Performing Multiphysics Analysis During Heterogeneous Integration

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3D-IC Solutions Sales

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3DIC Encapsulates Many Challenges ..

Traditional chiplet design and signoff

- Fit for purpose and manufacturable

Substrate design and signoff

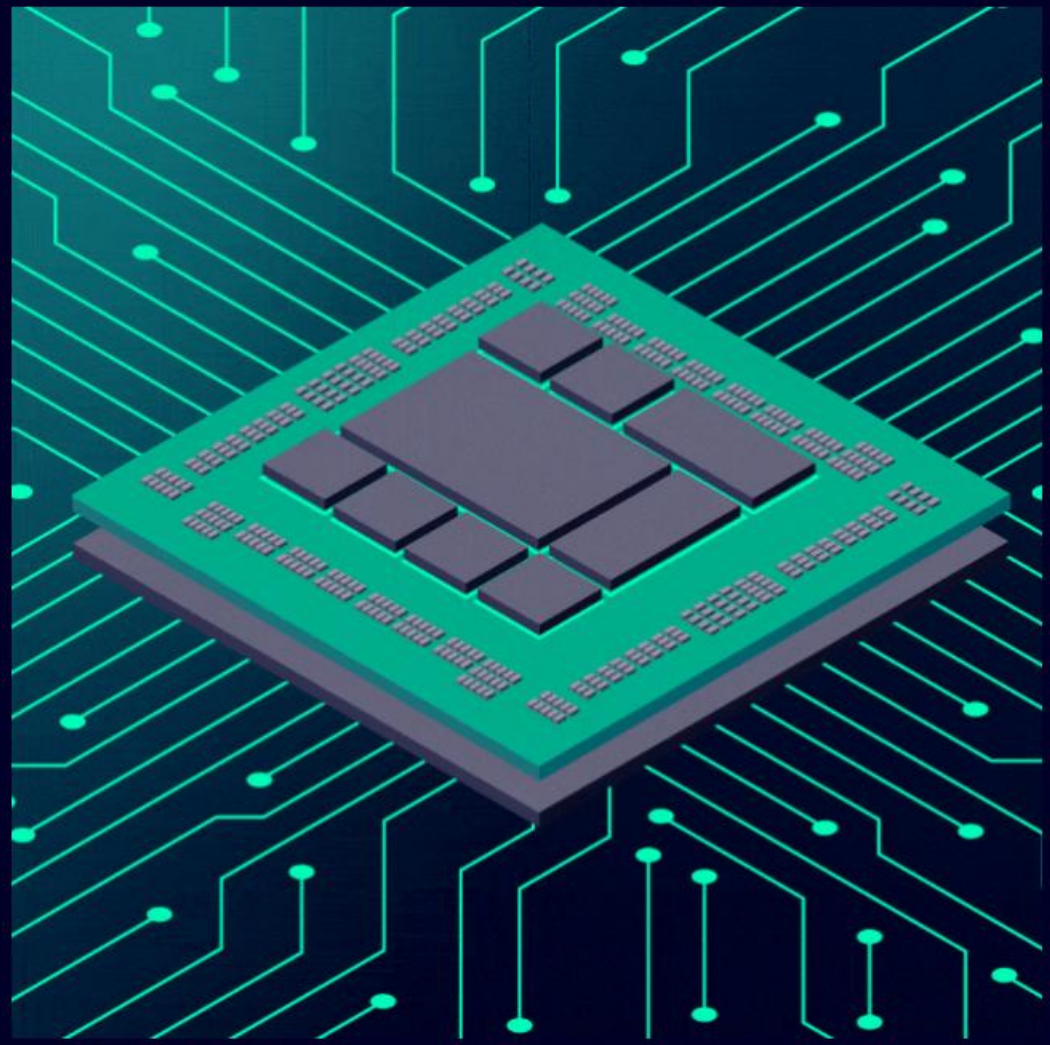
- Interposer and package Substrate

System-level planning and sign off

- Across multiple design domains

System-level “Multiphysics” design and signoff

- Die, package, in-system



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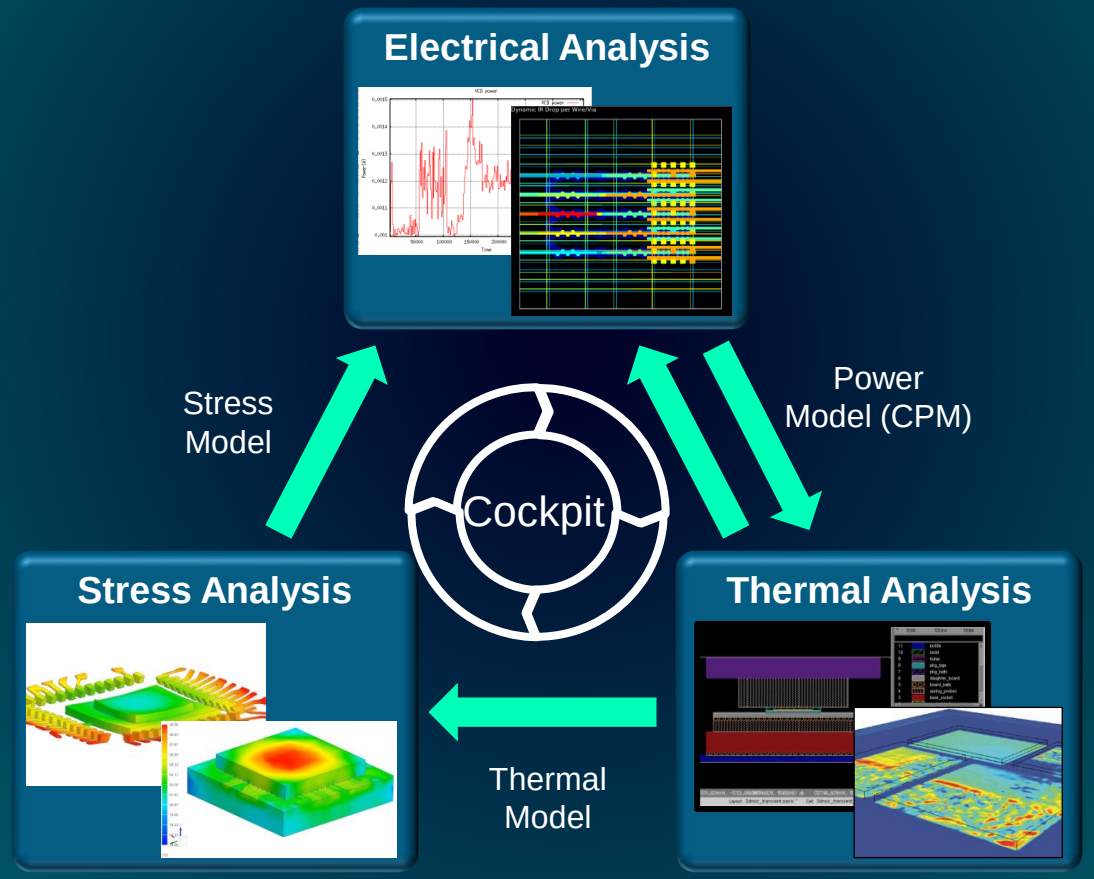
3DIC Multi-Physics Analysis



"multiphysics simulation (often shortened to simply "multiphysics") is defined as the simultaneous simulation of different aspects of a physical system or systems and the interactions among them." wikipedia

Electrical power affects thermal behavior

- Due to the resistance of the conductors

Thermal issues affect electrical behavior

- Resistivity of interconnects change with heat

Thermal issues affect stress behavior

- Different CTEs between substrates result into warpage

Stress issues affect electrical behavior

- Transistors characteristics change with applied stress

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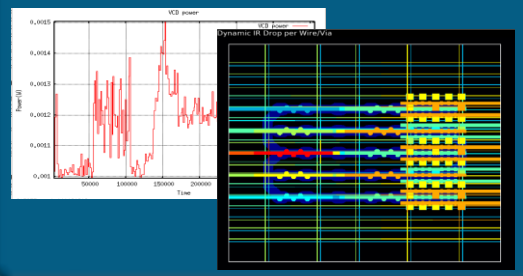
The System Designer Challenge

How Can EDA help?

