Packaging Evolution: From Basics to 3D Integration

Module 3: Thermal Simulations of Semiconductor Packages Using ANSYS

This module provides a hands-on walkthrough for performing thermal simulations of Flip-Chip BGA semiconductor packages using **ANSYS Icepak**, part of the **ANSYS Electronics Desktop (AEDT)** suite. The process includes package modelling, power source assignment, meshing, and thermal analysis with visualization.

3.1 Introduction to ANSYS Electronics Desktop (AEDT)

ANSYS Electronics Desktop is a unified simulation environment that integrates:

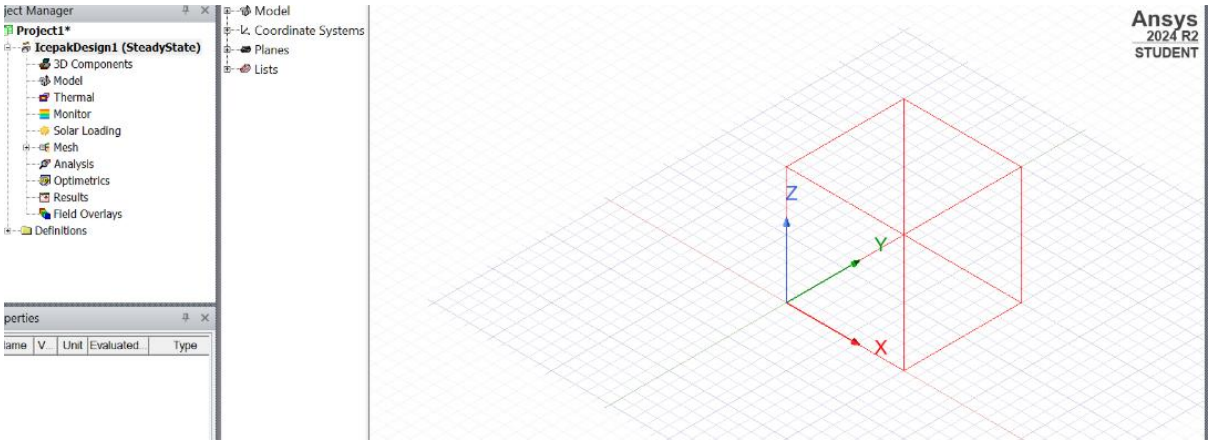
- **Electromagnetic (EM) Simulation**
- **Thermal Analysis**
- **Signal and Power Integrity Checks**
- **Electromechanical Co-simulation**

It is widely adopted in electronic systems design, particularly for PCBs, IC packages, and complete systems.

3.2 Setting Up a Flip-Chip BGA Package in Icepak

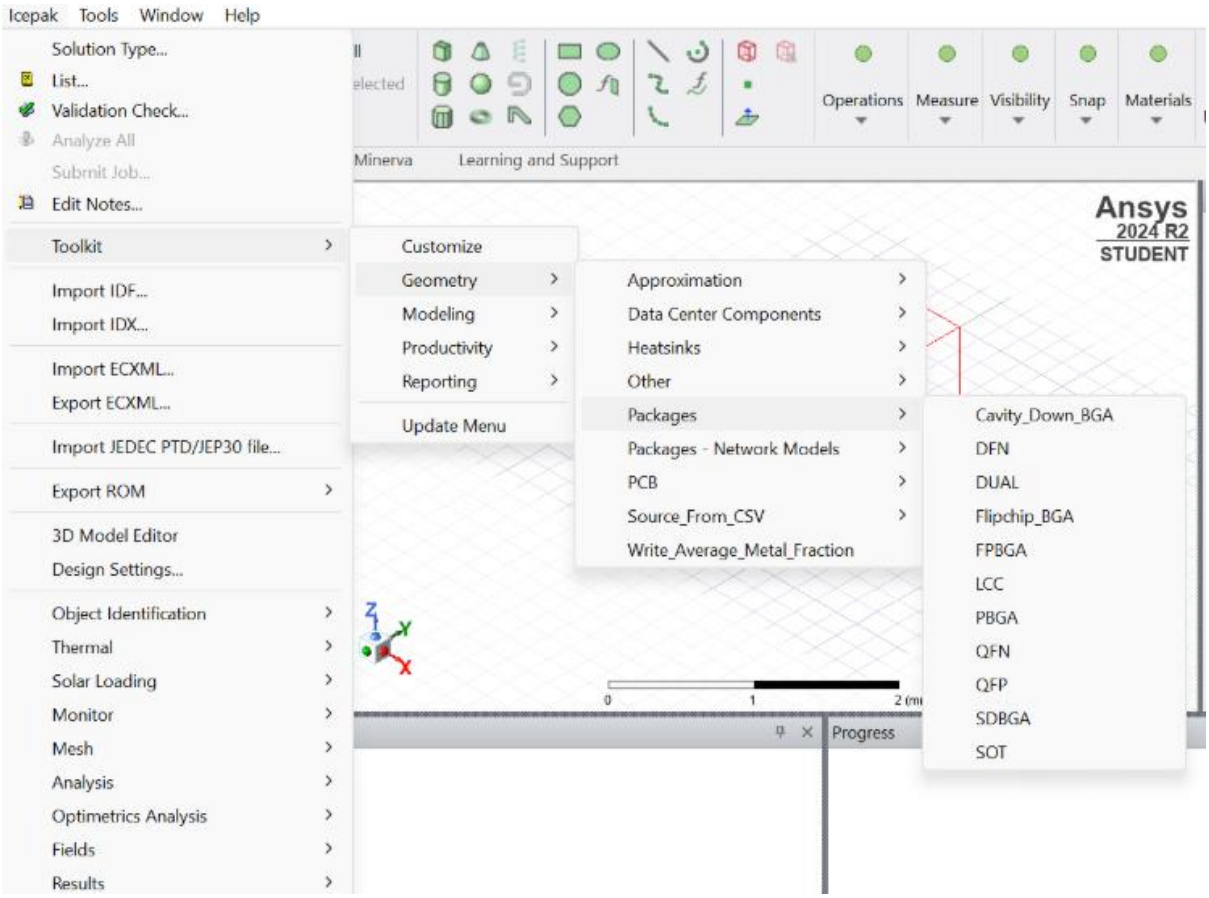
Step 1: Launch Icepak

- Open **ANSYS Workbench**
- Navigate to Project → Insert Icepak Design
- Click the **Icepak** tab to enter the modelling interface

