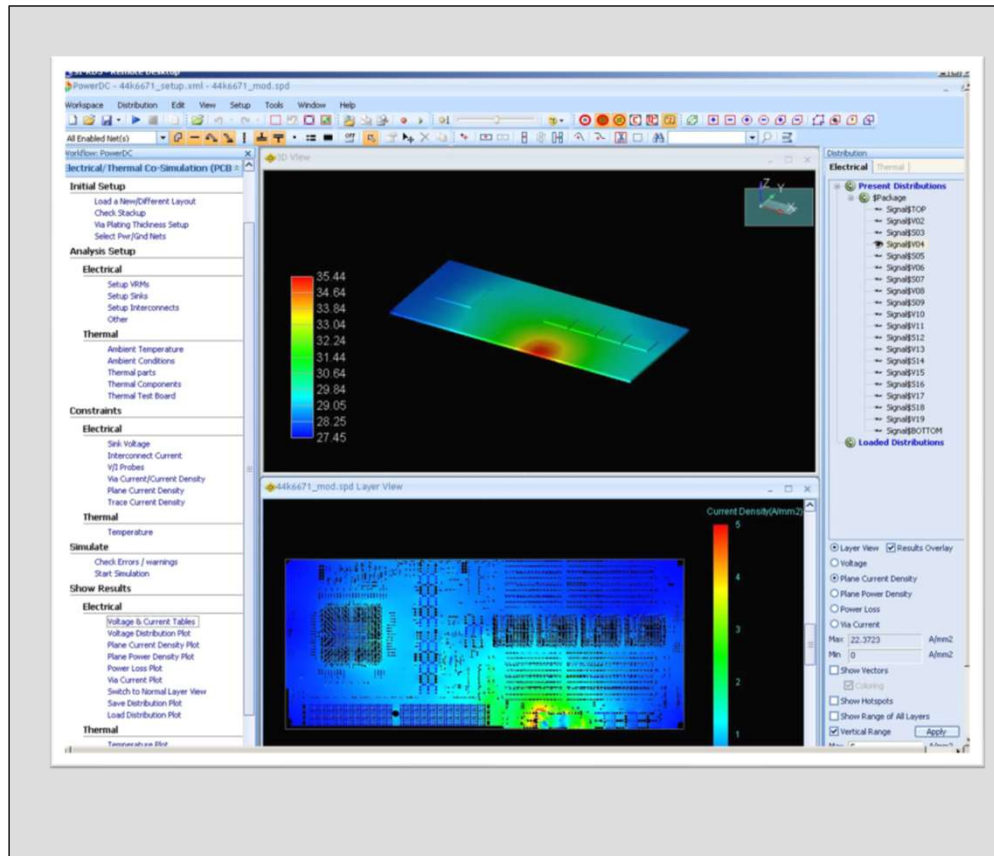
PowerDC

PowerDC is an efficient DC sign-off solution for IC package and PCB designs with electrical / thermal co-simulation to maximize accuracy. IR drop and current hot-spots are quickly pinpointed. Best remote sense locations are automatically found.

cadence®

PowerDC Primary Advantages

- ✓ The first and only integrated and automated electrical and thermal co-simulation for PCBs and packages

- ✓ Patented time saving automation for remote sense line positioning

- ✓ Fastest and most accurate IR drop solution

- ✓ Broad range of visualization options for rapid design improvement

- ✓ Unique block diagram results visualization supporting what-if updating
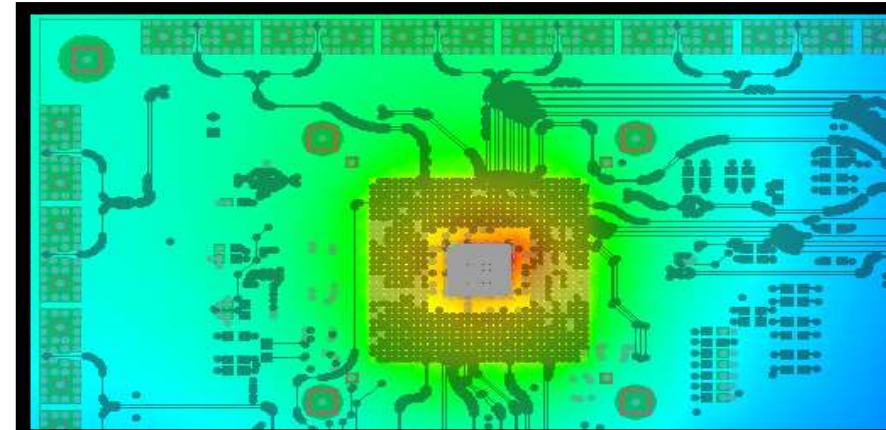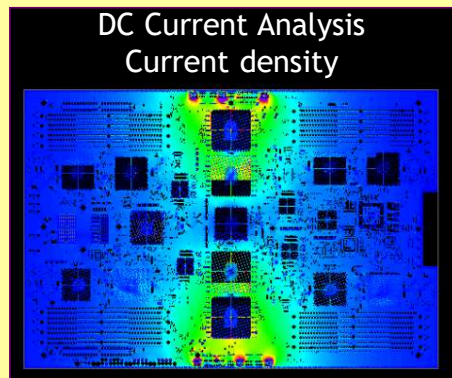

Current density & temperature
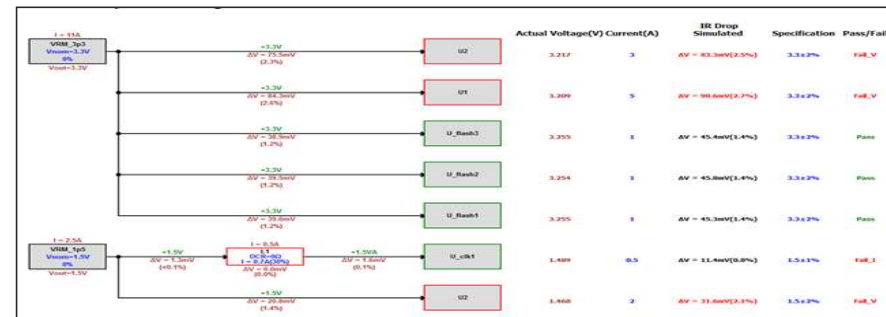
Power DC block diagram view

cadence®
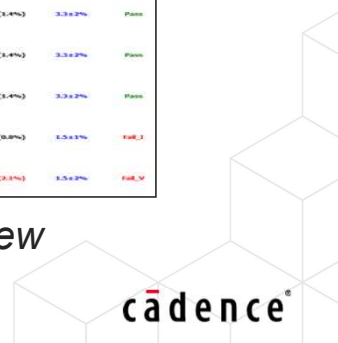
Electrical / Thermal Co-Simulation Flow