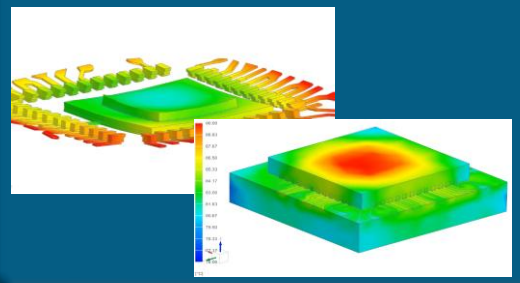
Electrical Analysis



System Level/3D-IC Designer

- Often has an EE or ME background
- Can't be an expert in every verification/analysis flow
- Needs to take "system level" decisions:
  - 3D-IC technology vendor
  - Substrate type (silicon interposer, organic interposer,
  - Die(s) floor planning, etc ..
    - Needs to take the decisions as early as possible

Stress Analysis



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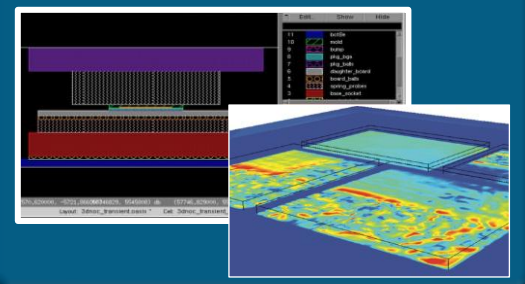

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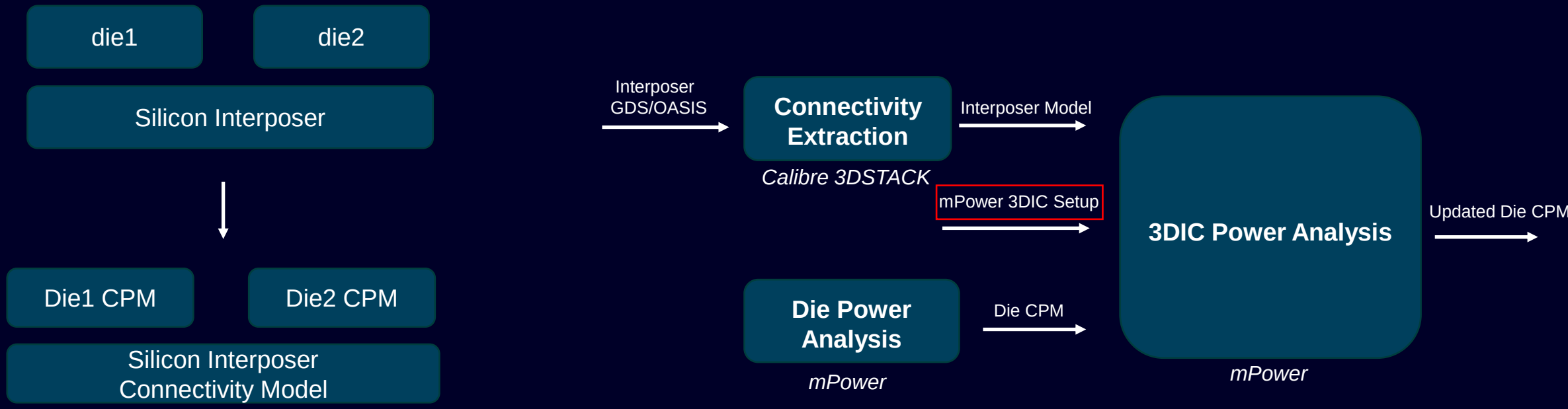
3D-IC Electrical Analysis

Power is delivered to the die “through” a silicon interposer

- How to account for interposer “non ideal” routing?