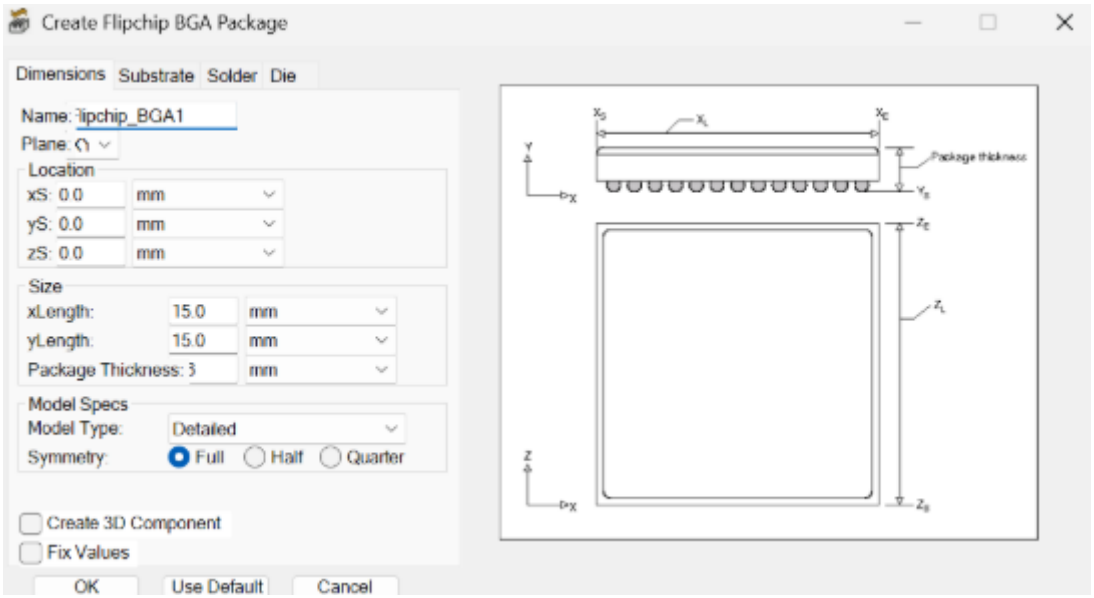


Step 2: Create Flipchip BGA Package

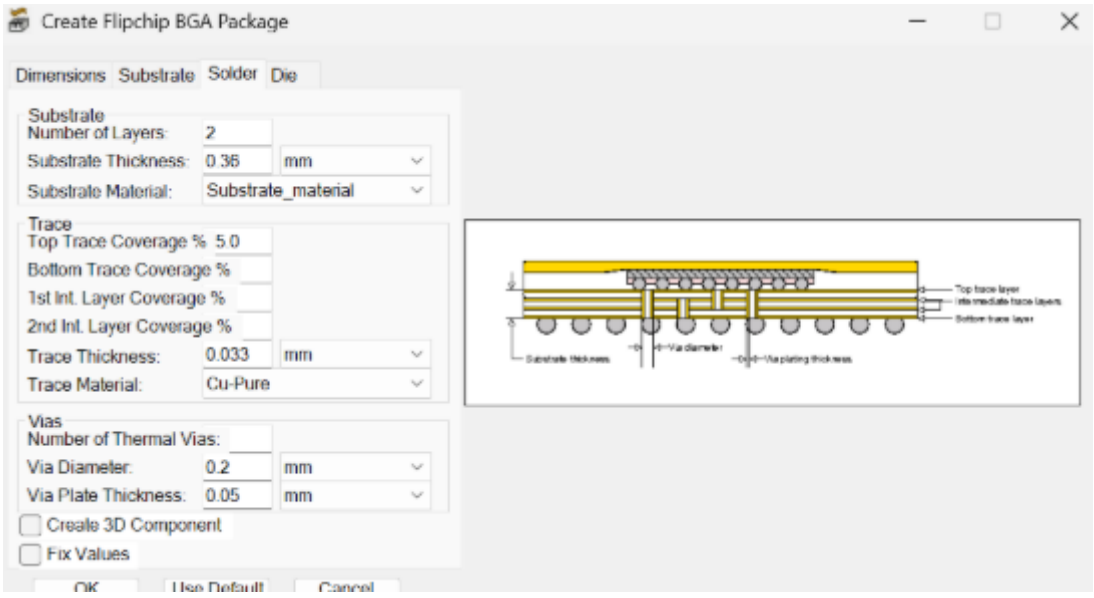
- Go to Toolkit → Geometry → Packages → Flipchip_BGA

