EIGHTEENTH ANNUAL
BiTS
TM
Burn-in & Test Strategies Workshop
March 5 - 8, 2017
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive – Session 7
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Session 7

Morten Jensen
Session Chair

BiTS Workshop 2017 Schedule

Solutions Day

Wednesday March 8 - 8:00 am

Teaming Up

"Applying FEA Simulation for Test Interface Unit"

Jason Koh - Test Tooling Solutions Group

"BI RHINO Handling Solution"

Yaniv Raz- Intel Corporation

"Optical Device Testing at Wafer Level and Package Devices"

Carl Kasinski – Aehr

"Fan-in WLCSP Test Requirements"

Mike Frazier - Mike Frazier

Applying FEA Simulation for Test Interface Unit

Jason Koh Shiann Chern
Test Tooling Solutions Group

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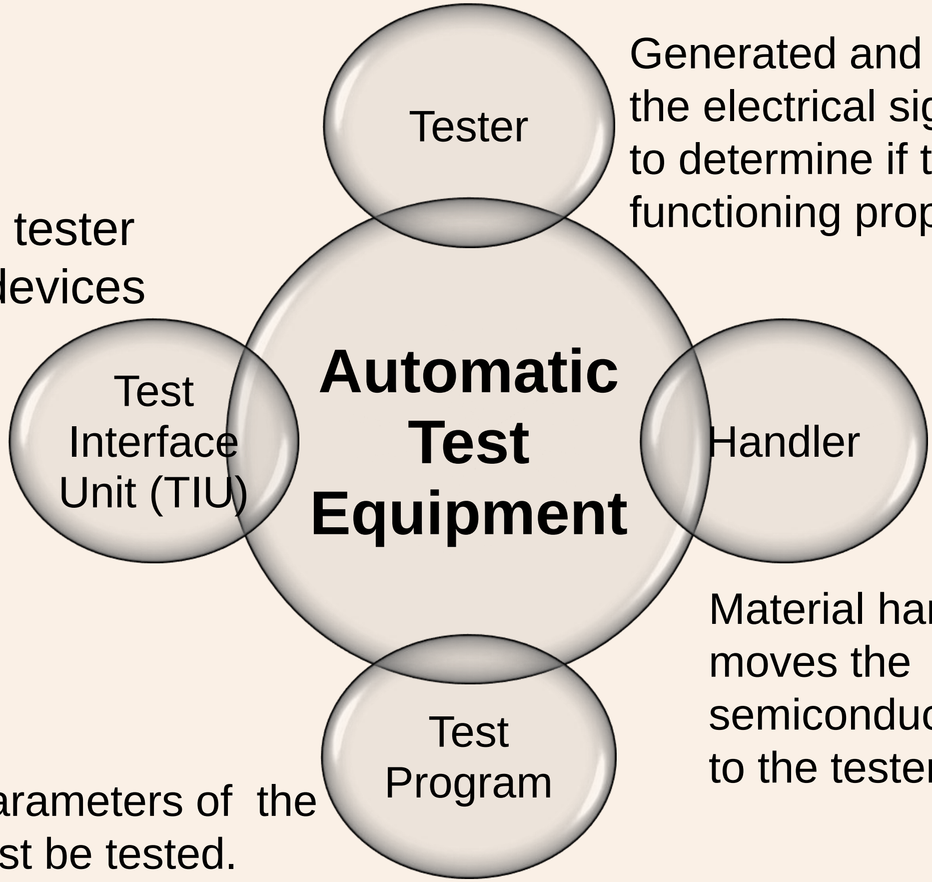
Contents

1. ATE & Test Interface Unit (TIU) Stack Up
2. TIU Challenges
3. TIU products that involved for FEA Simulation
4. Benefits and Challenges in FEA Simulation
5. FEA Simulation Process Flow
6. Test Socket Analysis & Example
7. Conclusions

Automatic Test Equipment (ATE)



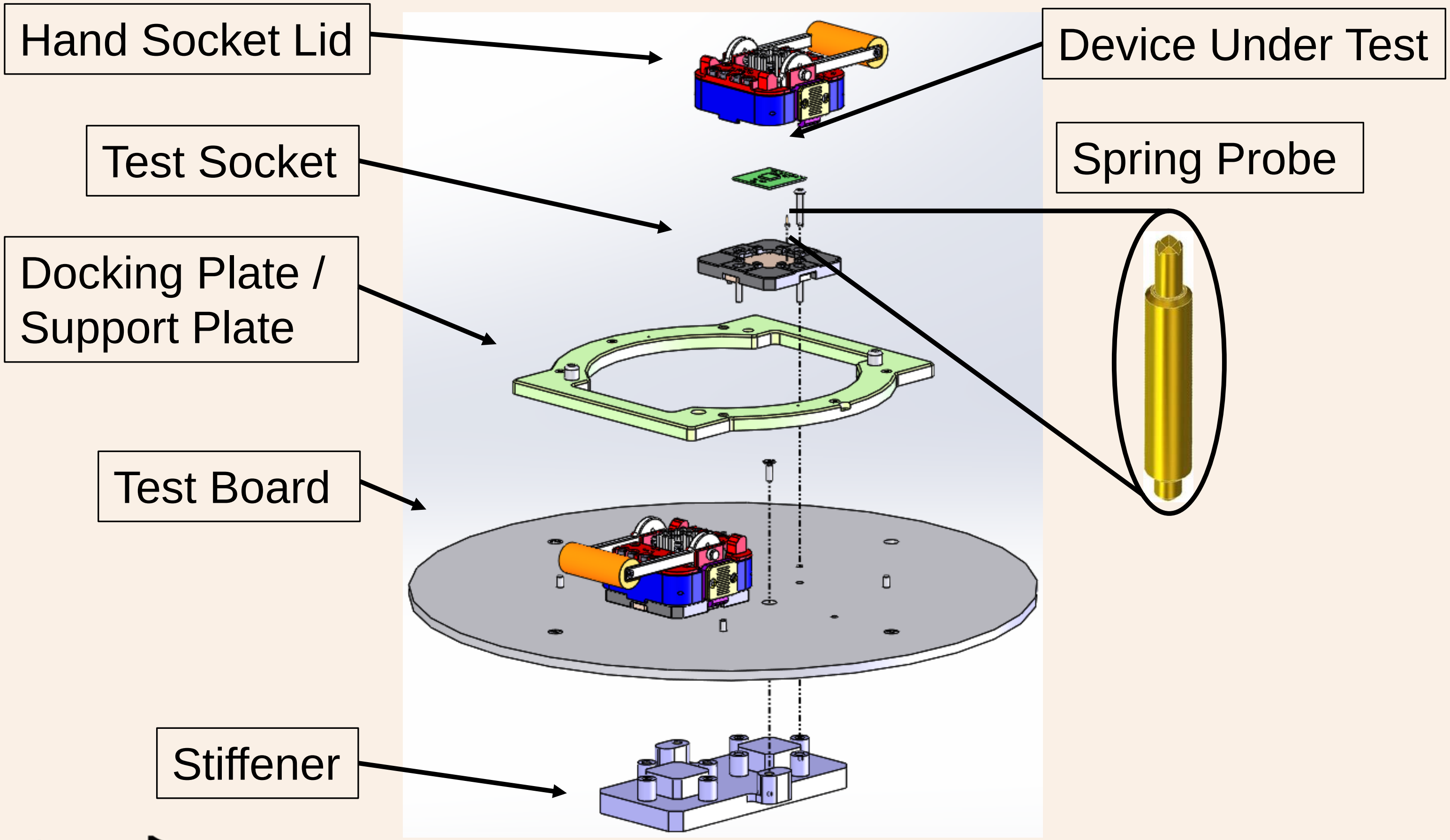
Generated and measured the electrical signals needed to determine if the device is functioning properly.