Die CPM needs to be updated with “Interposer” effect



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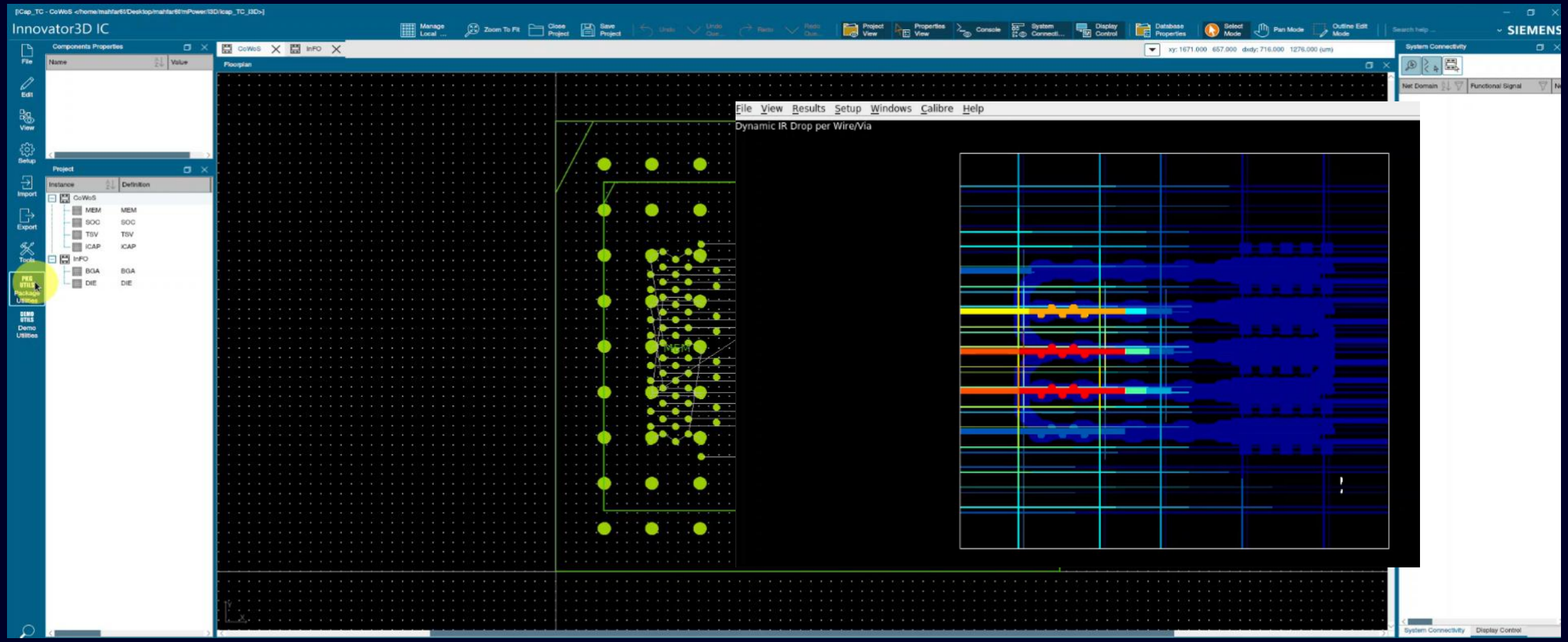
3D-IC Electrical Analysis: *Innovator3D IC & mPower 3D-IC*



3D-IC Thermal Analysis: *Need*

Greater thermal interaction

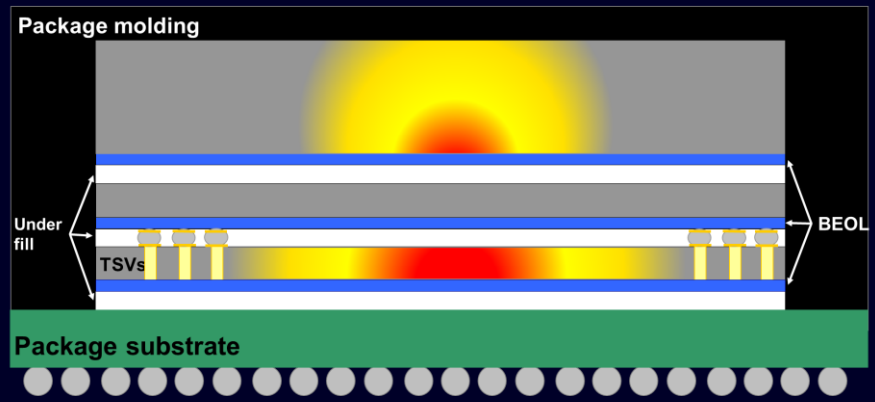
- Active dies are in closer proximity
- Heterogenous integration/different process nodes