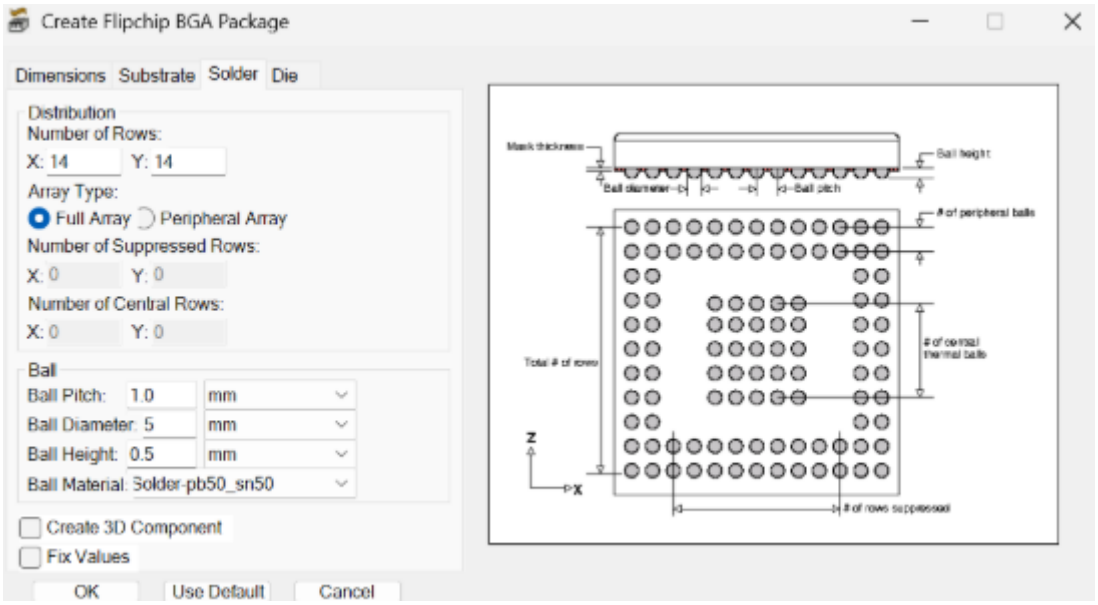


- In the configuration window, input:
  - **xLength**: 15 mm
  - **yLength**: 15 mm
  - **Package Thickness**: 3 mm
  - **Model Type**: Detailed
  - **Symmetry**: Full

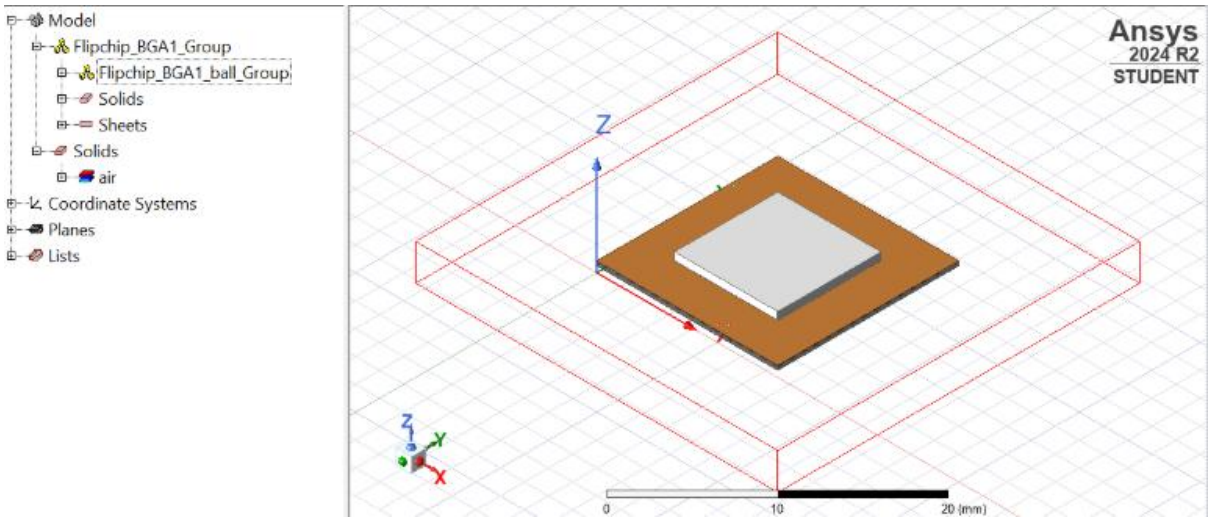

Create Flipchip BGA Package
Dimensions Substrate Solder Die
Name: lipchip_BGA1
Plane:
Location
xS: 0.0 mm
yS: 0.0 mm
zS: 0.0 mm
Size
xLength: 15.0 mm
yLength: 15.0 mm
Package Thickness: 3 mm
Model Specs
Model Type: Detailed
Symmetry: Full Half Quarter
Create 3D Component
Fix Values
OK Use Default Cancel
Package thickness


Create Flipchip BGA Package
Dimensions Substrate Solder Die
Die
xLength: 8.56 mm
yLength: 8.56 mm
Power: 1 W
SourceType: 2D source 3D source
Material: Si-Typical
Die Underfill
Bump size: 0.01 mm
Material: Flipchip_underfill
Heatsink
Include heatsink: Yes No
Thickness: 0.1 mm
Material: Cu-Pure
Create 3D Component
Fix Values
OK Use Default Cancel


Create Flipchip BGA Package
Dimensions Substrate Solder Die
Substrate
Number of Layers: 2
Substrate Thickness: 0.36 mm
Substrate Material: Substrate_material
Trace
Top Trace Coverage %: 5.0
Bottom Trace Coverage %
1st Int. Layer Coverage %
2nd Int. Layer Coverage %
Trace Thickness: 0.033 mm
Trace Material: Cu-Pure
Vias
Number of Thermal Vias:
Via Diameter: 0.2 mm
Via Plate Thickness: 0.05 mm
Create 3D Component
Fix Values