To allow the tester connect to devices under test.

Material handling moves the semiconductor devices to the tester.

Defined parameters of the device must be tested.

Thermal Interface Unit Stack Up (Manual Test)



Thermal Interface Unit Challenges

Challenges

- Narrow Pitch (<0.20mm)
- High pin count (4000++)
- High bandwidth, short pin requirement (Pin test height <2.0mm and below)
- High insertion force (TIU need to overcome100kgf)
- Time to market, Reliability and Cost

Impacts

- ➢ Spring probe diameter become more challenging.
- ➢ High warpage and high stress concentration on test socket.
- ➢ Thinner socket design potential to cause high deformation on socket body during preload stage.
- ➢ Hand socket lid, package, test socket, PCB and stiffener have structure stiffness concern.
- ➢ Product development cycle, factor of safety, material selection

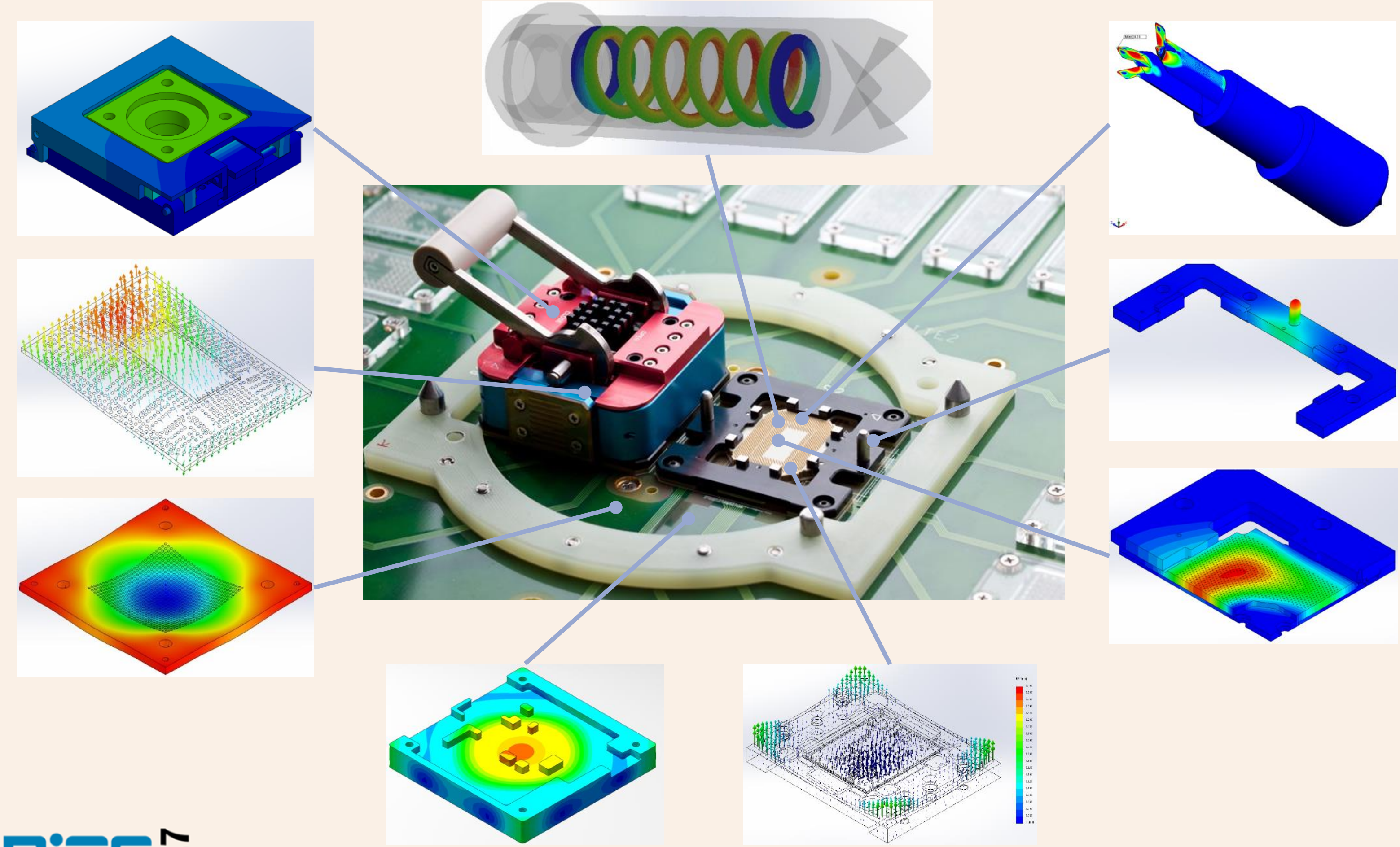
How to Approach New Challenges?

