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Modeling Investigation on the Relationship between Solder Joint Reliability and Die-to-Package Ratio

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Keywords— *Solder joint reliability; solder life; thermal cycling; die-to-package ratio; finite element modeling.*

I. OVERVIEW

- With the requirement to increase semiconductor package functionality, larger die is being forced to fit in a smaller package footprint and this results in higher die-to-package ratio.
- Fig. 1 shows a QFN (quad flat no lead) package mounted on PCB or printed circuit board.
- Die-to-package ratio (DPR) is defined as the ratio between the integrated circuit (IC) die size, Ld, and the package size, Lp.

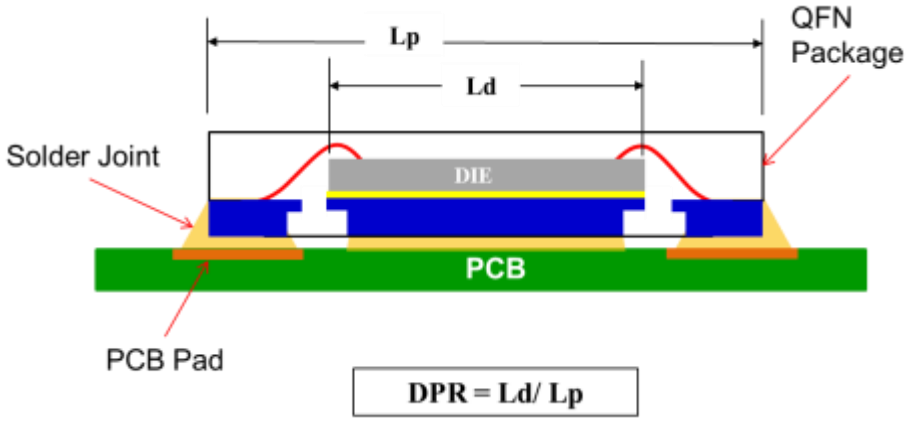

Fig. 1. Die-to-package ratio of a QFN package mounted on PCB.

II. PROBLEM IDENTIFICATION

- Thermal cycling of a board-mounted QFN package usually results in solder joint crack after certain number of cycles as shown in Fig. 2 and this is due to the package materials and PCB having different CTEs (coefficients of thermal expansion).
- Since the direction in package miniaturization is going towards higher die-to-package ratio, there is a need to establish the relationship between solder joint life and die-to-package ratio (DPR).

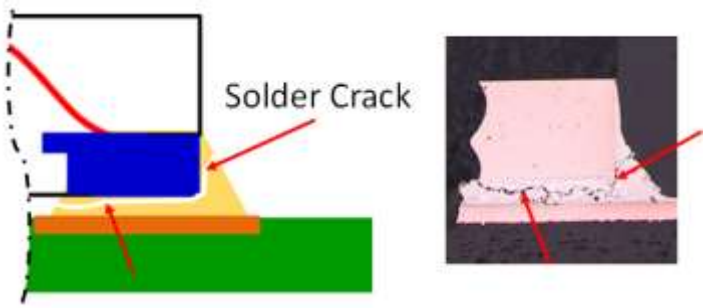

Fig. 2. Solder joint crack after certain number of thermal cycles.

III. SOLDER JOINT RELIABILITY MODELING

- Solder joint reliability modeling was performed to study the relationship between solder joint reliability and die-to-package ratio.
- Different die-to-package ratios were modeled and analyzed.
- Finite element modeling technique was used in the analysis as shown in Fig. 3.

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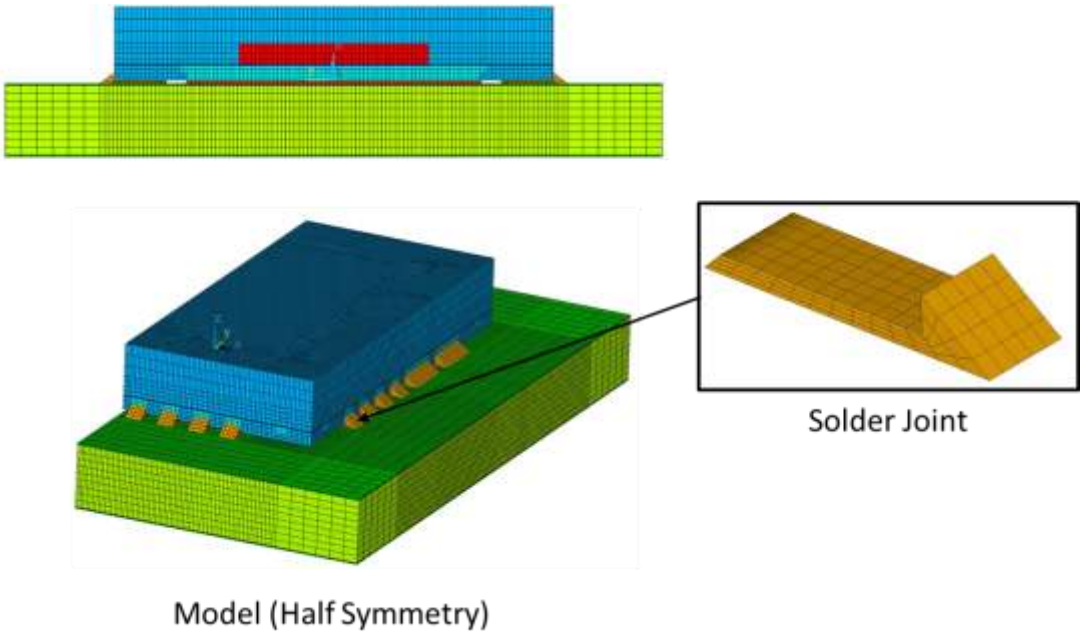