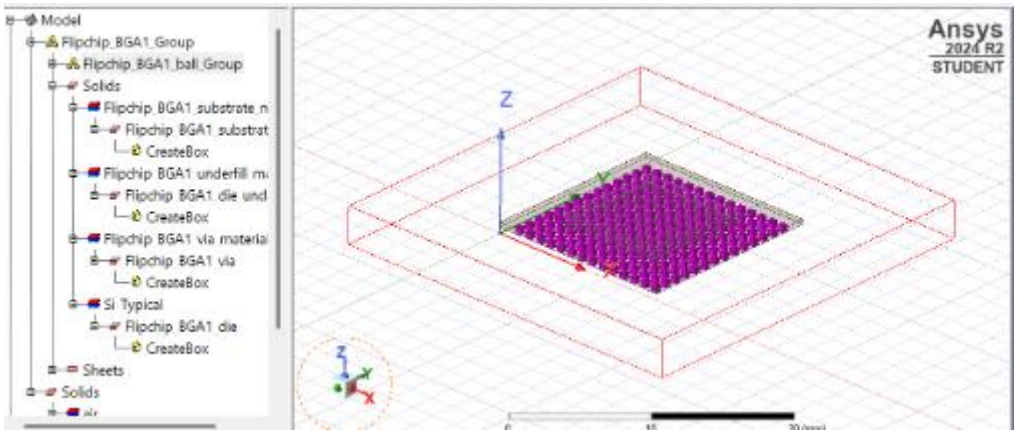


- Click **OK** to generate the 3D model

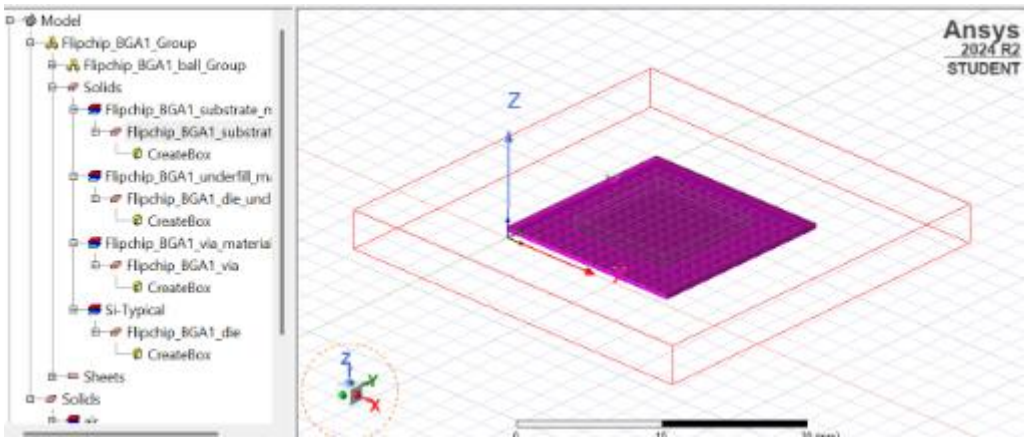


Step 3: Explore the Package Components

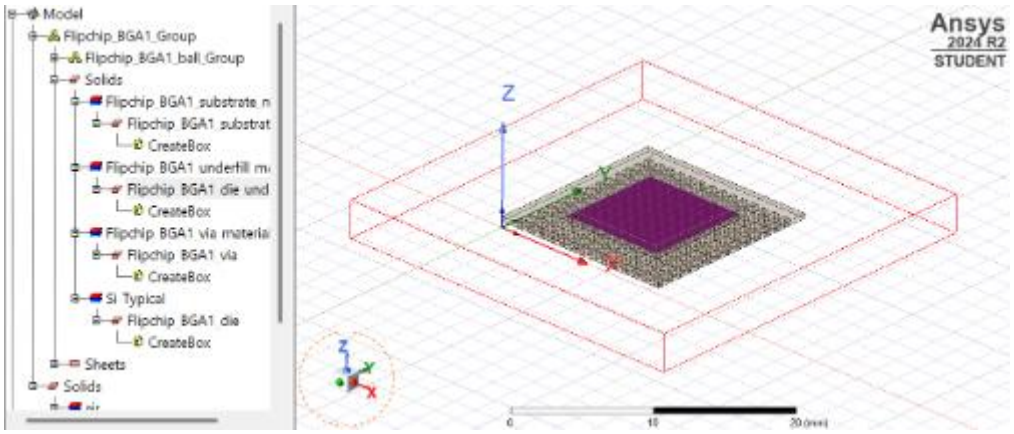
- In the **Model Tree**, expand Solids to view:
    - Ball Group



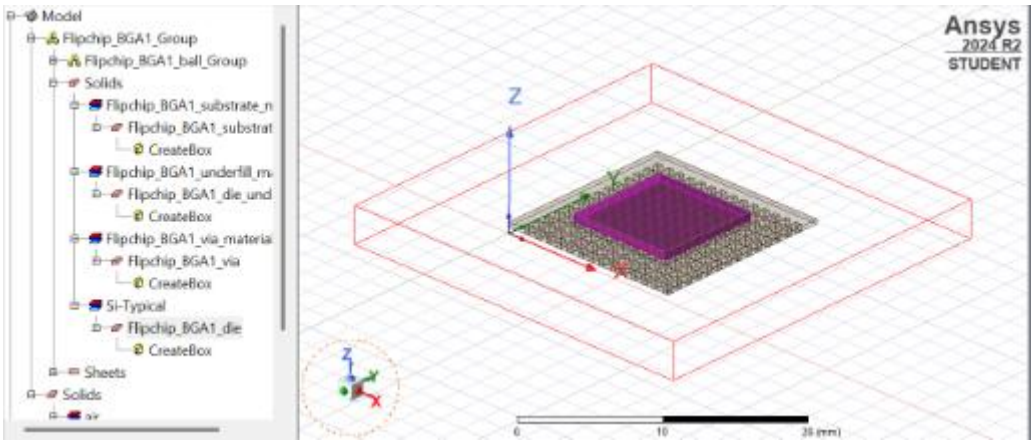
    - Substrate



    - Die Underfill



- Die



3.3 Material Definitions and Power Assignment

Step 4: Review Material Assignments

- Check and update material properties for all solids if needed (e.g., epoxy, silicon, copper).

Design List: Project1 - IcepakDesign1

Model | Thermal | Monitors | SolarLoading | Mesh Region | Mesh Operation | Analysis Setup

Name	Color	Model	Display Wire...	Visible	Material	Type
Region		☑	☑	☑	air	Solid
Flipchip_BGA1_die		☑	☐	☑	Si-Typical	Solid
Flipchip_BGA1_die_source		☑	☐	☑		Sheet
Flipchip_BGA1_die_underfill		☑	☐	☑	Flipchip_BGA1_underfill_material	Solid
Flipchip_BGA1_substrate		☑	☐	☑	Flipchip_BGA1_substrate_material	Solid
Flipchip_BGA1_via		☑	☐	☑	Flipchip_BGA1_via_material	Solid
Flipchip_BGA1_trace1		☑	☐	☑		Sheet
Flipchip_BGA1_ball		☑	☐	☑	Solder-pb50_sn50	Solid
Flipchip_BGA1_ball_1		☑	☐	☑	Solder-pb50_sn50	Solid
Flipchip_BGA1_ball_2		☑	☐	☑	Solder-pb50_sn50	Solid
Flipchip_BGA1_ball_3		☑	☐	☑	Solder-pb50_sn50	Solid
Flipchip_BGA1_ball_4		☑	☐	☑	Solder-pb50_sn50	Solid
Flipchip_BGA1_ball_5		☑	☐	☑	Solder-pb50_sn50	Solid
Flipchip_BGA1_ball_6		☑	☐	☑	Solder-pb50_sn50	Solid