- Design something that worked in the past and made it bigger/smaller.
- Use spreadsheets or hand calculations
- Build and test prototypes
- Trial and error method

Or

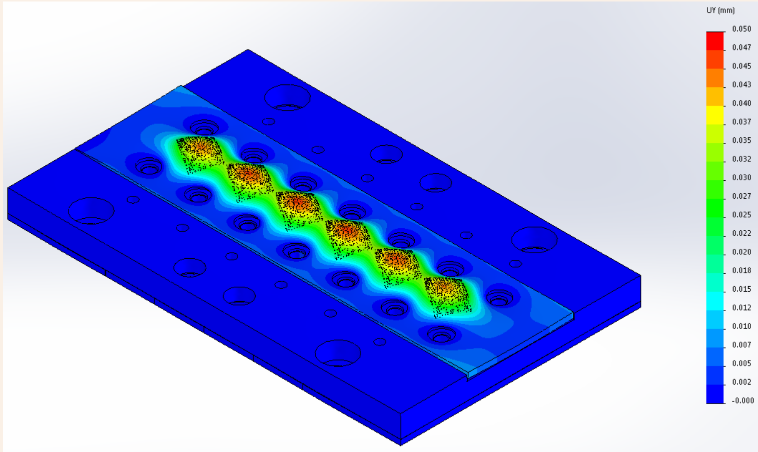
Utilize Finite Element Analysis method to solve your engineering problems

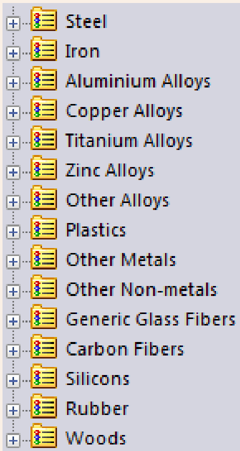
TIU Products that involved for FEA Simulation

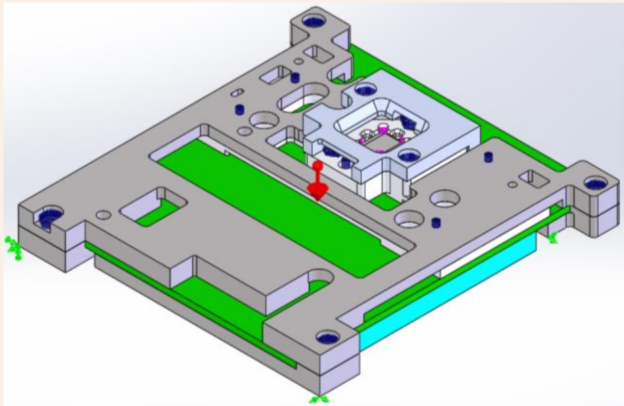


Benefits of FEA Simulation

- Solve a wide variety of engineering problems
- Can handle very complex geometry
- Useful for problem with complicated restrains and loading
- Analyze the impact of different material properties