Fig. 3. Finite element model of the QFN package used in the solder joint reliability analysis.

IV. Results and Discussion

- Based on the results shown in Fig. 4, the critical solder joint turns out to be the joint adjacent to the dummy joint at the package corner.
- The solder life was calculated using a volume-averaged technique to get the accumulated creep strain energy density per cycle for the solder material interface layer.

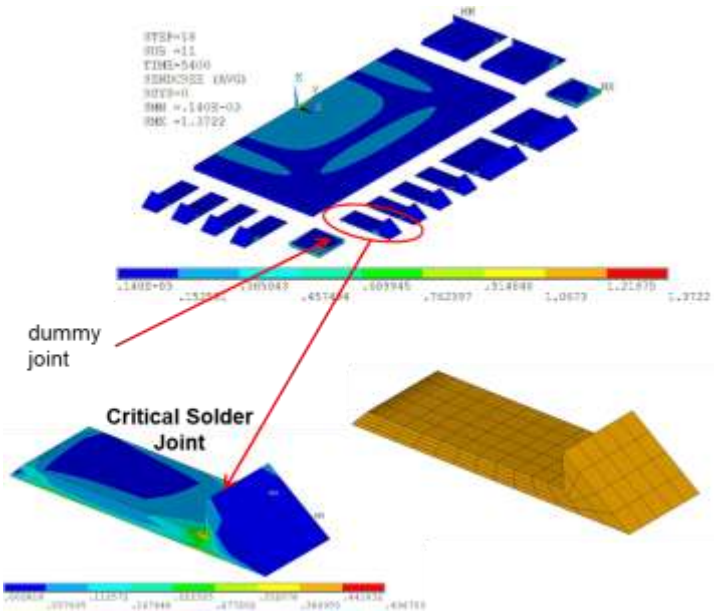

Fig. 4. Creep strain energy modeling result used to predict thermal cycling solder joint life.

- Solder joint life tends to increase with decreasing die-to-package ratio as shown in Fig. 5.
- The result clearly indicates the following:
  - The smaller the die (lower die-to-package ratio) the higher the solder life.
  - Using larger die would provide more functionality but has an impact on solder life.
- With the relationship between solder life and die-to-package ratio established for a specific board-mounted QFN package, the solder life could now be predicted easily for a given die-to-package ratio.

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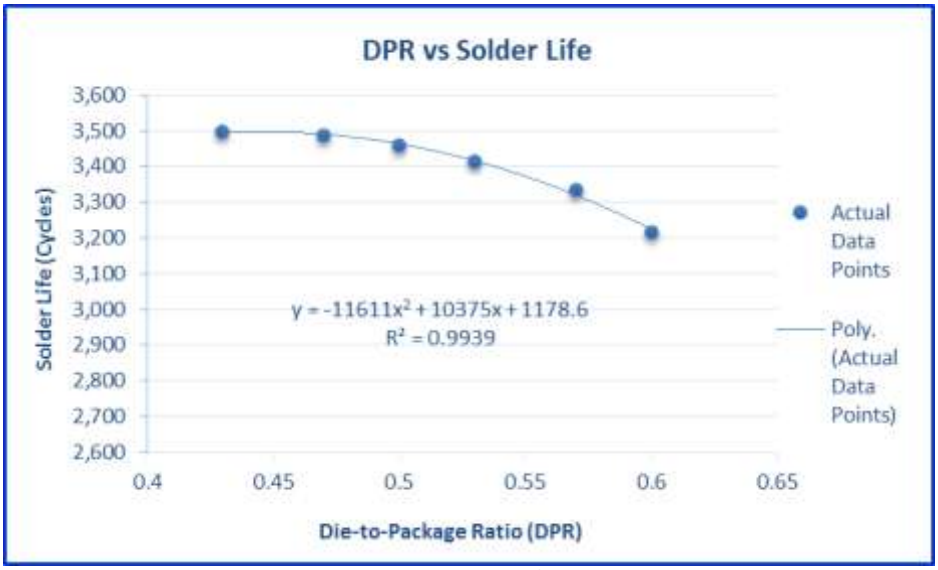

Fig. 5. Relationship between solder joint life and die-to-package ratio.

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