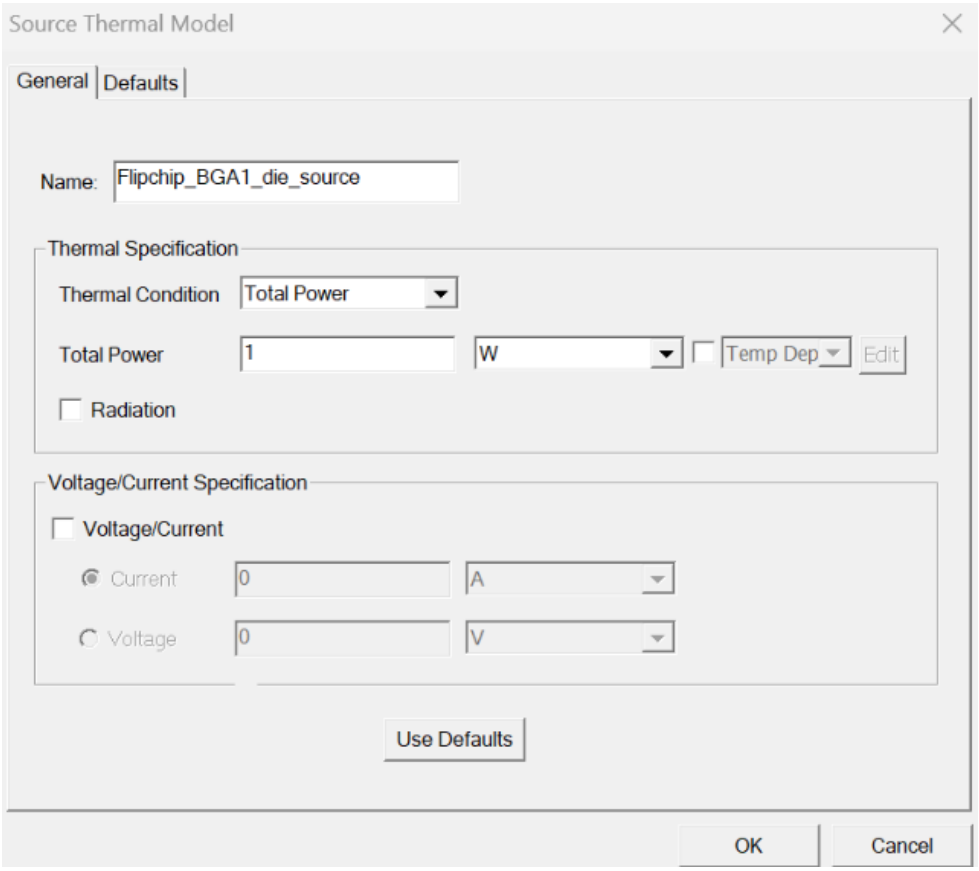
Delete | Properties | Select | Done

Step 5: Assign Thermal Power Sources

5.1 For the Die:

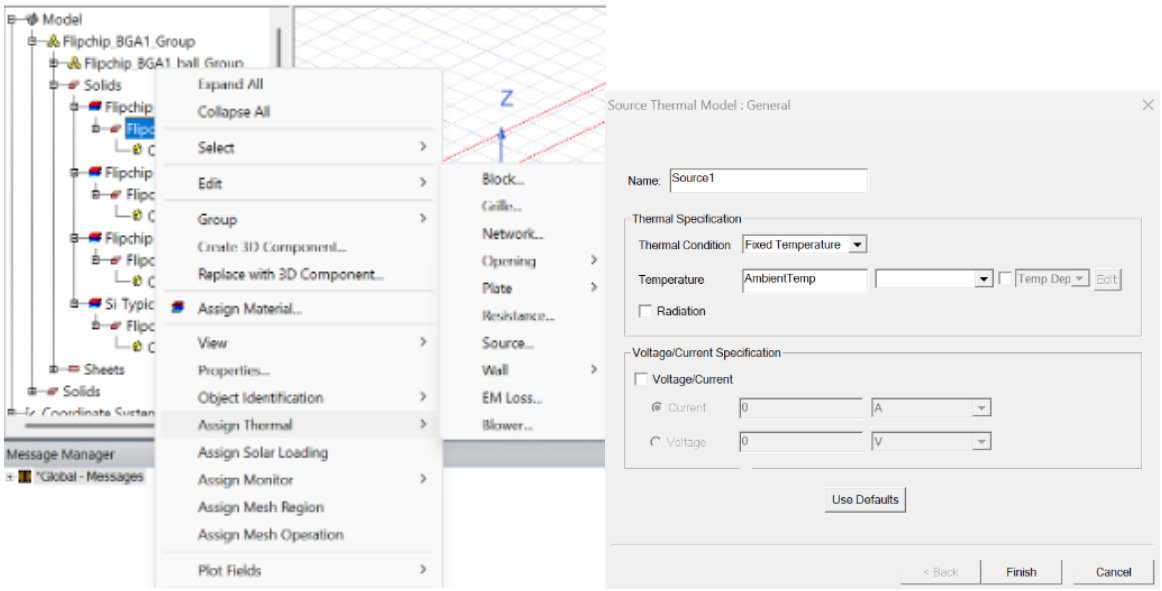
- Under Project Manager → Thermal, locate BGA1_die_source
- Set **Thermal Power Input**: 1 W

- Choose “Source Thermal Model”