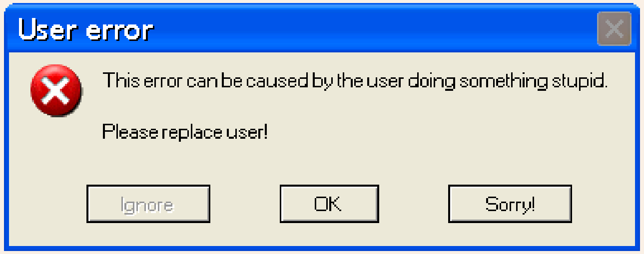




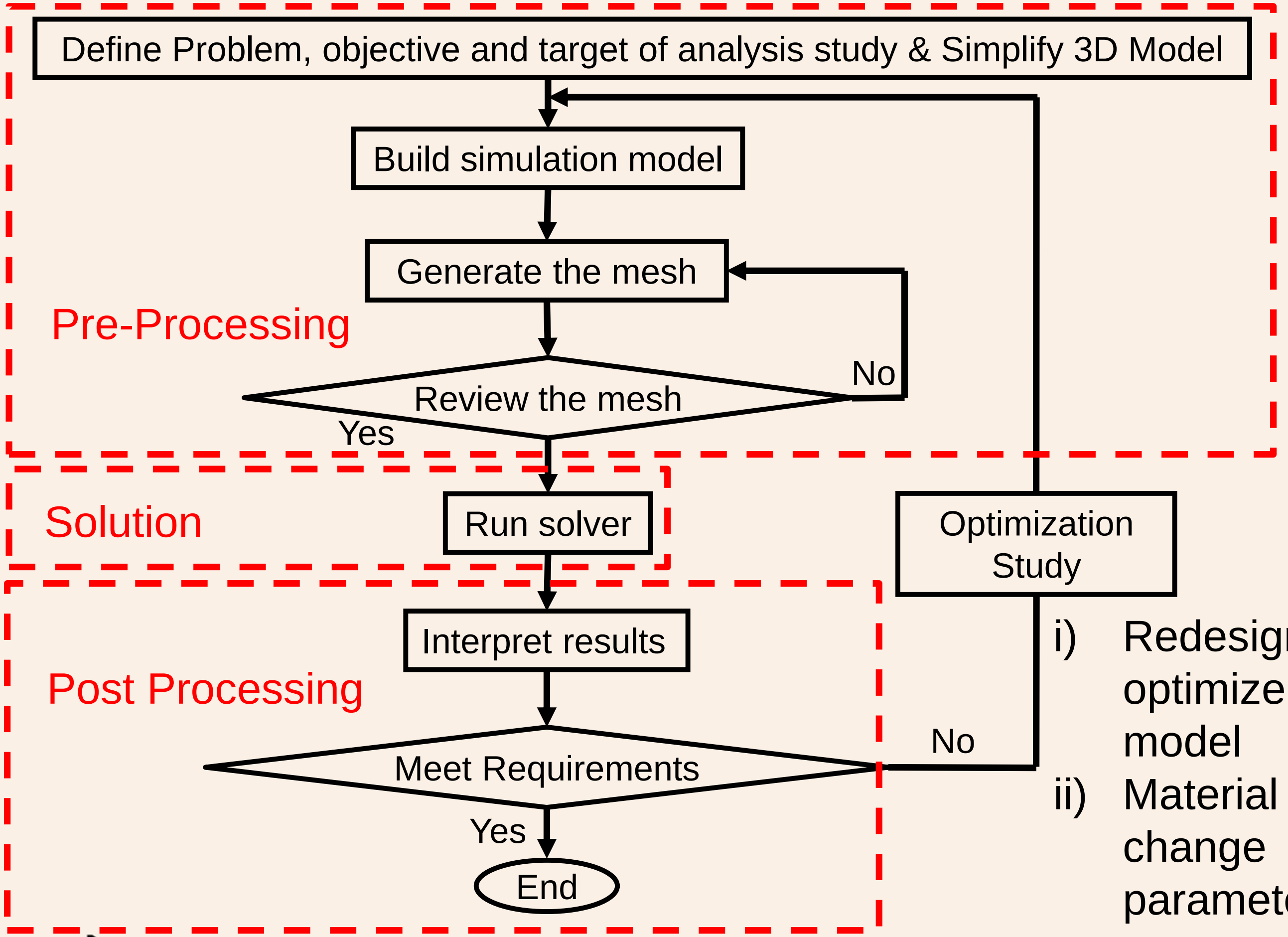


Challenge in FEA Simulation

- Simulation building requires experience and judgment in order to construct a good finite element model
- Simulation results may be difficult to interpret
- The simulation results provide "approximate" solutions
- The simulation has "inherent" errors
- Mistakes by users can be fatal



Typical FEA Process Flow Chart



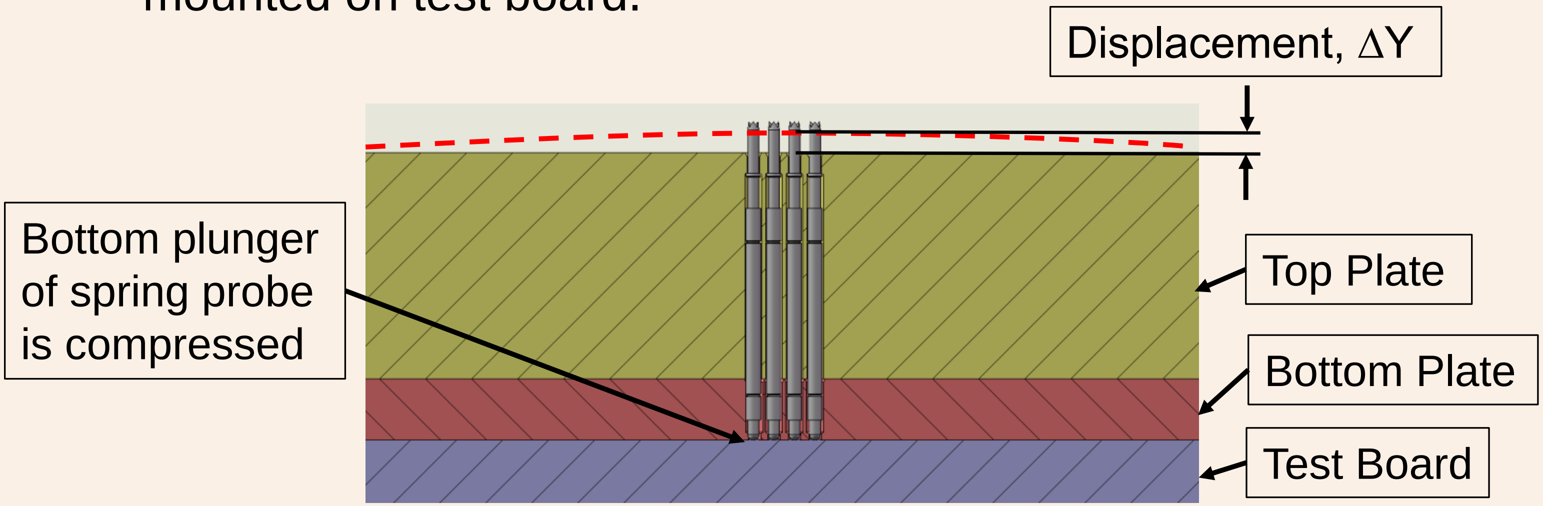
i) Redesign and optimize the model
ii) Material or change parameter study

Example Test Socket Warpage

Problem Statement:

i) Pin counts increase, stress and displacement on the test socket stiffness becomes a major concern.

ii) Stable electrical performance of spring probe, bottom plunger of spring probe is always compressed when test socket is mounted on test board.



