PCBA Flexural Fatigue Life Evaluation

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PCBA Flexural Fatigue Life Analysis

Test Objective
• To evaluate PCB fatigue life under bending loads
• To quantify the effect of board modulus and thickness on fatigue life

Methodology
• Step 1: Geometry and Material Properties
• Step 2: Loads and Boundary Conditions
• Step 3: FEA Result
• Step 4: Verification of FEA simulation with Test Data
• Step 5: Fatigue Life Estimation Result
• Step 6: Design Parametric Study
• Case Study Benefits
Step 1: Geometric Model & Material Properties

- Structure Dimensions
  \[ L : W : T = 142.7 : 87.9 : 1.64 \text{ (mm)} \]

- Material Properties for elastic model
  Young’s Modulus: 3.5 GPa
  Poisson’s Ratio = 0.34
Step 2: Loads & Boundary Conditions

Boundary constraints: $X=Y=Z=0$
Step 3: FEA Results

Displacement Plot at Z axis

Strain Contour Plot

Von Mises Stress
Step 4: Verification of FEA simulation with Test Data

Test Setup

Comparison of Force-Displacement Data

Load Displacement Curve

Variation of PCBA Strain with Applied Force

Calibrating Experimental and FEA Strain Data
Step 5: Fatigue Life Estimation

Fatigue Model: \[ \varepsilon = \frac{\sigma_f}{E} \left( N_f \right)^b \]

- \( \varepsilon \) = elastic strain amplitude
- \( \sigma_f \) = fatigue strength coefficient
- \( N_f \) = Cycles to failure
- \( b \) = fatigue strength exponent
- \( E \) = Young’s modulus

Fatigue exponent and coefficient are material properties and related to flexural strength and endurance limit.
Step 6: Design Parametric Study

Effect of PCBA Thickness on Flexural Fatigue

Fatigue life change with thickness change

- PCBA fatigue life deceased significantly when the thickness decreased to half. Reducing thickness was not acceptable for the current design.

- PCBA fatigue life increased with the increasing board modulus. Choosing stiffer PCBA board was a viable alternative for the next design revision.

Effect of PCBA Young’s Modulus on Flexural Fatigue

Fatigue life change with Young’s Modulus change
A similar quick turnaround test-analysis-prediction methodology can be useful for:

- Supplier qualification: Comparison of PCBA quality for multiple vendors
- Specification testing: Industry PCBA standard test (JEDEC 3 Pt. bend, IPC etc.)
- Design Limit Evaluation: Time independent step stress test to failure
- Design Sensitivity Analysis: Virtually quantify effects of material and geometry changes on product durability
- Develop Accelerated life tests: determine fatigue test limits for computing acceleration factors for relevant failure mechanisms