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A Study on the Impact of Solder Voids on the Solder Joint Reliability of a QFN Package

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I. Overview

- A QFN (quad flat no lead) package is usually mounted to the PCB (printed circuit board) using solder material to establish electrical and mechanical connection as illustrated in Fig. 1.
- To ensure the reliability of solder joint, the board-mounted package is subjected to thermal cycling and the solder joint connection is monitored to determine the number of thermal cycles before failure (solder joint life).

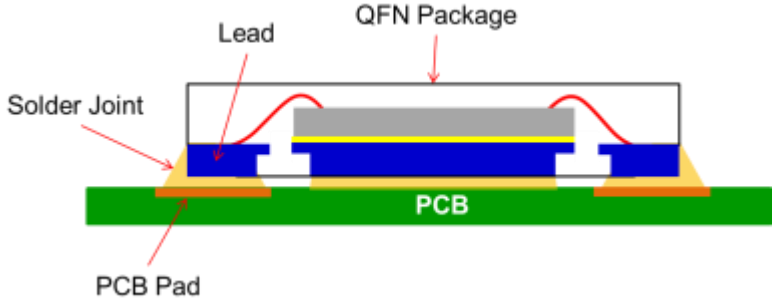

Fig. 1. Schematic of a QFN package mounted on PCB.

II. Problem Identification

- During thermal cycling of a board-mounted QFN package, the common failure is solder joint crack as shown in Fig. 2.
- Solder joint crack could not be avoided after a certain number of thermal cycles but it should not be an issue as long as the required number of cycles is achieved before solder joint connection fails.
- Another concern is that solder voids are usually present in the solder joint connection after solder joint reflow and its impact on solder joint reliability needs to be determined.

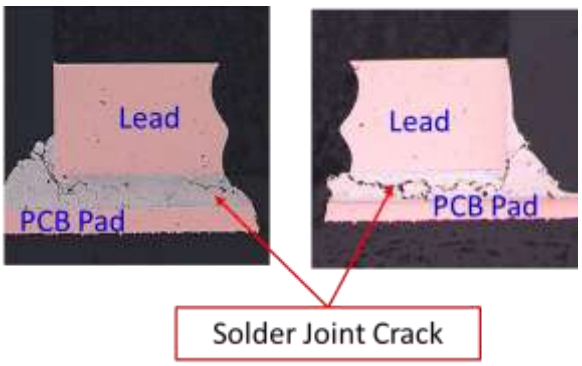

Fig. 2. Solder joint crack after certain number of thermal cycles.

III. Solder Joint Reliability Modeling

- To study the impact of solder voids on solder joint reliability, a finite element modeling was performed.
- Fig. 3 shows the finite element model used for the solder joint reliability modeling.
- The percentage of solder voids was varied in order to establish the relationship between solder voids and solder joint life.

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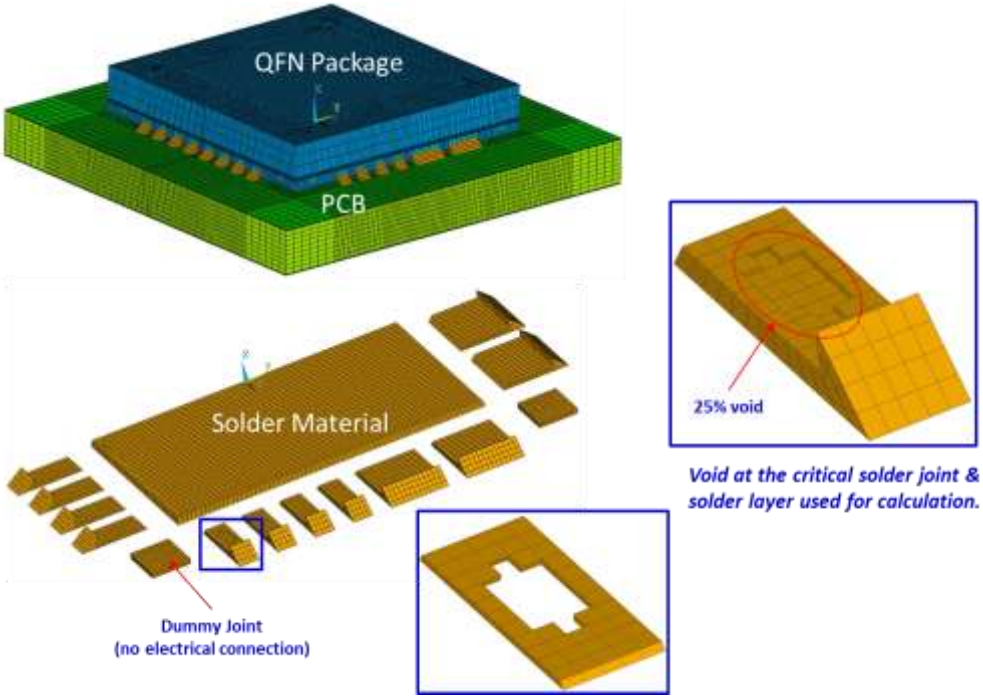

Fig. 3. Finite element model of the QFN package with solder voids.