Top Plate warpage by preload of spring probe on test board

Inputs for Analysis

Target

i) Less than 0.15mm for Top Plate coplanarity

ii) Material stress for factor of safety (FOS) at least or more than 2.0

Input

i) 3piece design, consist of Guide Plate (GP), Top Plate (TP) and Bottom Plate (BP)

ii) Spring Probe Preload 13gf

iii) Total 4352 pins counts

iv) Total preload acting on TP = 4352 * 0.013 kgf = 56.576kgf

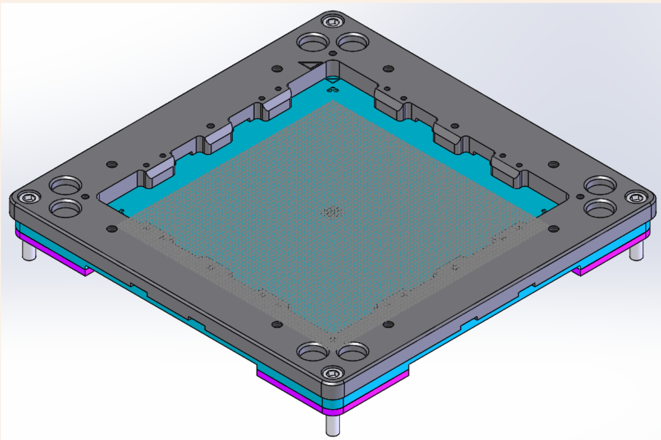
Type of Analysis

Linear Static FEA

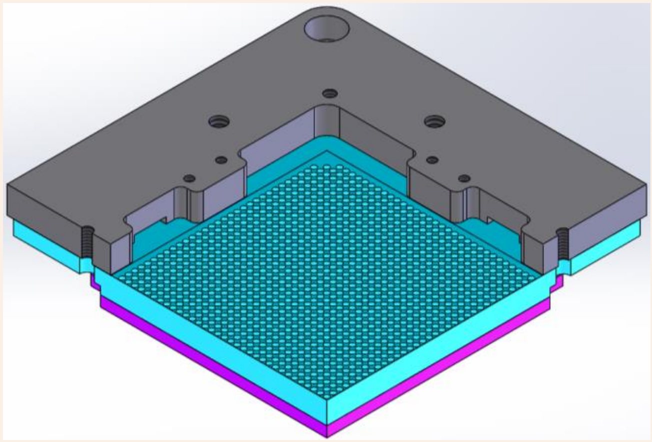
CAD Modelling for FEA

Guideline for 3D CAD Simplification

i) Remove outside corner chamfer and fillet.
ii) Remove small holes, slot and step cut outside the load path.
iii) Remove decorative and indication features
iv) Use of quarter of CAD model, if load and support are symmetry.



CAD Model



Simulation Model

Build Simulation Model

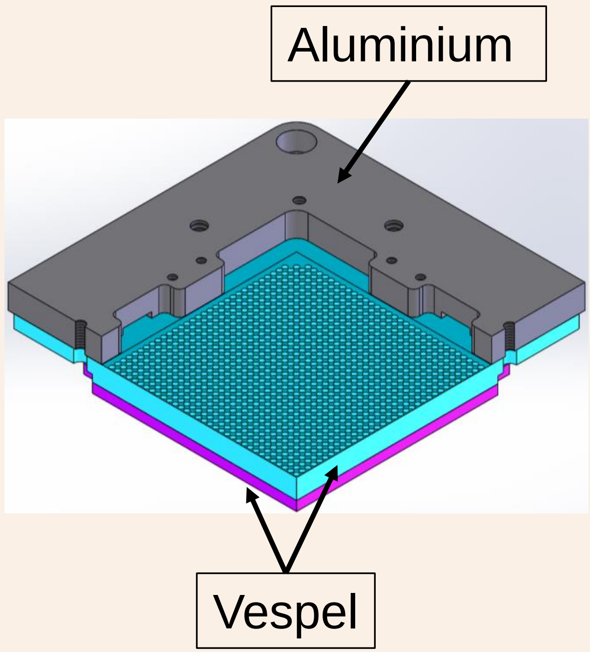
i) Assign Materials

Linear static FEA material property required are,

- Elastic Modulus, (E)
- Poisson's Ratio, (v)
- Shear Modulus, (G)

$$G = E / (2(1+v))$$

- Yield Strength (or Ultimate Strength)