PowerDC

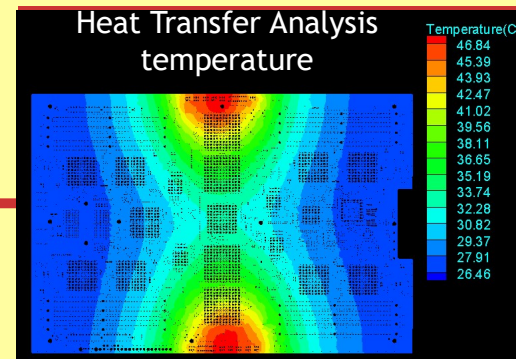| DC Current Analysis Current density		Heat Transfer Analysis temperature

Current density is an input for heat transfer analysis

Iteration

Temperature is an input for DC current analysis

Both electrical resistance and leakage power dissipation increase at higher temperatures

Joule and component heating will change temperature distribution

Temperature(C)
46.84
45.39
43.93
42.47
41.02
39.56
38.11
36.65
35.19
33.74
32.28
30.82
29.37
27.91
26.46

Sigrity provided the first integrated and automated electrical / thermal co-simulation tool in industry
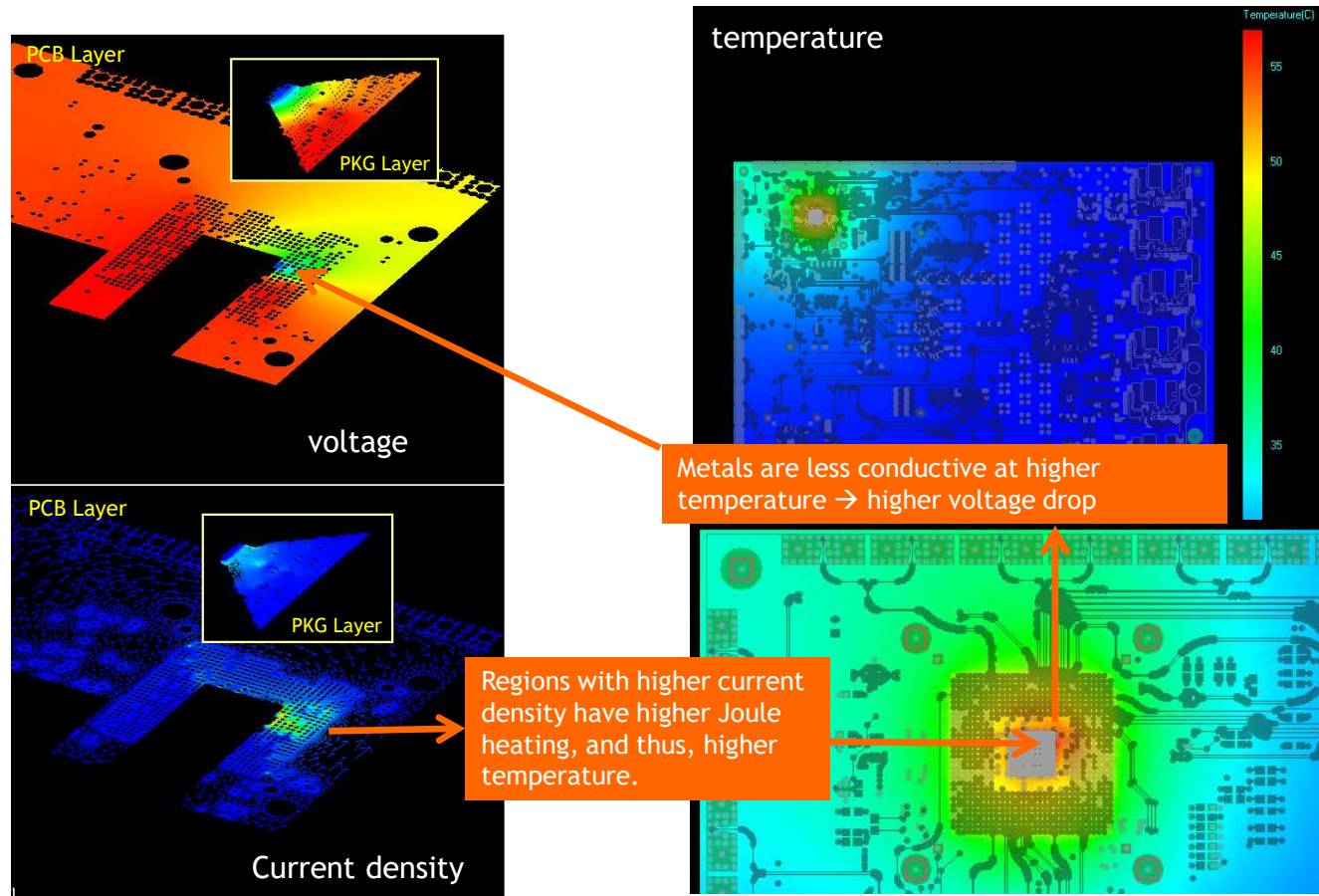
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Structures Modeled in Electrical-Thermal Co-simulation