Heat dissipation is a main challenge

- Higher power density
- Die bonding results into vertical thermal resistance
- Thinned dies results into lateral thermal resistance

Increased Thermal Gradients

- Non homogenous distribution of 3D interconnects



3D stacked IC

Thermal-related issues

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3D-IC Thermal Analysis: *Requirements*

Die Power Information

- Typically, PD team needs to freeze die design and run power analysis
- To enable early thermal analysis, cockpit platform should generate early power estimates

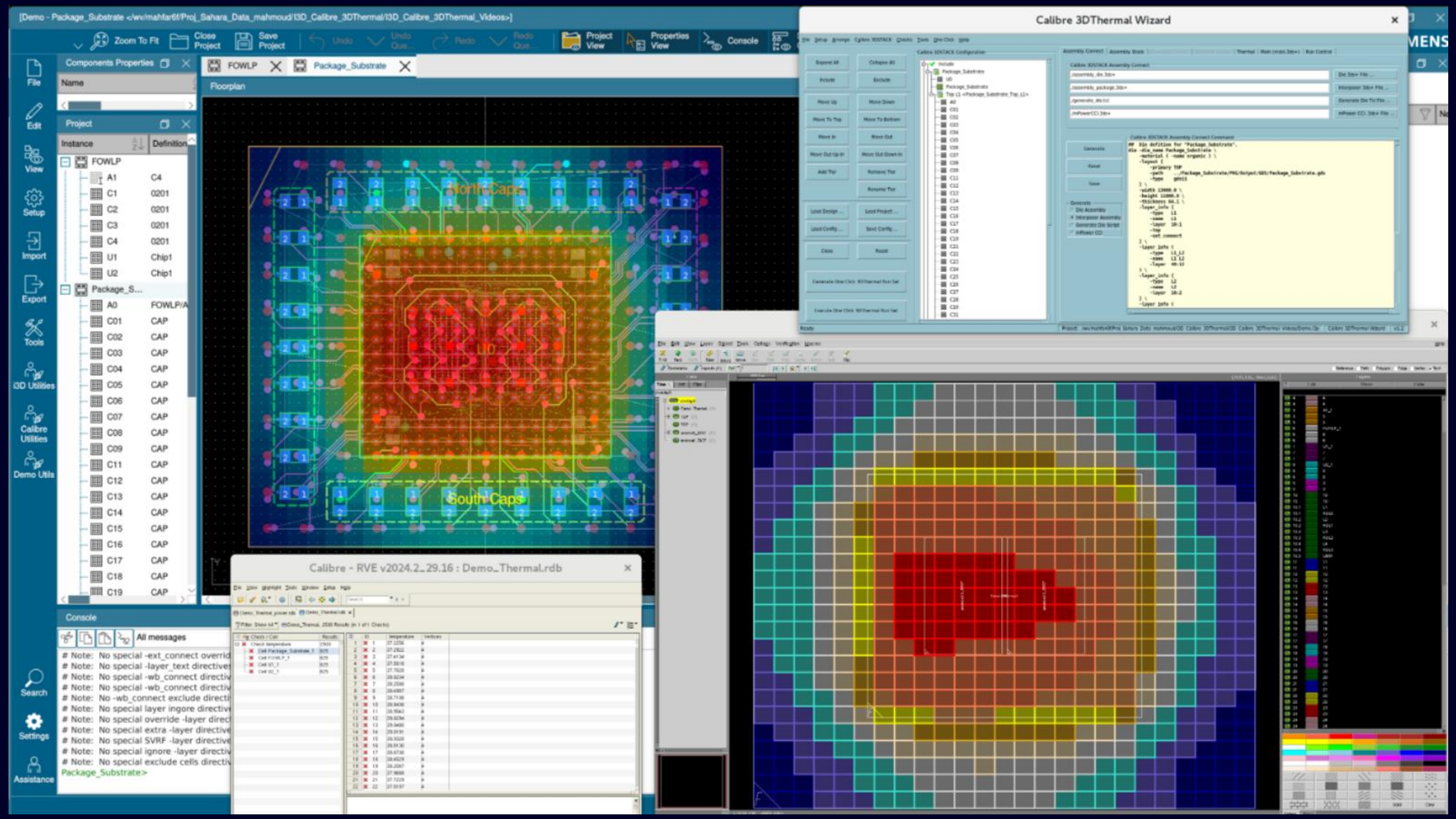
Material Thermal Properties

- Traditionally, die is modeled thermally as “silicon”
- How to account for metallization, TSVs, etc .. in die thermal modelling?
- For accurate die level analysis, “effective” thermal properties should be calculated