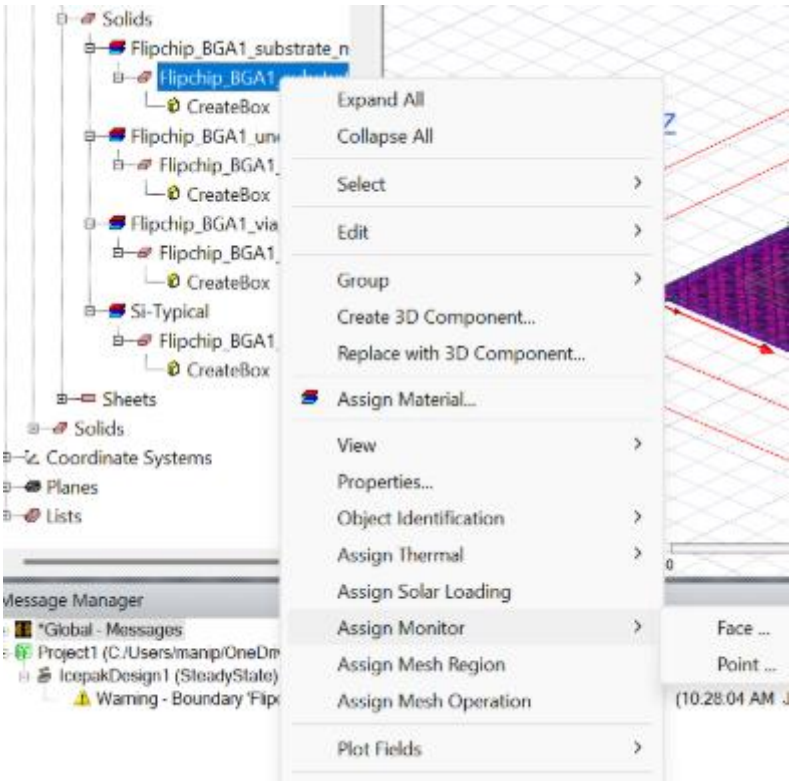
5.2 For the Substrate:

- Right-click Flipchip_BGA1_substrate → Assign Thermal → Source
- Set **Thermal Condition** to **Fixed Temperature (Ambient)**



Step 6: Add Temperature Monitors

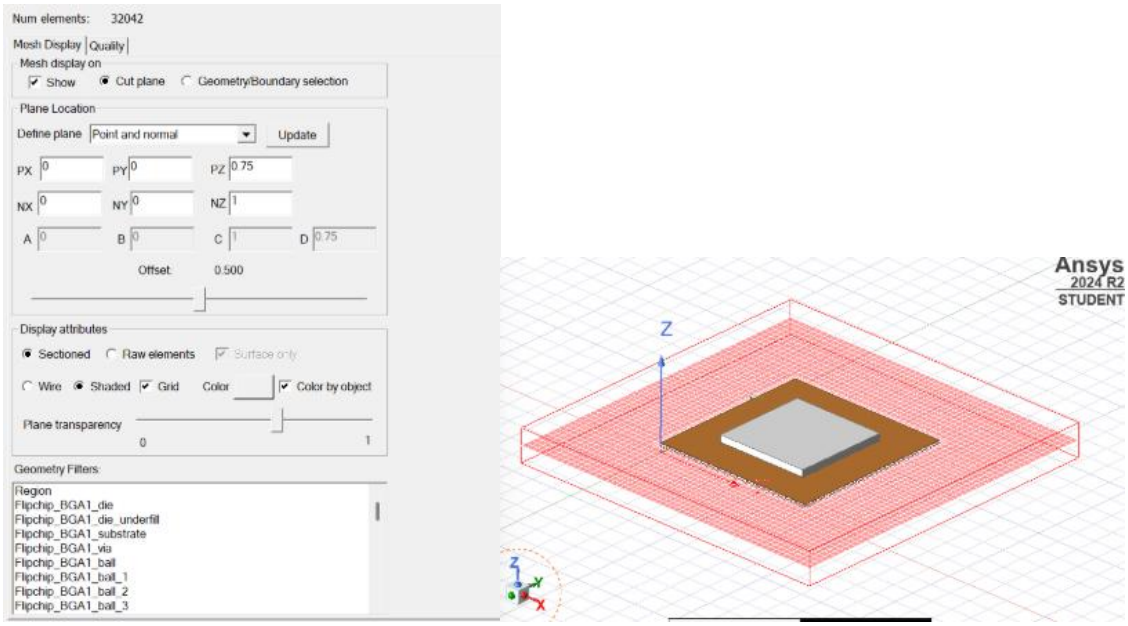
- Right-click each component (Substrate, Die, Underfill)
- Choose Assign Monitor → Point
- Select **Temperature** and click **OK**



3.4 Meshing and Analysis Setup

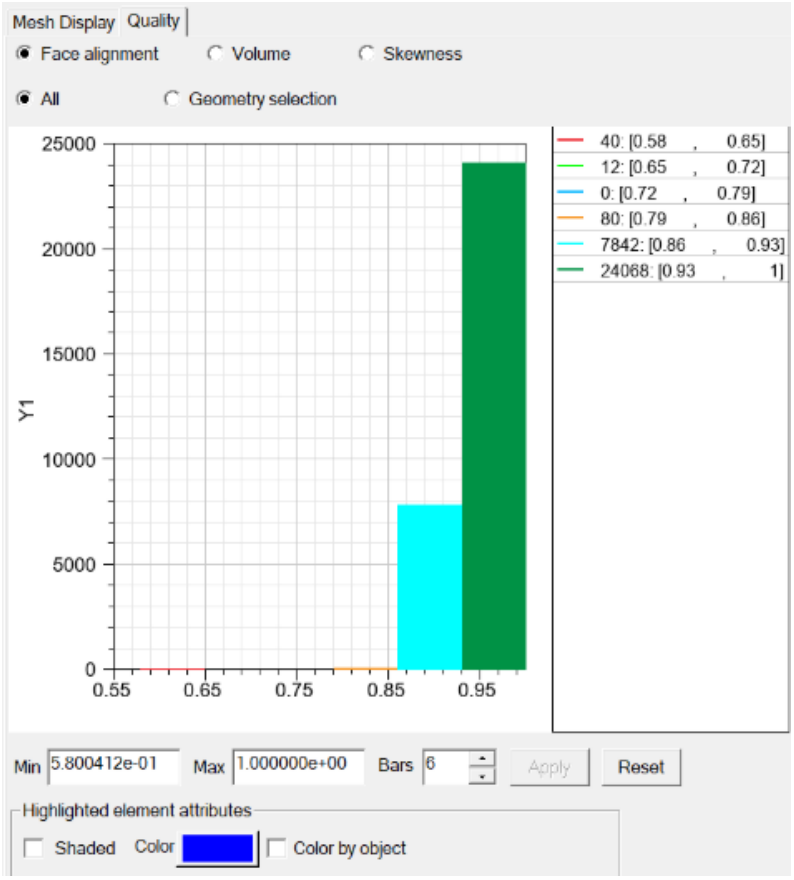
Step 7: Generate Mesh

- Go to the Simulation tab → Click Generate Mesh
- Save the file if prompted
- Wait for the mesh to complete; resolve or note any warnings