Finite element
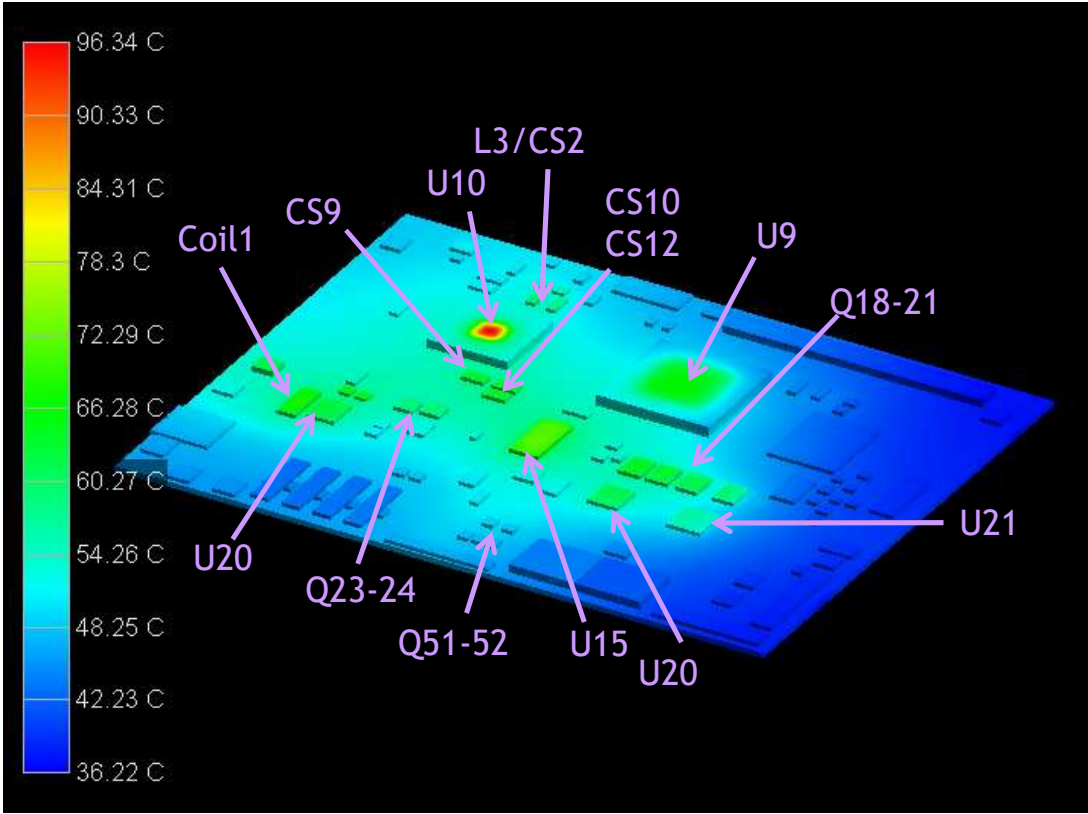methods are
used for
both electrical
and thermal
analysis

- Each and every via, ball, bump and wire are modeled separately
- Each and every stackup layer are modeled separately
- Temperature dependent material properties
- Heatsink, heat spreader, TIM, and thermal slugs

68.69
64.39
60.09
55.79
51.49
47.2
42.9
38.6
34.3
30
25.7

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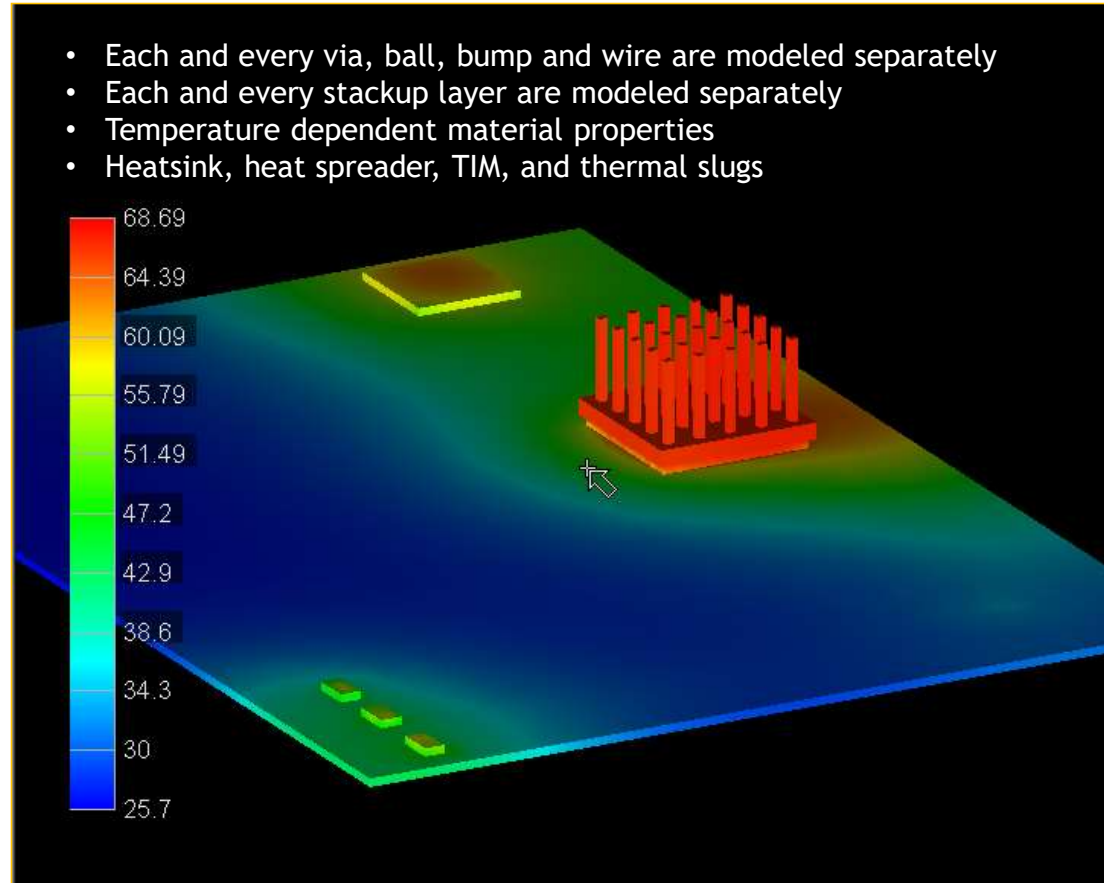
Voltage, current density and temperature distributions
(by *PowerDC*)