3D-IC Assembly Data

- Does the user need to describe assembly, again?!
- Cockpit platform already includes the assembly database

3D-IC Thermal Analysis: *Innovator3D IC & Calibre 3DThermal*



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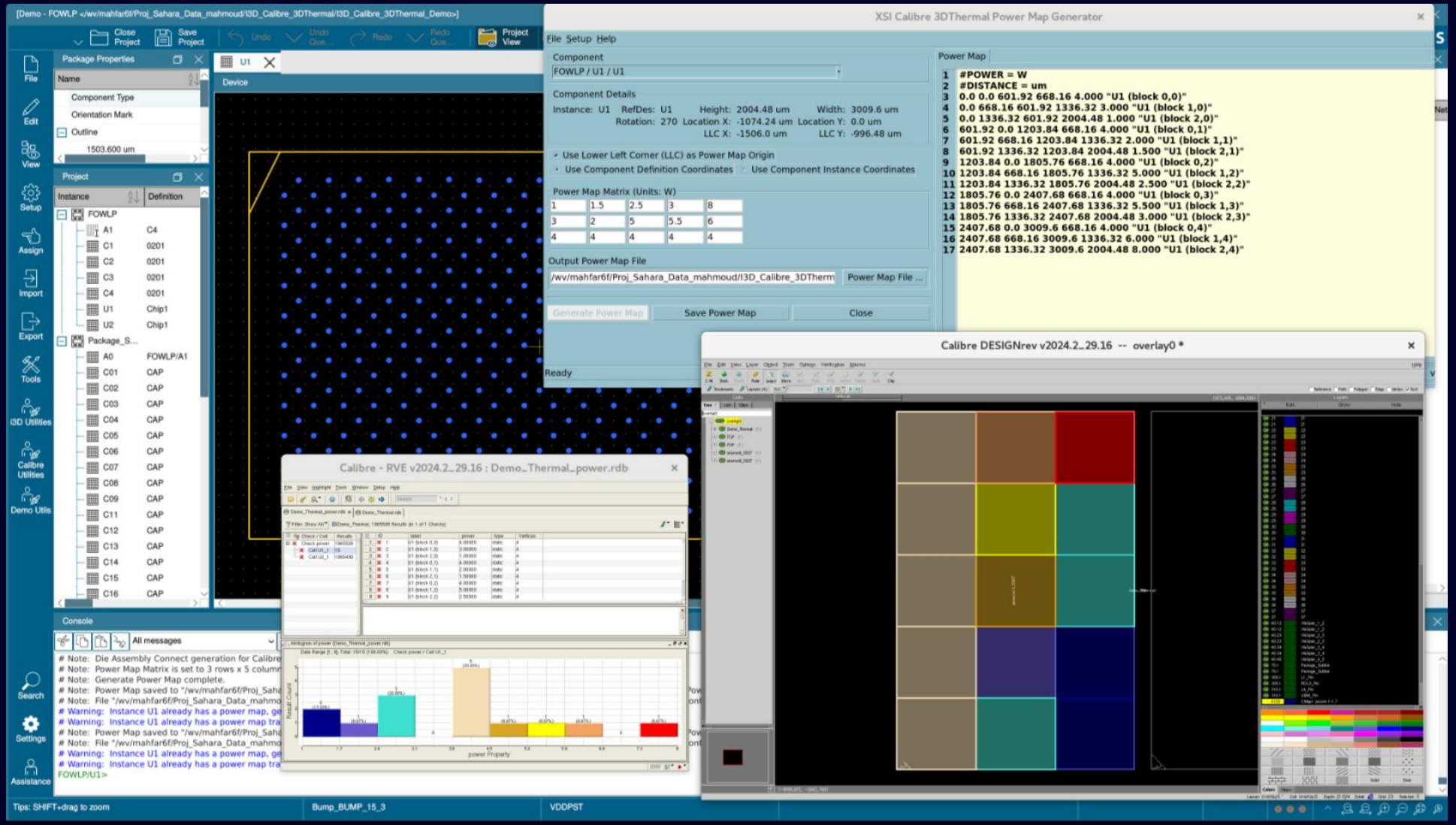
3D-IC Thermal Analysis: *Innovator3D IC Power Map Generation*