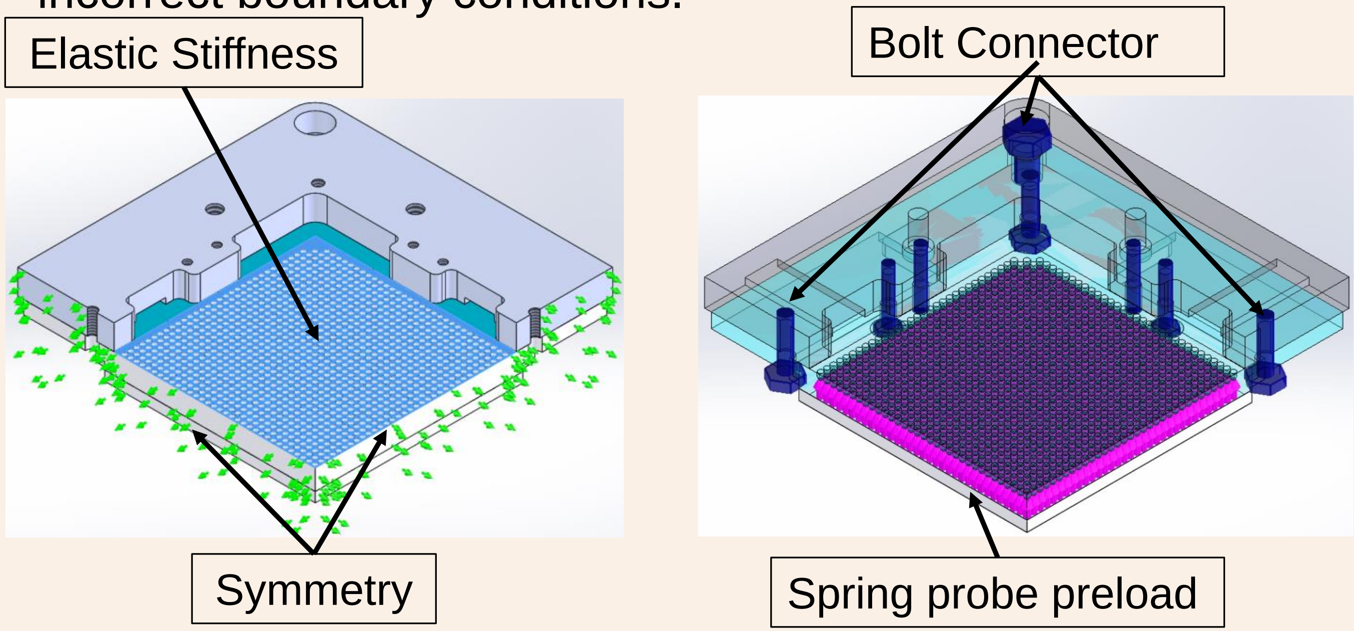


Material		Elasric Modulus GPa	Poisson's Ratio	Yield Strength MPa
GP	Aluminium	72.0	0.33	505
TP & BP	Vespel	4.0	0.41	155

Build Simulation Model

ii) Apply Boundary Conditions & Loads

- The choices of boundary conditions & external loadings have a direct impact on the overall accuracy of the model.
- Over-constrained model will cause stiff model due to apply incorrect boundary conditions.

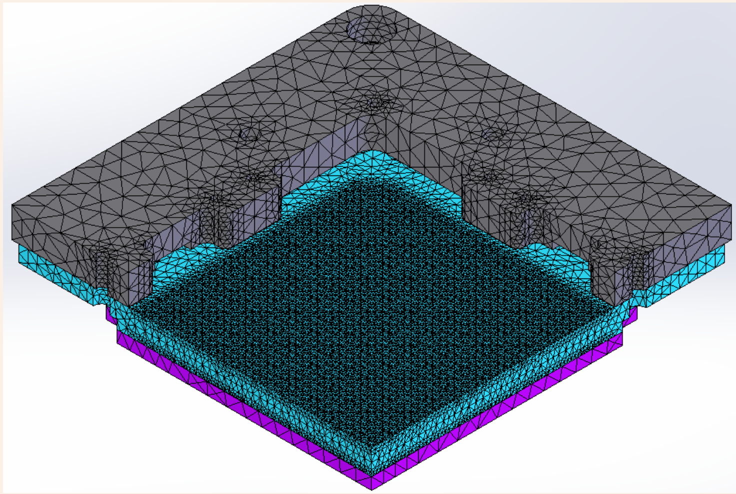


Build Finite Element Mesh

Generate & Review the Mesh Modelling

- Accuracy of the solution is primarily dependent on the quality of the mesh.
- Check the mesh quality (Aspect Ratio, Distortion Element)
- Apply mesh control on critical area

Study name	F (-Default-)
Mesh type	Solid Mesh
Mesher Used	Curvature based mesh
Jacobian points	4 points
Mesh Control	Defined
Max Element Size	2.8 mm
Min Element Size	0.56 mm
Mesh quality	High
Total nodes	1158482
Total elements	698528
Maximum Aspect Ratio	9.7947
Percentage of elements with Aspect Ratio < 3	92
Percentage of elements with Aspect Ratio > 10	0
% of distorted elements (Jacobian)	0
Remesh failed parts with incompatible mesh	Off
Time to complete mesh(hh:mm:ss)	00:01:24
Computer name	TTDMSIMULATION



Mesh View

FEA Solver

Run Solver

Factors when choose the proper solver

	Direct Sparse	Iterative
DOF over 1,000k		☺
Multiple Cores, More RAM, More Disk Space	☺	
Single parts or less assembly parts		☺
Assembly with lots of contact set	☺	
Analysis with No Penetration contacts	☺	
Mixed-mesh models	☺	
Models of parts with widely different material properties	☺	

