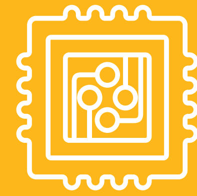
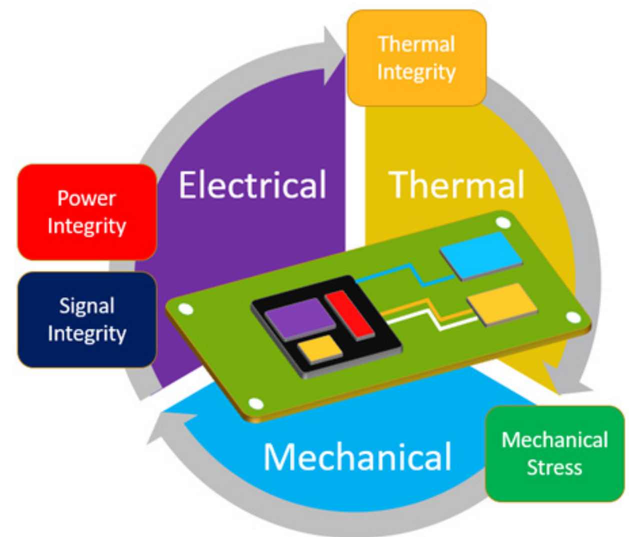
Ansys



Ansys RedHawk-SC Electrothermal

Multiphysics Solution for 2.5D/3D-IC Systems: Thermal, Electrical, and Mechanical Signoff

Next-generation semiconductor products increasingly rely on vertical integration technologies to drive system density, speed, and yield improvement. Due to the increased coupling effects across multiple physics, co-simulation and co-analysis of these phenomena are critical for a robust chip-package-system design. Advanced 2.5D/3D-IC systems are constructed with multiple dies, interposers, package and printed circuit board (PCB), which make the coupling effects even more of a challenge. Ensuring power integrity (PI), signal integrity (SI), thermal integrity (TI) and their interactions requires a new approach. Ansys RedHawk-SC Electrothermal™ is an innovative and comprehensive 2.5D/3D-IC multiphysics prototyping and sign-off solution that addresses these challenges.

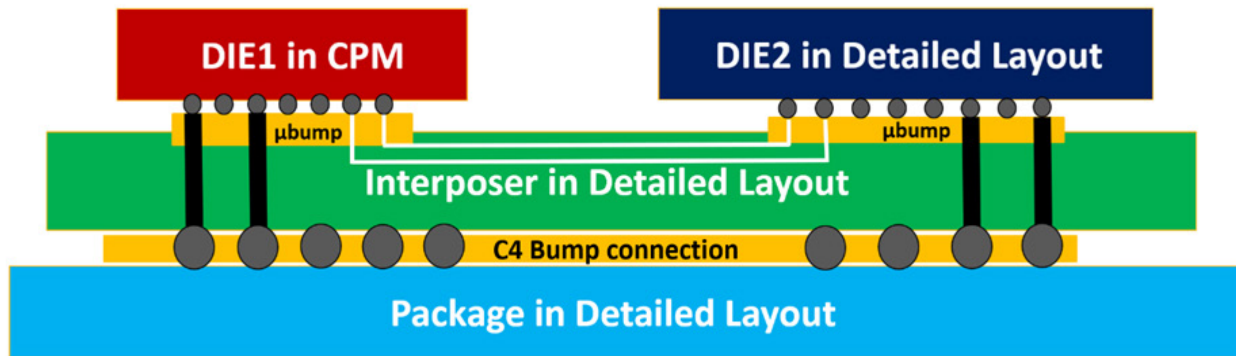


Product Highlights

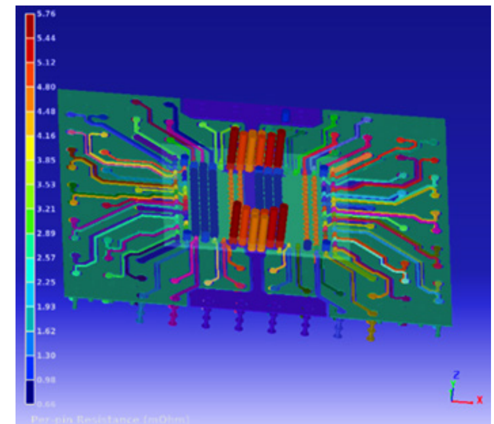
Ansys RedHawk-SC Electrothermal is a multiphysics electrothermal chip-package-system simulation platform that is based on industry-standard Ansys golden solvers. It can be used by chip and package designers to concurrently analyze multi-die chip packages and interconnects for power integrity, layout parasitic extraction, signal integrity, thermal profiling, and thermo-mechanical stress impact. The multiphysics analysis provides the accuracy needed to model the impact of one physics on another, such as the thermal impact on mechanical stress or on voltage drop, which impact the results significantly. As an advanced option of Ansys RedHawk-SC™, powered by the cloud-native Ansys SeaScape™ platform and patented machine learning (ML) algorithms, RedHawk-SC Electrothermal enables high-capacity electrothermal analysis for early-design exploration, post-layout design verification, and design signoff of the chip-package-system. RedHawk-SC Electrothermal is foundry certified for system-in-package, 2.5D IC with silicon interposer, and 3D-IC with through-silicon-via technologies.