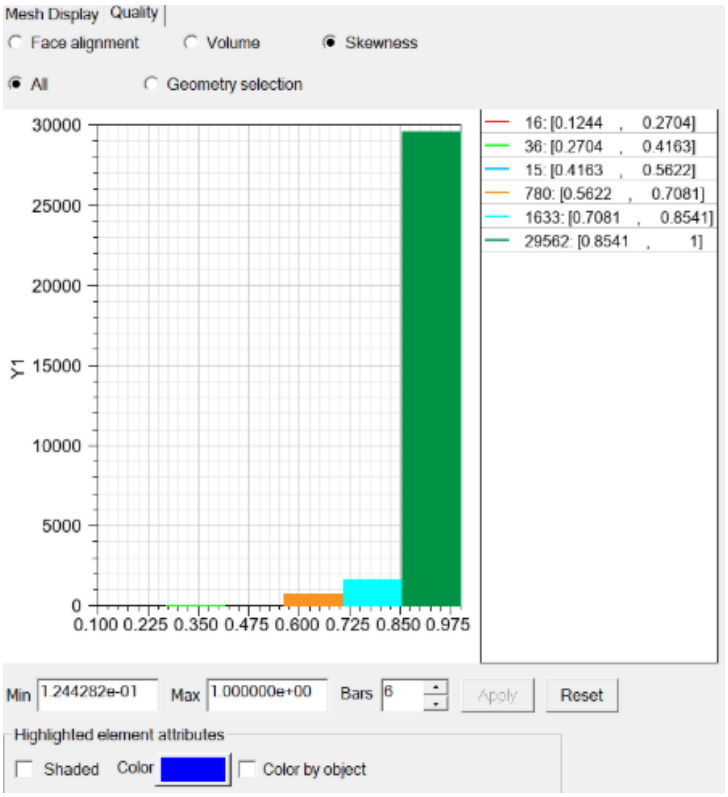


Step 8: Review Mesh Quality

- Go to Mesh Visualization → Quality
- Inspect:
    - **Face Alignment**



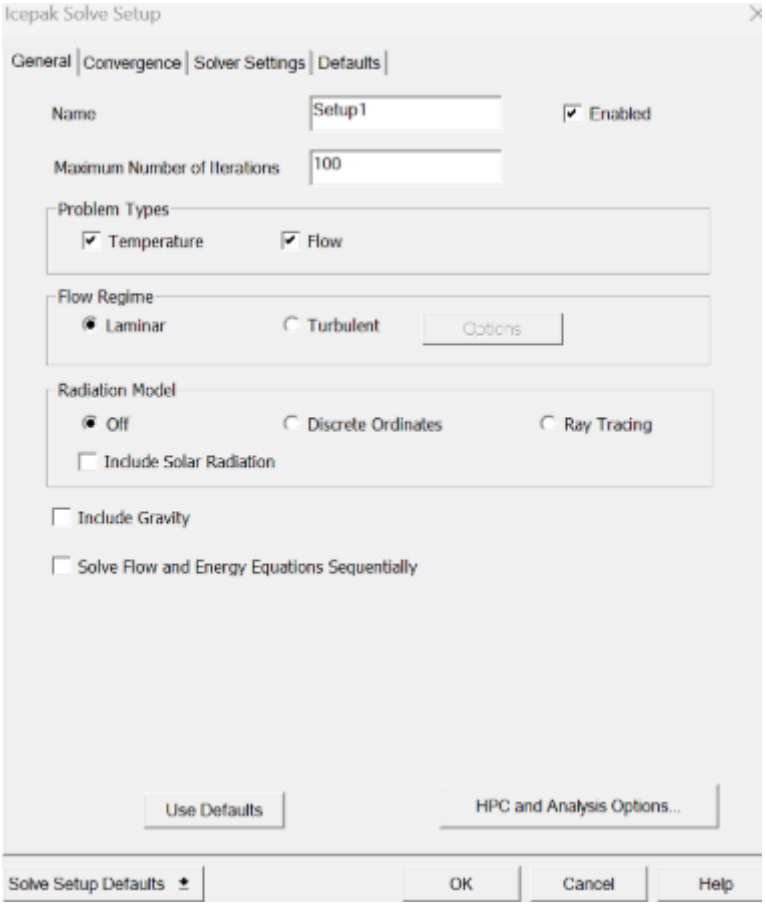
- **Skewness**



- **Element Volume**

Step 9: Add Thermal Analysis Setup

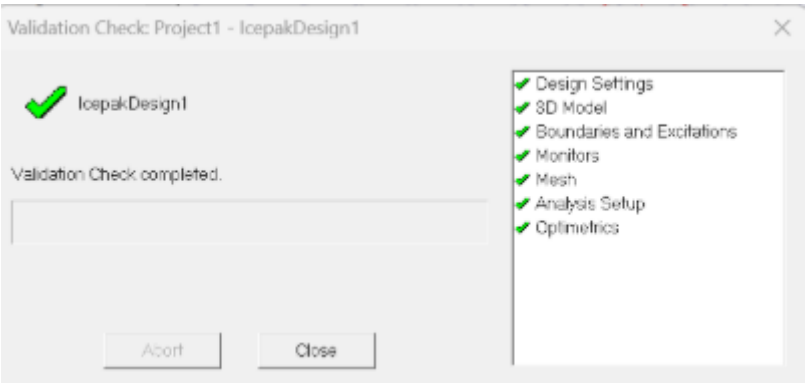
- In Project Manager, right-click Analysis → Add Analysis Setup
- Use default solver settings unless customization is required



