In this tutorial you will learn how to setup up and run a computational thermal analysis.

- ANSYS ICEPAK
  - Electronics thermal management

- Joule Heating / Resistive Heating
- Computational Fluid Dynamics
Assumptions

- 400 micron Pitch Probe Geometry
- Generic Probe Design
- Joule Heating Along One Axis
- Heat Sinks have constant temperature
  - 50°C DUT temp
  - 20°C LBD temp
- Material is Beryllium Copper
Probe Types

- Spring Pin
- Vertical Probe
- Cantilever Probe
- Solid Probe
Real Geometry vs. Physics Geometry
Real Geometry vs. Computational Geometry

Real Geometry

Computational Geometry

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Real Geometry vs. Computational Geometry

Spring pins and solid probes all have electrons traveling in one axis and no changes are required for the computational model.
Mesh Settings

- **Mesh Type**
  - Mesher-HD → CAD Geometry

- **Max element size**
  - X, Y, and Z directional sizes of the background mesh
  - Balance between accuracy and runtime

- **Minimum Gap**
  - All geometries below this tolerance will be ignored by the mesher
Meshing Verification

• **Face Alignment**
  – Range from 0 (bad) to 1 (good)
  – Face alignment must be greater than 0.05
  – Best results above 0.15

• **Volume**
  – Determines if you use double or single precision solver (1e-13)

• **Skewness**
  – Skewness determines how close to ideal a face or cell is
  – Should be above 0.02
Visual Inspection of the Mesh
Material Properties and Joule Heating

Density = 8321.0 kg/m³
Specific heat = 419.0 J/kg-K
Conductivity type = Isotropic
Conductivity = 95.0 W/m-K
Joule Heating of a Physics Rod

Smaller Cross Sectional Area More Heating

Smaller Length Heating
Adding Heat Sinks

- Heat sinks being applied
  - 50°C DUT temperature
  - 20 °C Load board trace temperature
Vertical Probe

Largest Distance Between Heat Sinks (Longest Probe)
Cantilever Probe

Small Cross-Sectional Area Leads to a Large Current Density
Spring Pin

1st Iteration
Improved Accuracy

Increasing Overdrive is equal to
More Surface Contact of Heat Sink
Solid Probe
Joule Heating is very small based off of large cross sectional area and short electrical path.
Adding Contact Resistance and Natural Convection

Highest temperature at contact interfaces
Probe Type Conclusions

- Vertical Probe has the longest length leading to higher temperatures.
- The cantilever probe has a small cross sectional area leading to high current density.
- The Spring Pin has a contact resistance between the tips and the barrel leading to increased heating.
- Solid Probe has the lowest Joule heating effect, but has internal contact resistances.
Increasing Accuracy

• Adding Real Heat Sinks
  – Active DUT Heating
  – Conduction to Retaining Features
  – Natural Convection
  – Contact Resistance
  – Load Board Trace Cooling
Computational Conclusion

• Generate physical geometry for computational requirements
• Conduct accurate meshing and validate
• Review results and iterate with increasing complexity for best correlation to reality
Why Should You Care?

• Tomorrows devices will have higher transistor density and run hotter. We must address that today.

• Leveraging computational thermal analysis at the wafer scale will create better and faster designs pushing innovative solutions.
Questions?