3D-IC Physical Model Prototyping, Extraction and Assembly

Ansys RedHawk-SC Electrothermal features 2.5D/3D-IC multi-die auto assembly with accurate footprint connection and physical model verification. At the early design stage, the interface net connections between the die, the interposer, and the package components can be parameterized to quickly prototype the system. With the complete package and interposer layout files, high-capacity power signoff is achieved through a patented smart pin-grouping algorithm during parasitic extraction. In a heterogenous system with multiple dies, dies can be modeled as a flat physical model, a hierarchical physical model, or a reduced physical model in the form of an Ansys CPM™ (chip power model). CPM includes the parasitics of the power delivery network (PDN) and I/O network and the demand current from instances in the chip. As an industry-proven technology, CPM accounts for the electromagnetic (EM) coupling effects between the signal nets and the PDN. The entire assembled physical model can be used for chip-package-system power integrity (PI) and power-aware signal integrity (SI) analyses.

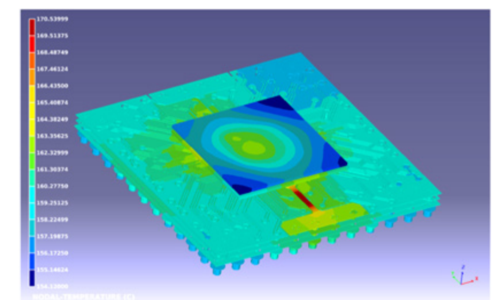


Chip-Package-System Power Integrity Analysis and Signoff



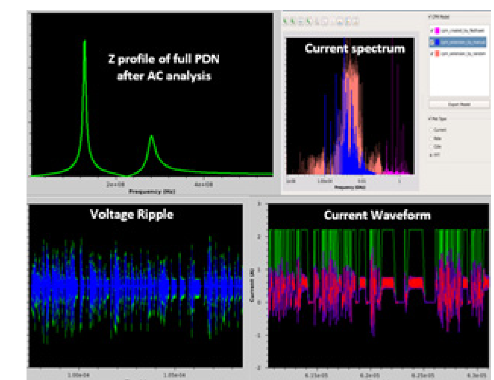
RedHawk-SC and RedHawk-SC Electrothermal provide the capacity for a fully-detailed PDN parasitic extraction for 2.5D/3D-IC designs and electrical simulation of designs that are billions of instances in size. Static and dynamic voltage drop and electromigration of the chip-package-system PDN can be simulated down to the gate instance level to identify local hotspots. Using Ansys PowerArtist™ power profiles across long vectors early at the RTL (register transfer level) design stage, RedHawk-SC Electrothermal additionally models the low-frequency power noise for 2.5D/3D-IC package power integrity. The power, noise and reliability engines are certified accurate by all major foundries for all advanced FinFET processes and are proven in hundreds of silicon tapeouts.

Static and Transient Thermal Analysis



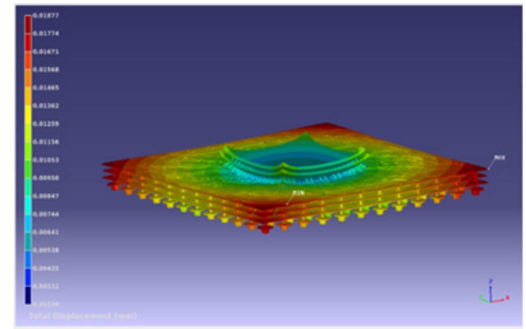
RedHawk-SC Electrothermal solution uses the Finite Element Method (FEM) solver of industry's gold-standard Ansys Mechanical™ to build a three-dimensional simulation model of the thermal conduction paths. It delivers a complete electrothermal co-simulation solution for a multi-die system including the package and printed circuit board (PCB). RedHawk-SC Electrothermal provides system assembly capabilities to connect multiple compact chip-level thermal models, Ansys Chip Thermal Model (CTM™), to enable chip-package-system thermal analysis. In addition to static analysis, it supports fast transient thermal flow for analysis of thermal throttling behavior by exercising different system power states such as standby, low-power, and operation modes. RedHawk-SC Electrothermal transient thermal analysis can directly consume early-stage RTL power waveforms from PowerArtist for emulator-generated long patterns, enabling critical design tradeoffs based on real-life application scenarios.

Chip-Package-System Co-optimization for SI, PI, TI



Ansys RedHawk-SC Electrothermal solution supports both GUI and script-based links with Ansys OptiSLang™ to explore design parametric optimizations such as the bump pitch, the wire width and bump diameter. It features automatic parameter sampling, fast iterations and comparisons, as well as complete exploration coverage. Users can perform comprehensive sensitivity analysis of the parameters on the PDN, heat source, thermal boundary conditions, signal net geometry, and other design parameters to discover the best design solution.

Multiphysics Capability for Electrical, Thermal and Mechanical



RedHawk-SC Electrothermal interfaces with several industry gold-standard Ansys signoff tools to achieve multiphysics simulation that is essential for accuracy in order to avoid design respins. It provides the junction temperature profile between the die and the package to RedHawk-SC, which then performs thermal-aware chip-centric voltage drop, electromigration (IR/EM), and self-heating analyses for individual die signoff. Not accounting for the junction temperature can lead to either a potential design failure or overdesign. In addition, RedHawk-SC Electrothermal can take the die pad current profiles from RedHawk-SC to perform a package and PCB electrothermal co-simulation that models the Joule heating effect of currents in the wires. An accurate analysis should model the thermal convection from air flow and the thermal conduction from heat sink(s). RedHawk-SC Electrothermal chip-package-system analysis uniquely uses system heat transfer coefficients (HTCs) from Ansys AEDT™ Icepak™ to deliver predictable results. Thermal conditions can result in significant warpage in the system. RedHawk-SC Electrothermal integrates the Ansys Mechanical engine to identify design weaknesses in the 2.5D/3D-IC packages through electrothermal stress and warpage simulation.

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