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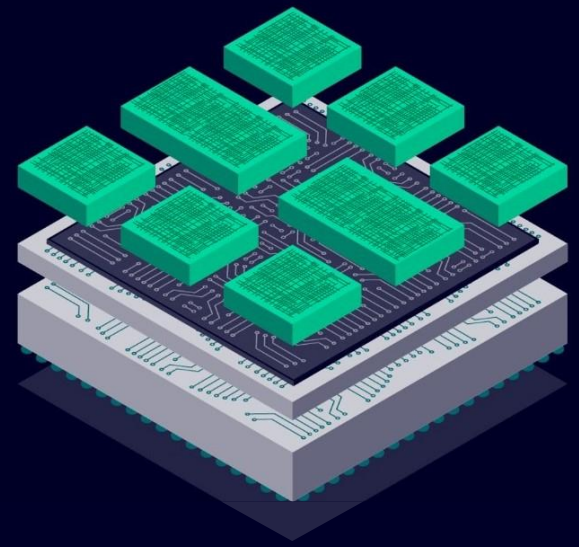
3D-IC Thermal Analysis: *Enable Thermal Through Design Cycle*

As design matures

Feasibility Analysis – *Accurate/early enough for floor planning decisions*

- Calibre 3Dthermal is easy to use for system designer
  - Calibre interface
  - Simplified setup compared to CFD tools/Automated setup using i3D
- Die GDS is not 100% ready – model as silicon
- i3D enables generation of “early” power map
- i3D enables thermal map overlay to visualize effect on floorplan



Sign off Analysis – *“die level” focus*

- Insert “accurate” power map after die power analysis
- Die GDS is ready – model using EFFP (silicon + metals/TSVs)
- Calibre 3DThermal enables electro-thermal simulation

Sign off Analysis – *“system level” focus*

- Use thermal models from Calibre 3DThermal as input to Simcenter FloTherm (die + Package + PCB)

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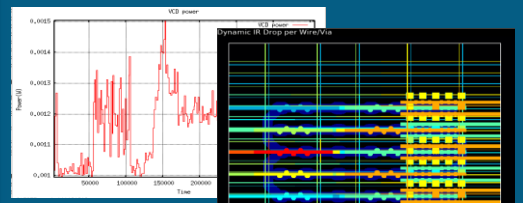
The System Designer Challenge: *Summary*

Innovator3D IC as a Multiphysics Cockpit

- An automated setup generation for every respective tool
  - i3D generates setup for mPower and Calibre 3DThermal (and more!)
- Multiphysics tools with the “IC” look & feel (Calibre-based)
- i3D/Calibre allows early vs. sign off analysis

Electrical Analysis



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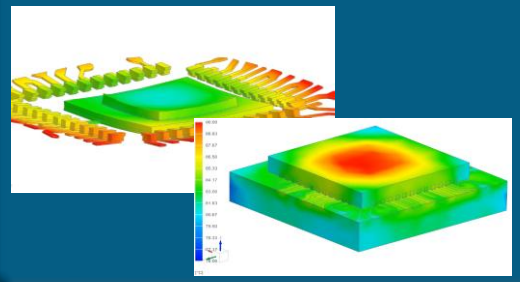

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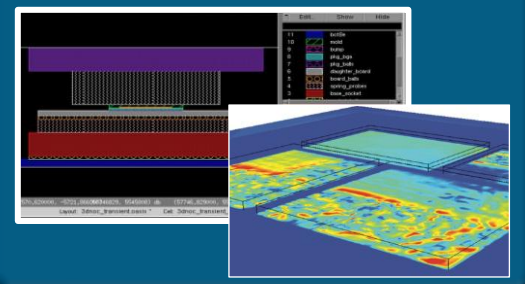

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Q&A