

# Possible Applications for Green's Functions in Simulation Software

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# Green's Functions for Simulation Software

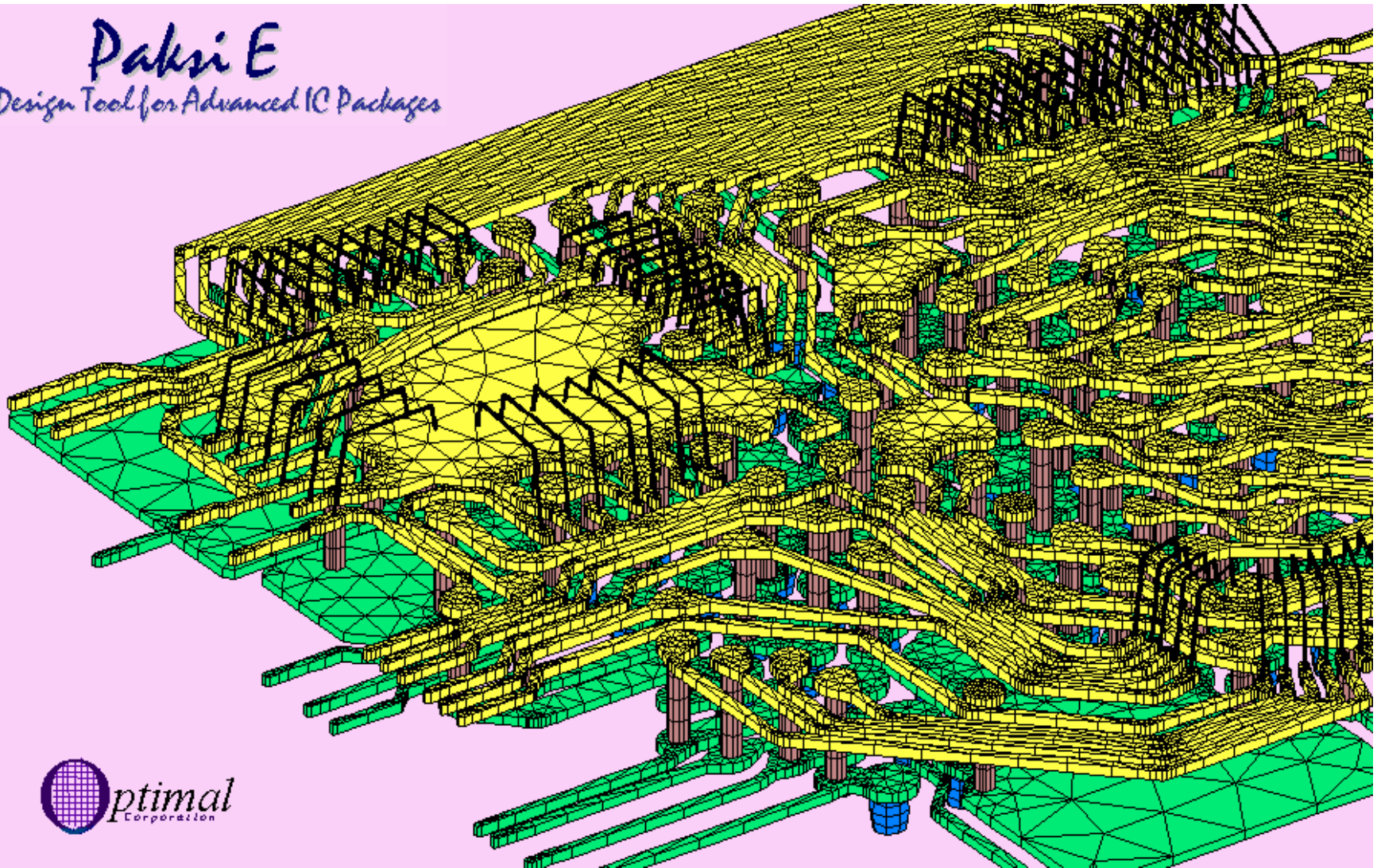
- Solution of 3-D Field Equations is now a standard part of the Industrial Design Process
  - ANSYS Finite Element Code
    - Solve for Strain and Stress fields
    - Solve Poisson Equation for Temperature Fields
  - Fluent or FlowTherm Finite Volume CFD Codes
    - Solve Navier-Stokes for Fluid Velocity Fields
  - PakSi-E Finite Element Code
  - Many Other Examples

# Green's Functions for Simulation Software

- Commercial Simulation Software is applied to very large, very detailed models
- Up to 1,000,000 Finite Elements in Thermal/Stress/Electrodynamic Analyses
- Up to 1,000,000 Finite Volumes in Computational Fluid Dynamic Analyses
- Solution must run overnight

# Green's Functions for Simulation Software

*Paksi E*  
*Design Tool for Advanced IC Packages*



# Green's Functions for Simulation Software

- Iterative Solution of Poisson Equation for  $10^6$  Elements is just barely possible in 12 hrs
- The pressure is always on from designers for models with more detailed, realistic geometry
  - Add more and more elements
  - The solution must be available in the morning
- A Green's function solution can be much faster than an iterative solution.