3.5 Running Simulation and Viewing Results

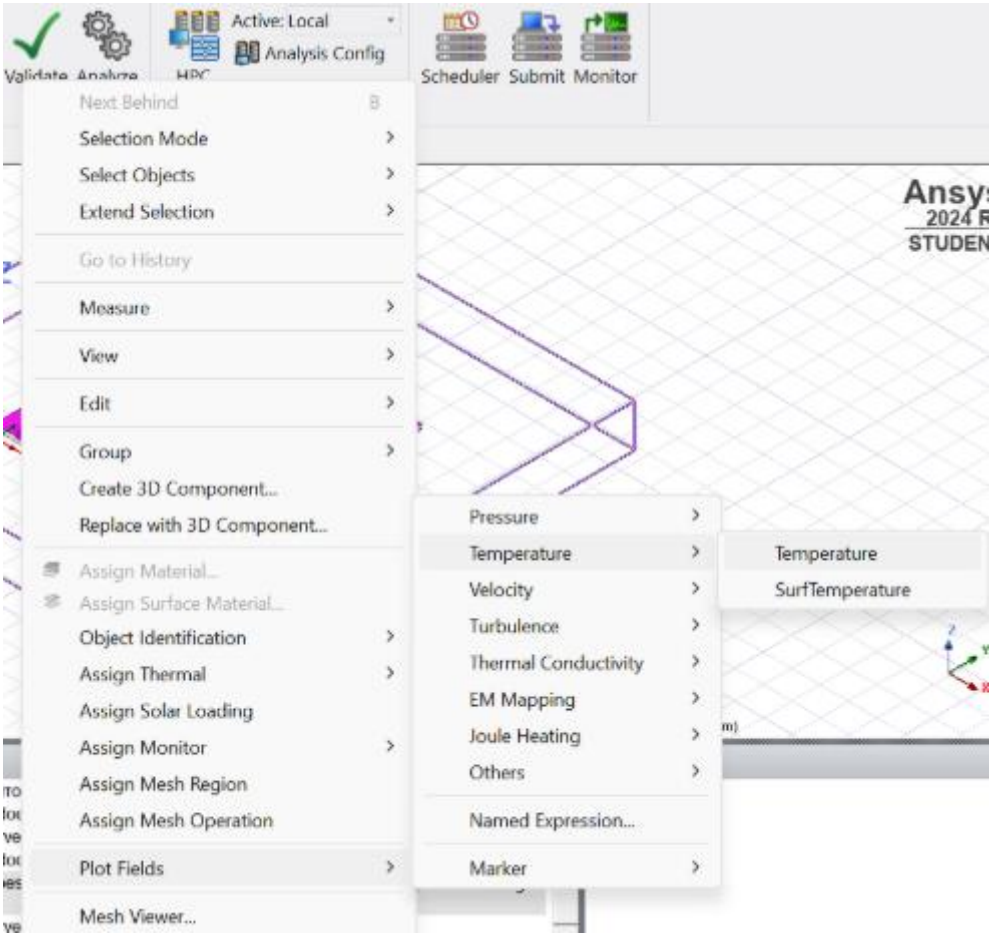
Step 10: Validate the Simulation

- Click Validate in the top toolbar
- Ensure all green ticks are shown, this confirms a correct setup



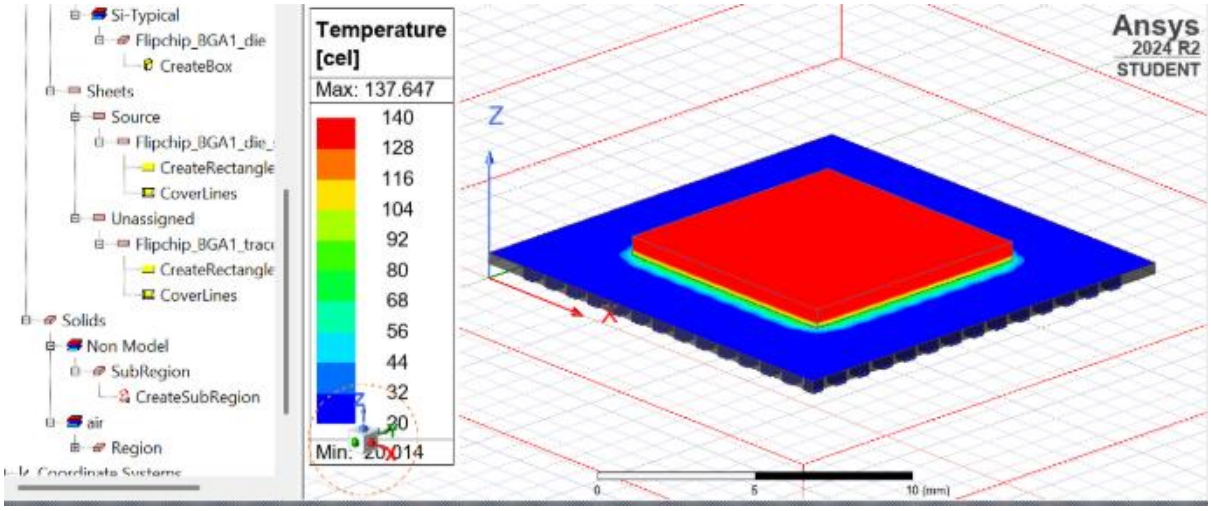
Step 11: Run Simulation and Plot Temperature Field

- Click Analyse All to start the solver
- Upon completion, select the Flipchip - BGA package in 3D view
- Right-click → Plot Fields → Temperature → Temperature
- In Plot Settings:
    - Enable **Specify Name/Folder**
    - Choose **Plot on Surface Only**
    - Enable **Gaussian Smoothing** for clarity



Final Output

A complete thermal simulation of the Flipchip BGA package is successfully executed for a **1 W power input**, with the temperature distribution visualized over the package components.


Si-Typical
Flipchip_BGA1_die
CreateBox
Sheets
Source
Flipchip_BGA1_die_
CreateRectangle
CoverLines
Unassigned
Flipchip_BGA1_trac
CreateRectangle
CoverLines
Solids
Non Model
SubRegion
CreateSubRegion
air
Region
Temperature [cel]
Max: 137.647
140
128
116
104
92
80
68
56
44
32
20
Min: 20.014
Z
X
Ansys
2024 R2
STUDENT
0
5
10 (mm)