PCB Layer

PKG Layer

voltage

PCB Layer

PKG Layer

Current density

temperature

Temperature(C)

55

50

45

40

35

Metals are less conductive at higher temperature → higher voltage drop

Regions with higher current density have higher Joule heating, and thus, higher temperature.
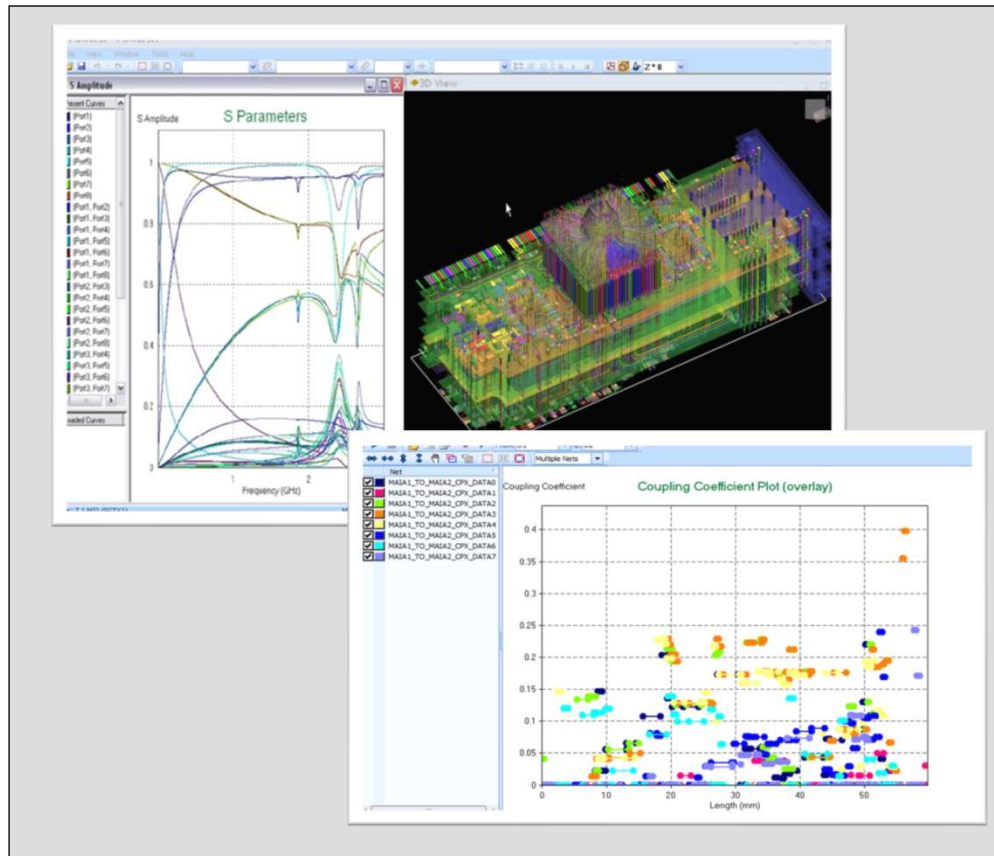
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Simulation and Measurement Correlation

PowerDC

Measurement

COIL1 : 66.5 ℃ / 68.2 ℃
CS9 : 64.4 ℃ / 63.6 ℃
CS10/CS12 : 62.7 ℃ / 63.5 ℃
L3/CS2 : 59.1 ℃ / 59.9 ℃
Q18-21 : 63.8 ℃ / 64.4 ℃
Q23 : 59.5 ℃ / 59.2 ℃
Q24 : 58.9 ℃ / 58.8 ℃
Q51 : 52.8 ℃ / 58.6 ℃
Q52 : 59.1 ℃ / 59.2 ℃
U9 : 67.3 ℃ / 66.5 ℃
U10 : 94.2 ℃ / 96.3 ℃
U15 : 71.9 ℃ / 72.6 ℃
U19 : 62.8 ℃ / 63.1 ℃
U20 : 64.6 ℃ / 61.5 ℃
U21 : 60.3 ℃ / 56.3 ℃

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PowerSI

PowerSI is an advanced signal integrity, power integrity and design-stage EMI solution. Supports S-parameter model extraction and provides robust frequency domain simulation for entire IC package and PCB designs.

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PowerSI Primary Advantages

- ✓ Market leader with more than 15 years on the market

- ✓ Highly accurate modeling of layout structures

- ✓ Ability to handle general n-terminal component models

- ✓ Unique capability for ensuring accuracy down to DC (patent pending)

- ✓ Targeted workflows to streamline operations

- ✓ Integration with 3D solution
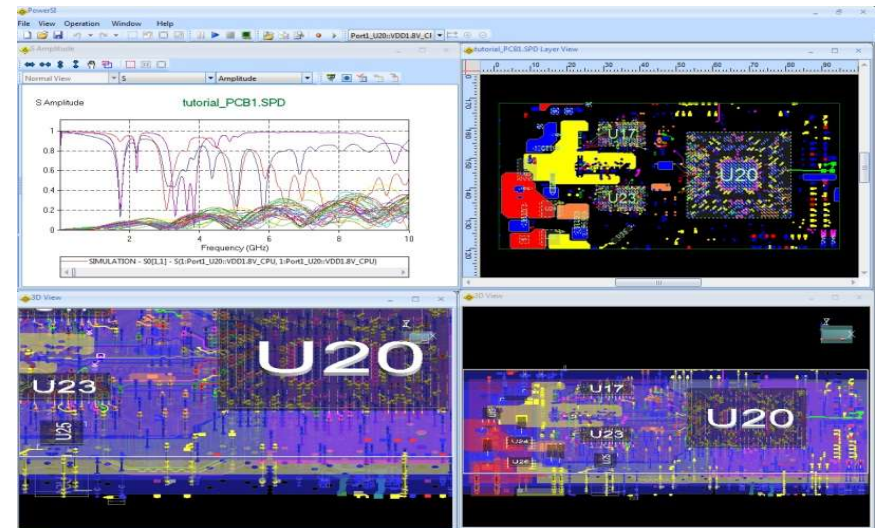
Frequency domain SI, PI and EMC
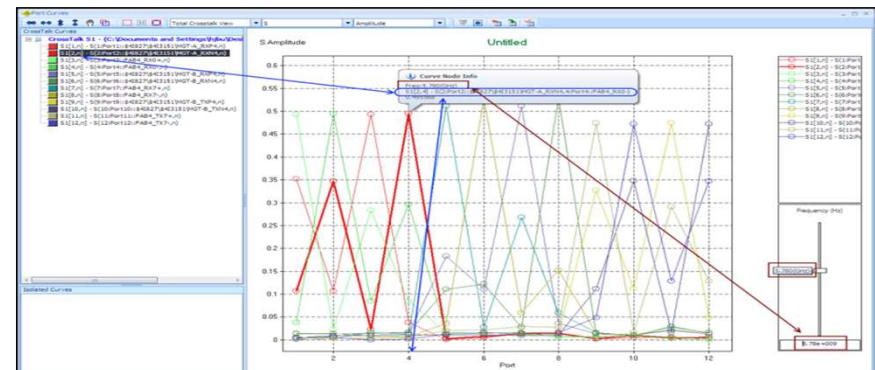
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Cadence Uniquely Positioned for 3D Analysis