IV. Results and Discussion

- With solder joint reliability modeling, the solder life is calculated using the creep strain energy density result as shown in Fig. 4.
- In order to predict the solder life, the critical solder joint was identified.
- The critical solder joint is an active joint that is expected to fail earlier than the other electrically connected joints and is selected for life cycle prediction.
- A volume-averaged technique was implemented to get the accumulated creep strain energy density per cycle for the solder material interface layer.
- 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.

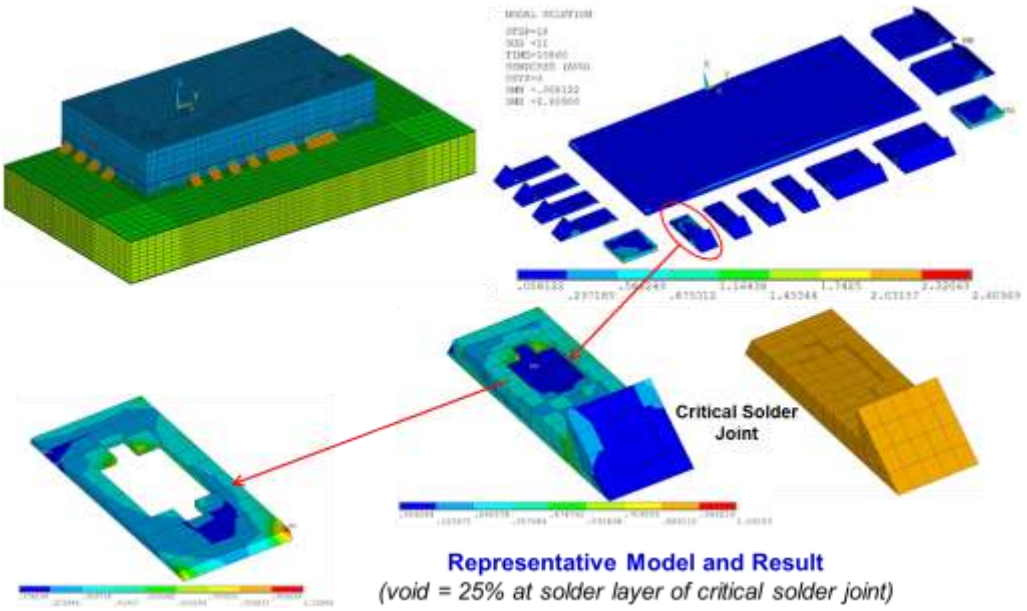

Fig. 4. Creep strain energy modeling result used to predict thermal cycling solder joint life.

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- As shown in Fig. 5, a 25% solder void when located at the critical solder joint would reduce the solder life by ~31%.
- Results clearly indicate that smaller solder void percentage would result in higher solder life.
- So the solder voids must be minimized through reflow process optimization and other void reduction methods in order to achieve higher solder life.
- Solder voids must also be avoided in critical solder joints.

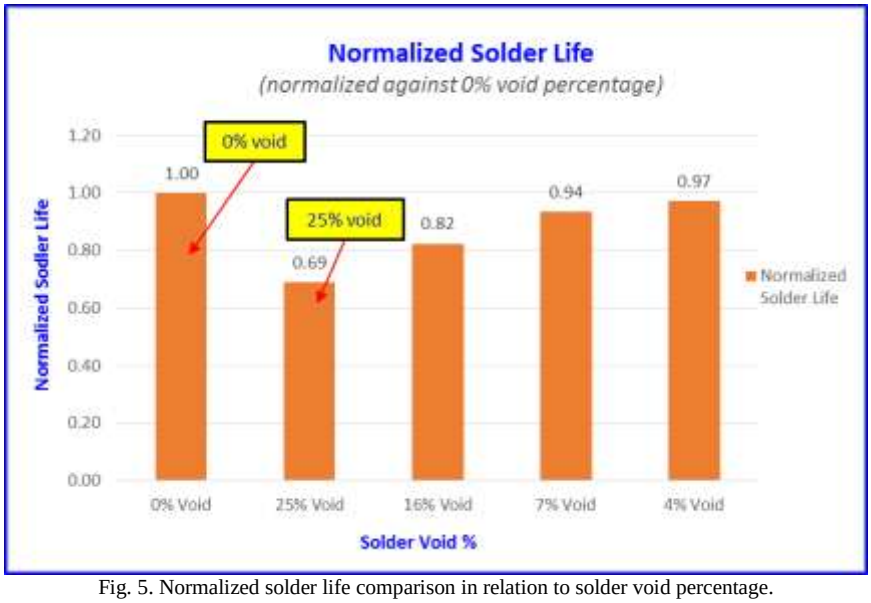

Fig. 5. Normalized solder life comparison in relation to solder void percentage.

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