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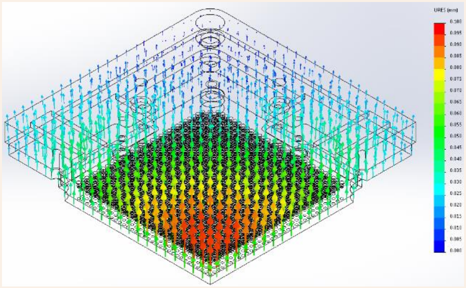
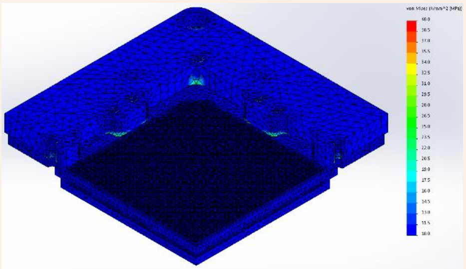
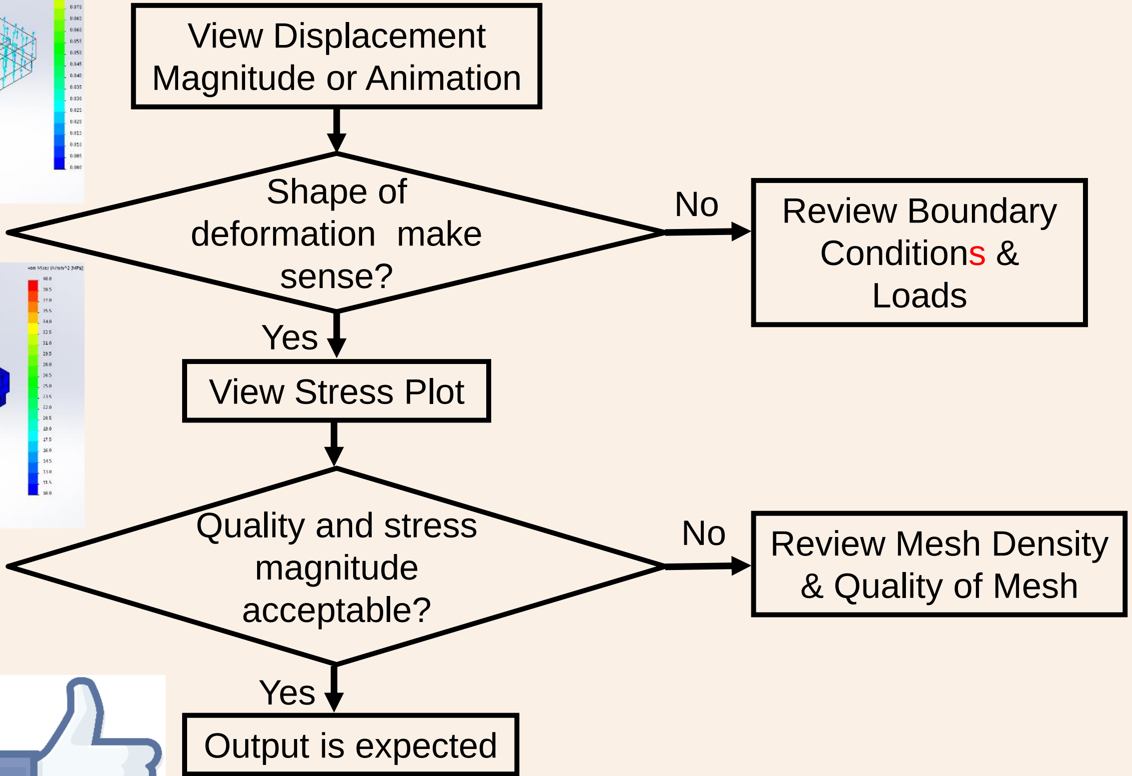
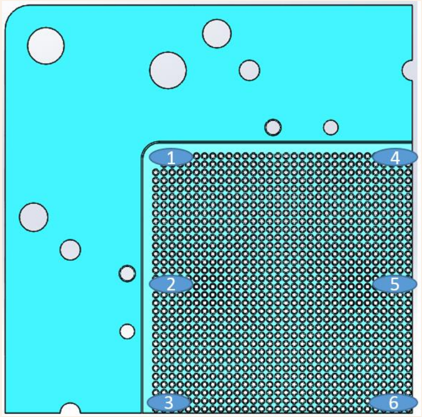
Analyzing the Simulation Results



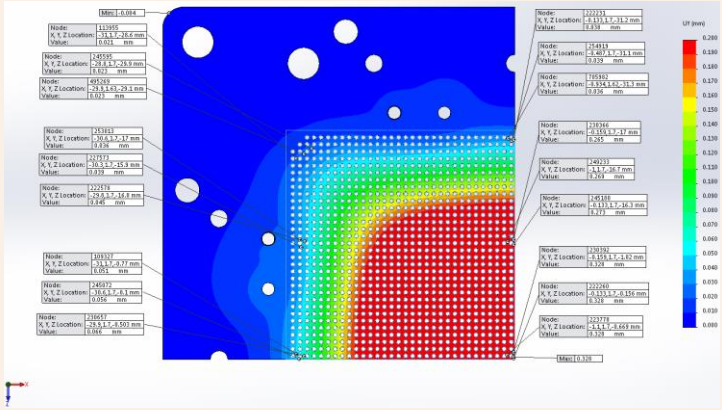




Physical & Virtual Correlation



Measurement Area



Probe Point from Simulation

Area	Measured Y-Displacement	FEA Results Y-Displacement	FEA vs Measured Δ Percentage, %
1	0.024	0.022	5.6
2	0.042	0.040	4.0
3	0.059	0.058	2.3
6	0.040	0.038	5.8
7	0.248	0.269	8.5
8	0.312	0.328	5.1

A good correlation between simulation and measured deformed of test socket.

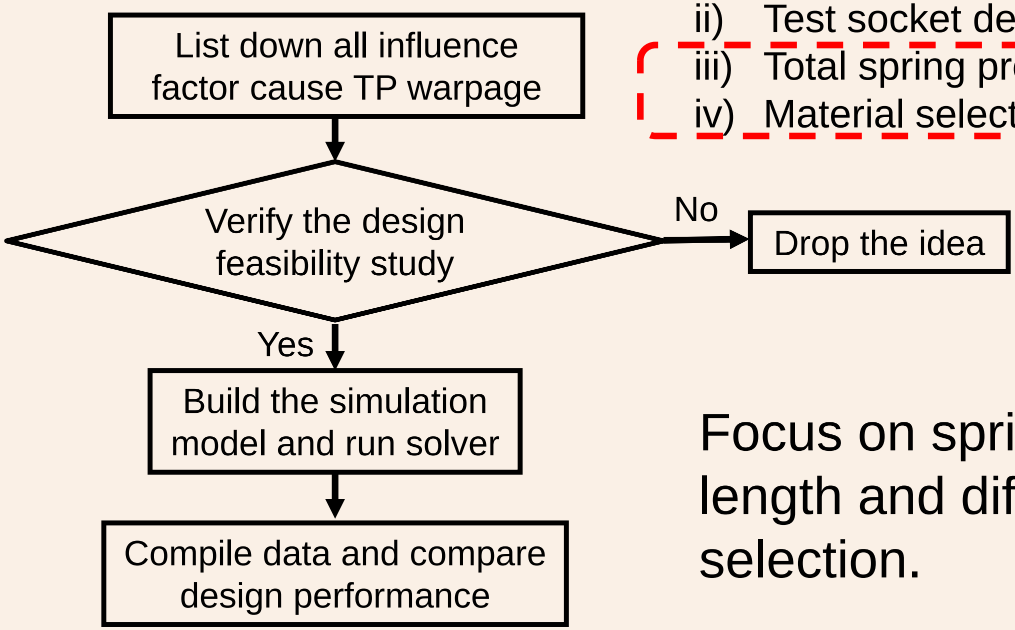
Meet Requirement?