Sigrity

Add key attributes of Sigrity technology

Mature 3DEM technology
- Proven accuracy
- MCAD support
- Accurate meshing

Voltus

With key attributes of Voltus technology

Revolutionary technologies
- Massively distributed matrix solver
- Large scale distributed processing platform

System Analysis BU

Providing a full IC/package solution for EM and thermal, expandable into multi-domain system analysis
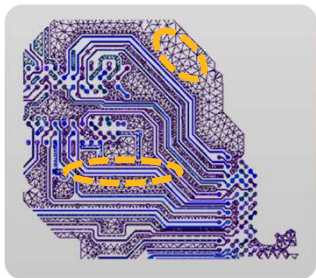
Clarity™ 3D Solver
- Up to 10x performance
- Virtually unlimited capacity
- Golden accuracy
- Cadence integration

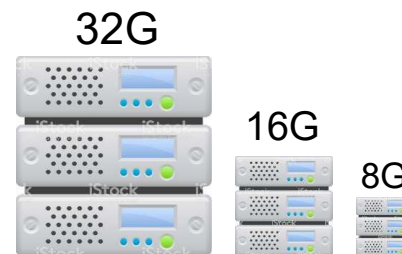cadence®

Clarity™ 3D Solver Technology

Achieving massive performance, scalability, with 3D accuracy
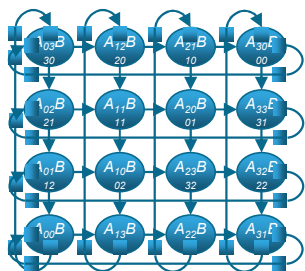
Meshing Technology

- Structure aware
- EM significance
- Parallel ready
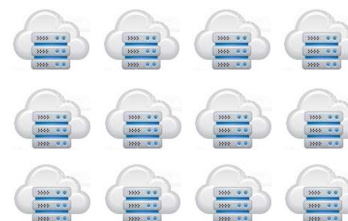
Virtually Unlimited Capacity

32G

16G

8G

- Auto-partitioned
- Low-capacity machines
- Unbounded scalability

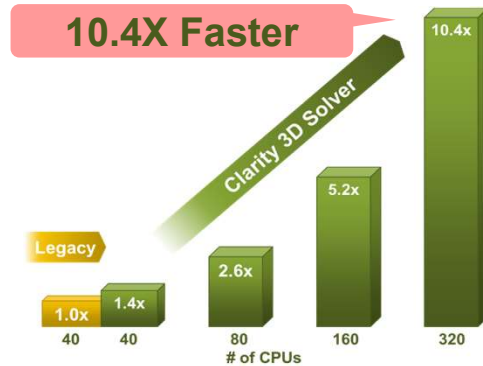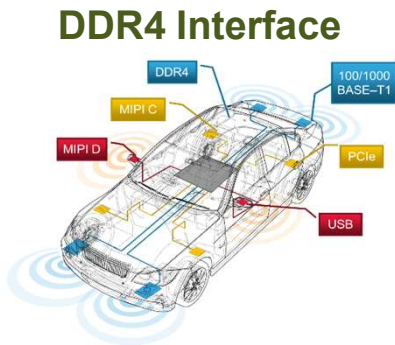## Massively Parallelized Matrix Solver

- Breakthrough algorithm
- Near-linear scalability
- Without any accuracy loss

Cloud-Optimizing Distribution

- Dynamic deployment
- Fault-tolerant restart
- Prioritizes lower cost

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Elastic Computing Architecture

112G Connector-PCB Interface

DDR4 Interface

12.3X Faster

Clarity 3D Solver

Legacy				
1.0x	1.6x	2.9x	6.2x	12.3x
40	40	80	160	320

# of CPUs

10.4X Faster

Clarity 3D Solver

Legacy				
1.0x	1.4x	2.6x	5.2x	10.4x
40	40	80	160	320

# of CPUs

Performance

Accuracy

Scalability

- Scalability enabled by elastic computing architecture
  - The same design can be run through with different number of CPUs
- Virtually unlimited capacity
  - Huge designs can be run through
  - Only 32G 8CPU workers are required
- Error tolerant scheduling
  - Auto recover, early start, etc...