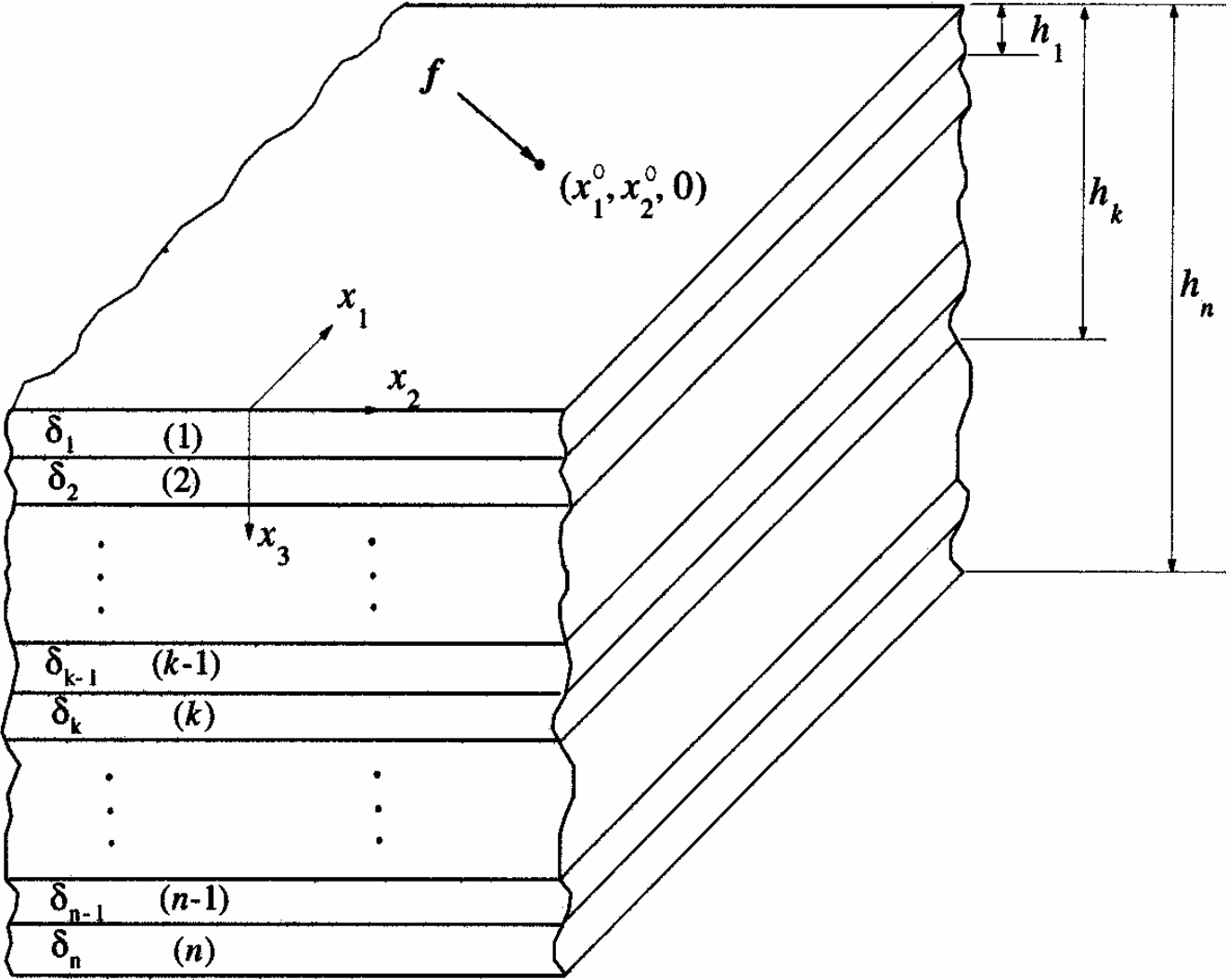
# Green's Functions for Simulation Software

- One particular possibility for introduction of a Green's Function solution - IC package Design
- Integrated Circuit (IC) package design requires analysis of inductance and capacitance of circuit nets in the package, as well as voltage wave travel time and wave shape distortion by cross-talk.
- Ideally this analysis would be done with a 3-D solution of Maxwell's Equation.
- Currently, Finite Element Solutions are limited by the need for overnight solution

# Green's Functions for Simulation Software

- Geometric Considerations
  - IC Packages are a stackup of thin layers
  - The layer materials alternate (conducting, non-conducting)
  - Need 3-D Multi-Layer solutions
  - Pan, Yang and Yuan have developed 3-D multi-layer solutions for stress-strain analysis for the *Lanis* program

# Green's Functions for Simulation Software





# Green's Functions for Simulation Software

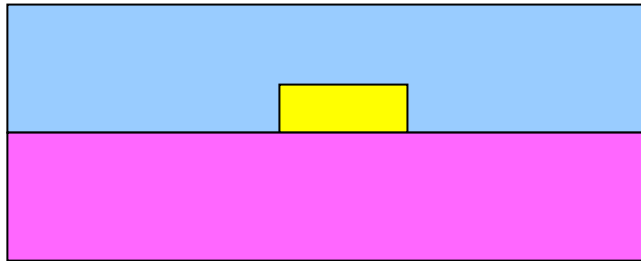
**Perfect Conductor:**



$$\mathbf{E}_t = \mathbf{0}$$

$$\mathbf{B}_n = \mathbf{0}$$

**Interface Continuity:**



$$\varepsilon_1 E_{1n} = \varepsilon_2 E_{2n}$$

$$\frac{B_{1t}}{B_{2t}} = \frac{\mu_1}{\mu_2}$$

# Green's Functions for Simulation Software

Green's function solutions for 3-D Wave equation, the Helmholtz equation, or even the Poisson/Laplace equations in a stacked multi-layer geometry could improve the speed and therefore the practicality of IC simulation software.

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