4352L-BGA	DOE1
Pin Length, mm	3.00
Total Pin Preload (kgf)	56.576
Material (GP)	Aluminium
Material (TP & BP)	Vespel
Max Y-Displacement (TP) (mm)	0.328
Max Von Mises Stress (TP) (MPa)	67.0
Factor of Safety (TP)	2.31

- Target 0.150mm for TP coplanarity
- Maximum displacement from simulation 0.328mm
- Unstable electrical spring probe performance cause by high warpage
- TP material stiffness is not enough
- Thin TP thickness cannot withstand high pin force
- Improvement study is required

Optimization Study

i) Total spring probe force
ii) Test socket design
iii) Total spring probe length
iv) Material selection



Focus on spring probe length and different material selection.

Optimization Study

4352L-BGA	DOE1	DOE2	DOE3	DOE4	DOE5
Pin Length, mm	3.00	4.70	5.70	5.70	5.70
Total Pin Preload (kgf)	56.576	56.576	56.576	56.576	56.576
Material (GP) & Elastic Modulus	Aluminium, 72 GPa	Aluminium, 72 GPa	Aluminium, 72 GPa	Aluminium, 72 GPa	Stainless Steel, 190 GPa
Material (TP & BP) & Elastic Modulus	Vespel, 4 GPa	Vespel, 4 GPa	Vespel, 4 GPa	Torlon, 14.6 GPa	Torlon, 14.6 GPa
Max Y-Displacement (TP) (mm)	0.328	0.250	0.189	0.107	0.093
Max Von Mises Stress (TP) (MPa)	67.0	64.5	64.4	65.1	63.5
Factor of Safety (TP)	2.31	2.40	2.41	2.64	2.71

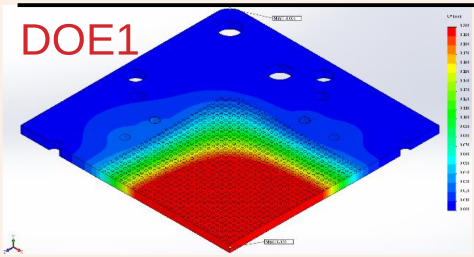
↑ Pin length (DOE1 -> DOE 2 -> DOE3)

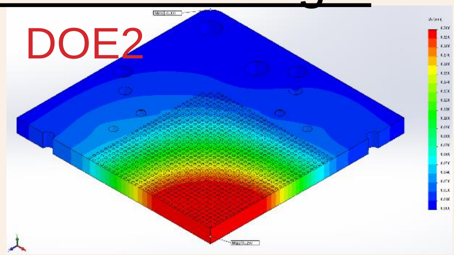
↑ High stiffness material applied on socket body (DOE 3 -> DOE4-> DOE5)

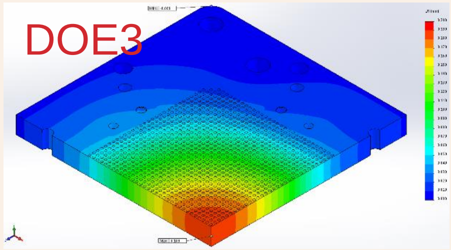
↓ Maximum Y-Displacement

Optimization Study

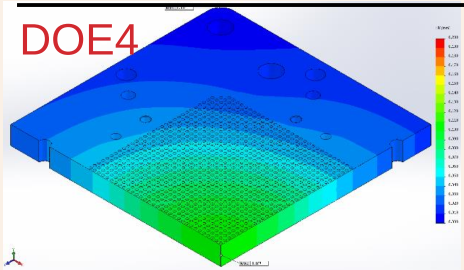
Simulation model failed to meet target

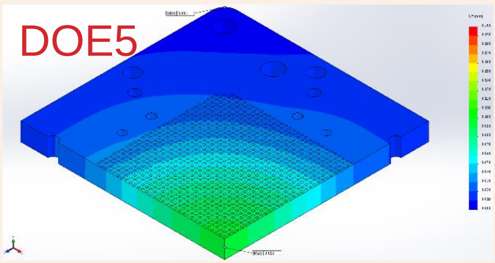


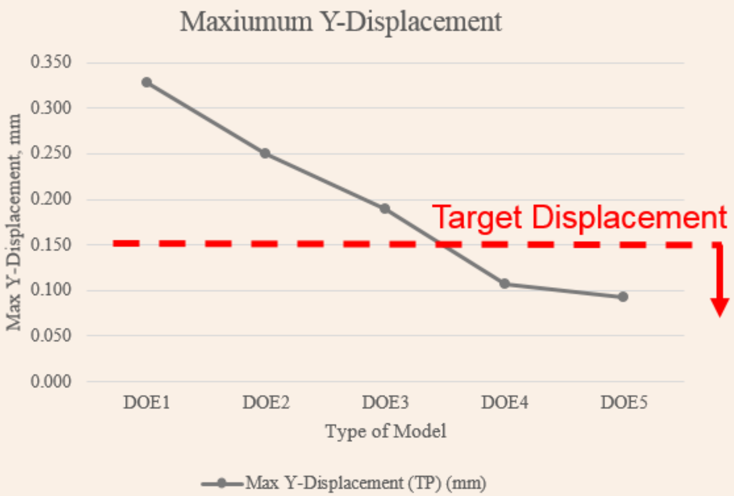




Simulation model meet target







Conclusions

- FEA simulation help engineers filter out potential risk and gain a much broader picture for better decisions making.
- Training is required and the opportunity to practice extensively.
- Comparing simulation results with physical data if possible.
- Finite Element Analysis make a good engineer great, and make a bad engineer dangerous.
- "Garbage in = Garbage Out" - magic box dilemma