Clarity™ 3D Solver accelerates design cycle time with optimized system interconnect designs

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Clarity™ 3D Solver – Gold-Standard Accuracy, Extreme Performance
Innovation through parallelization

- **Massively Parallel Execution**
  - Multi-threaded
  - Distributed processing
  - Cloud ready

- **Virtually Unlimited Capacity**
  - Large structures can be solved on either small or large computers; no need to segment structures
  - Nearly linear scalability when adding computing resources

- **No Loss of Accuracy**
  - Lab measurement correlation
  - Adaptive mesh and frequency sweep results remain consistent when adding computers / CPU cores

Clarity™ 3D Solver
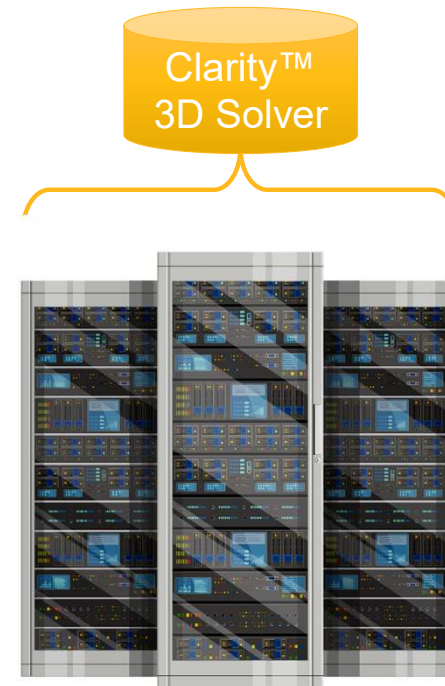
Massively Parallel Architecture Offers up to 10X Better Performance

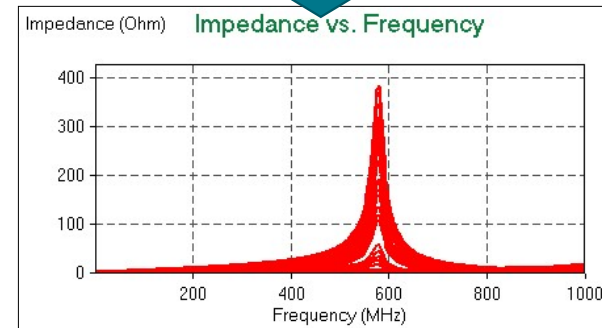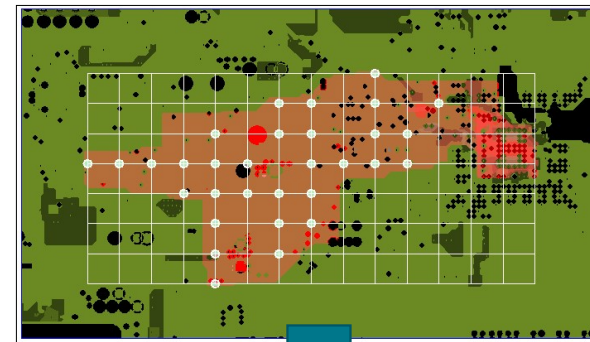**cādence®**
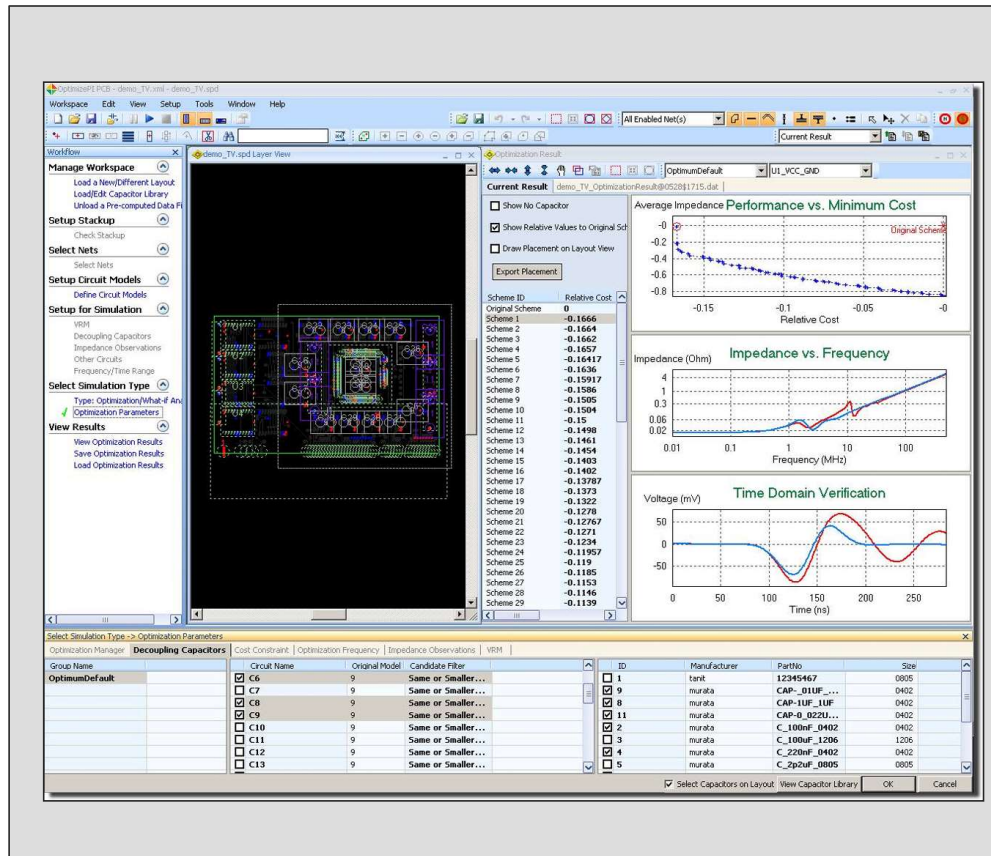
OptimizePI

OptimizePI is a highly automated board and IC Package AC frequency analysis solution. Supports pre- and post-layout decap studies and identifies impedance issues. Decap implementations are optimized for performance and cost.
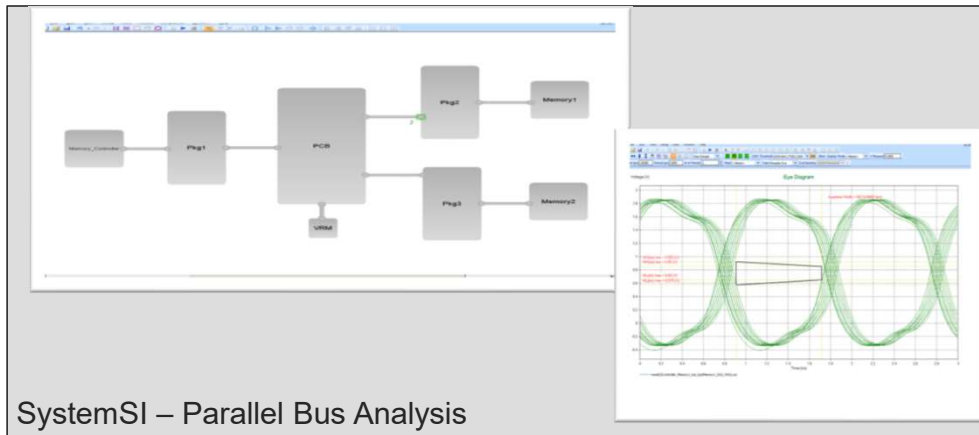
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OptimizePI Primary Advantages

- ✓ Automated decap optimization and verification features

- ✓ Clear presentation of economic benefits from decap optimization

- ✓ Flexibility in meeting targeted objectives (performance, cost, area …)

- ✓ Easy-to-use AC analysis environment.

- ✓ Unique device impedance and EMI resonance checking

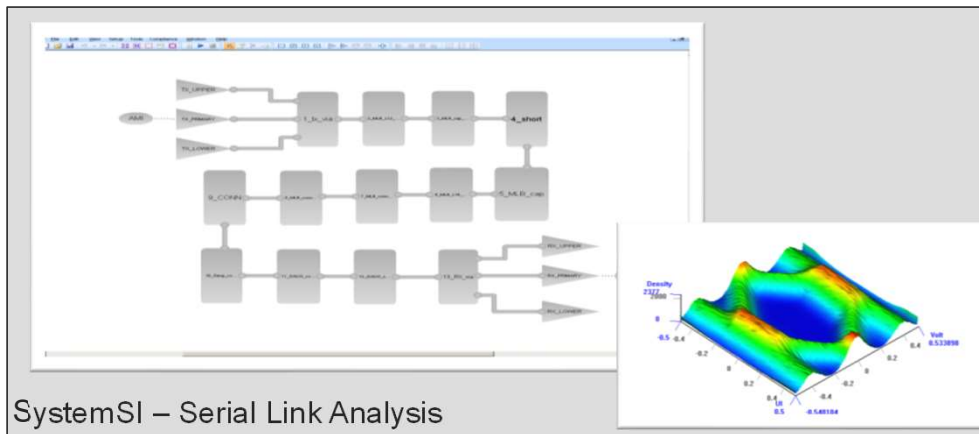- ✓ Support for early-stage studies and post-post layout verification

Automated positioning of EMI decaps

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Channel Analysis Products
End-To-End System Level Analysis

System level analysis:
Die-to-Die high speed channels and buses

Task focused signal integrity solutions primarily focused on end-to-end interface analysis (ex. DDR, SerDes).

SystemSI Modules for:
Serial Link Analysis and
Parallel Bus Analysis

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SystemSI

SystemSI – Parallel Bus Analysis

SystemSI – Serial Link Analysis

SystemSI is a comprehensive and automated signal integrity environment for the accurate assessment of high-speed chip-to-chip system designs. Ensures robust parallel bus and serial link interface implementations.

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SystemSI Primary Advantages
(EDN Top Product 2010)

- ✓ Fastest, most advanced channel simulation engine

- ✓ Simplified model connections with Model Connection Protocol (MCP) and block-wise editor

- ✓ Highly automated measurement and reporting capabilities

- ✓ Unique AMI IP library for model generation

- ✓ Clear linkage between schematic model and physical layout

- ✓ Early studies supported with accurate 3D FEM based Via Wizard
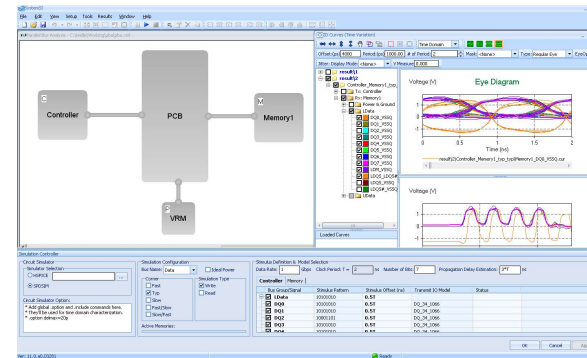

Above = DDR / Below = Serial Link

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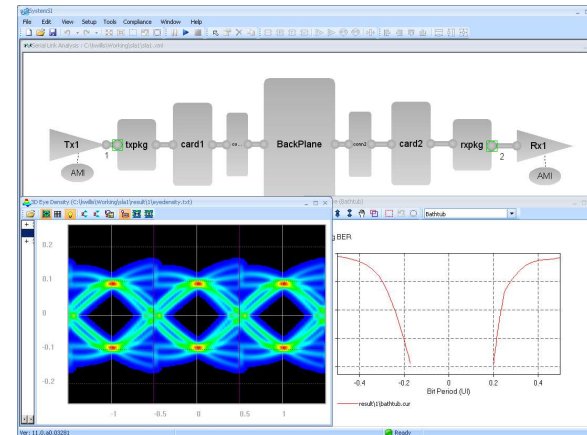
Thermal Basics – FEA vs. CFD

- FEA (Finite Element Analysis): in the context of thermal, it is used to solve conduction problems within solids in detail with convection and radiation effect taken into account in a simplified manner with a boundary condition of heat transfer coefficient.

- FEA allows detailed and accurate conduction analysis
- FEA simplifies convection and radiation with a boundary condition with a heat transfer coefficient (no actual simulation of a fluid)

Air at T=25°C
PKG=1W
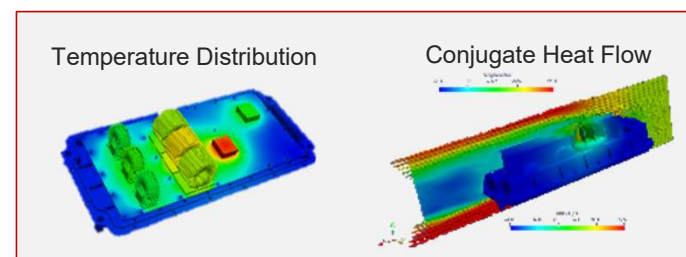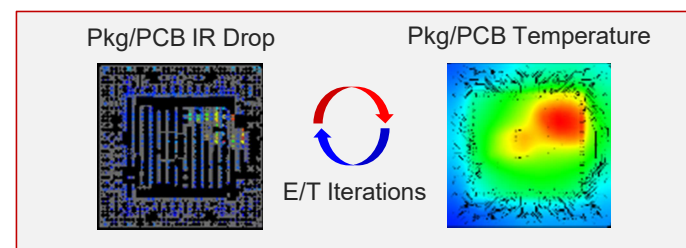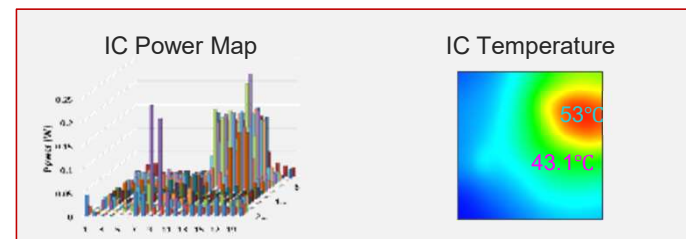PCB
Conduction
Convection + Radiation
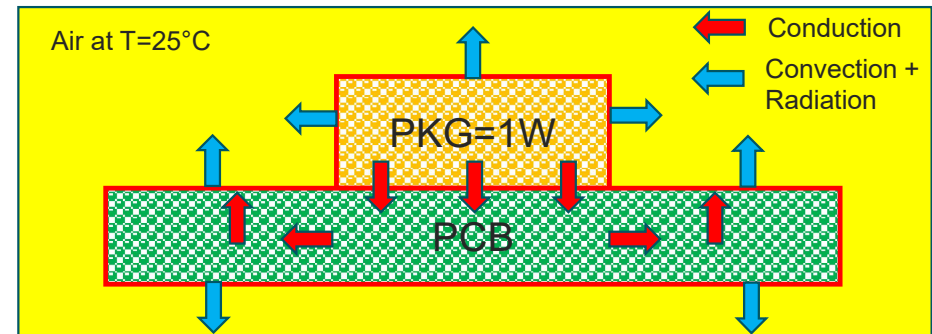
- CFD (Computational Fluid Dynamics): in the context of thermal, it is used to solve conduction in a simplified manner (typically) and convection and radiation in detail by actual simulation of fluid flow (e.g.) fan blowing air over a PCB)

- CFD allows conduction analysis with simplified structures typically.
- CFD does the actual detailed simulation of convection and radiation. There is no boundary condition of heat transfer coefficient

Air at T=25°C
PKG=1W
PCB
Conduction
Convection + Radiation

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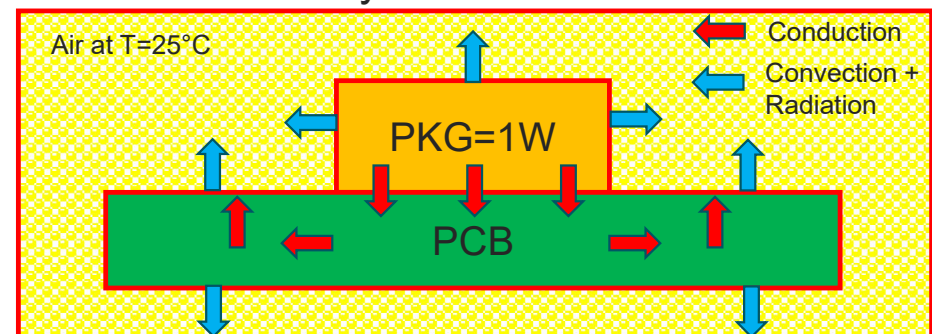
Celsius - Electrical-Thermal Co-Simulation for Multi-Physics Designs

- **IC-centric approach**
  - Integrated with chip-level tool for accurate power profile
  - Addresses 3D-IC, die-to-die bonding, and TSVs

- **Package/PCB-centric approach**
  - Finite element analysis (FEA) + computational fluid dynamics (CFD) techniques for both transient and steady-state simulation
  - Resolves detailed 2D layered and 3D structures

- **System-centric approach**
  - FEA + CFD techniques for both transient and steady-state simulation
  - In addition to pkg/PCBs, includes heat sinks, enclosures, …

IC Power Map   IC Temperature

53°C
43.1°C

Pkg/PCB IR Drop   Pkg/PCB Temperature

E/T Iterations

Temperature Distribution   Conjugate Heat Flow

Celsius™ Thermal Solver enables IC-centric, package/PCB-centric, and system-centric applications

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Seamless Integration with Cadence Implementation Platforms
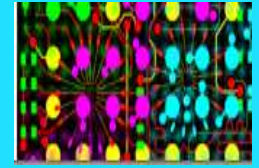## Ease of use for productivity gains

- Integration with Virtuoso® Platform
  - Highly optimized design environment for simulation, layout,…
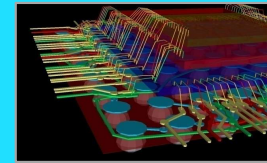 - Interoperability with Cadence® SiP Layout
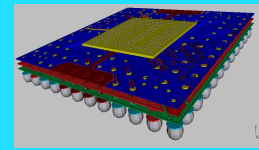

Virtuoso Layout   **SiP**

- Integration with Allegro® Technology
  - Advanced package and board designs, without data transfer
  - Advanced, foundry-certified 3D-IC reference design flow

Allegro   **WLCSP/ InFO**

- Integration with Cadence digital chip "full-flow"
  - Voltus™ solutions for static and transient power profiling
  - Innovus™ Implementation System for physical design implementation, including 3D-IC

Innovus   **Voltus**

Celsius™ Thermal Solver: the fastest path to Intelligent System Design™ closure

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