The Effect of Solder Paste Volume on Chip Resistor Solder Joint Fatigue Life

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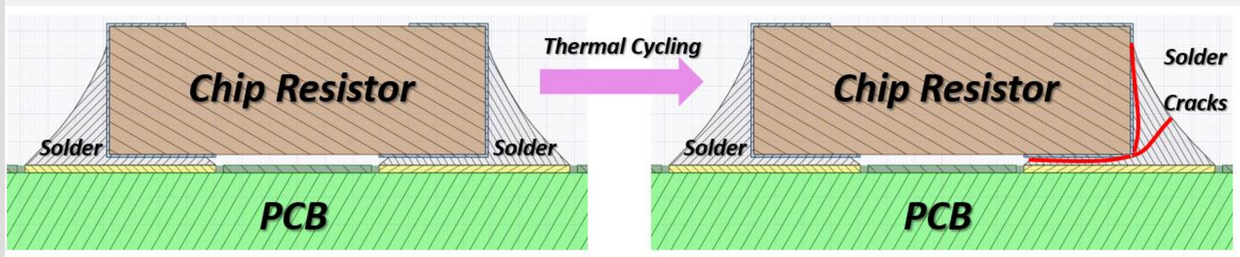
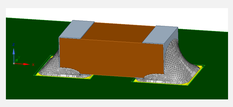
Background

- Board level reliability under temperature cycling
- Solder joint fatigue develops due to CTE mismatch

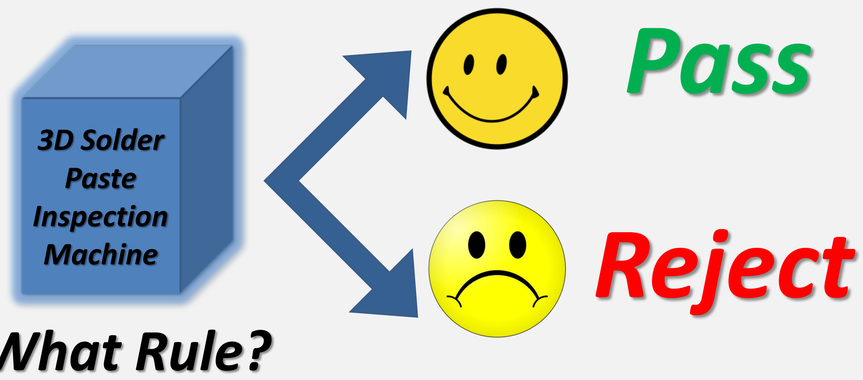


Objectives

- 3D solder paste inspection machine is used to inspect each solder joint shape & volume
- Define rules for inspection machine to screen out unreliable components
- Establish correlation between solder paste volume and solder joint fatigue life

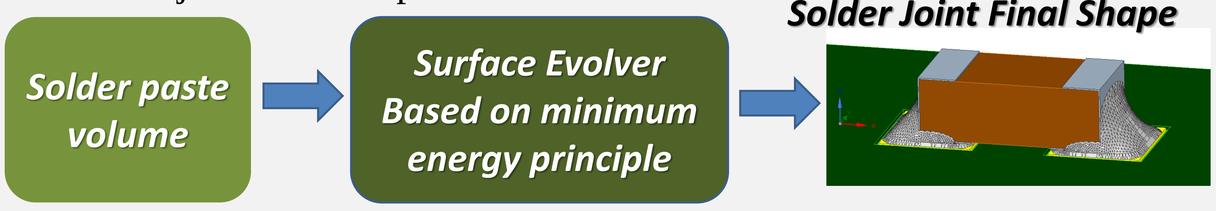


Chip Resistor Assembly



Methodology

- Solder joint final shape?



- Solder joint fatigue life prediction?

- Darveaus's model

Cycles to Crack Initiation: $N_o = K1(\Delta W_{\text{ave}})^{K2}$

measurement

Crack Growth Rate: $\frac{da}{dN} = K3(\Delta W_{\text{ave}})^{K4}$

Characteristic life

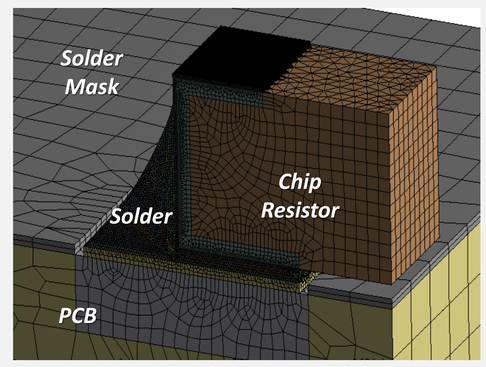
$$N = N_0 + \frac{a_{final}}{da/dN}$$

a is crack growth length, N is cycle number, $K_1 \sim K_4$ are constants.

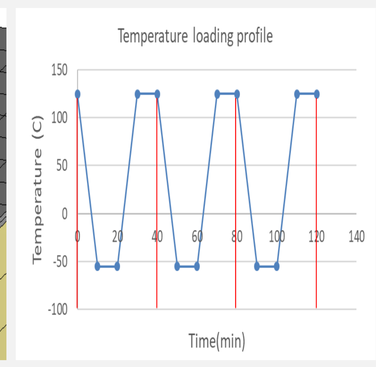
Finite Element Modeling

- Design of experiment
  - Different amount of solder paste volume is applied on each side of the chip resistor
  - 100% is set as standard volume, 50% and 150% are also used

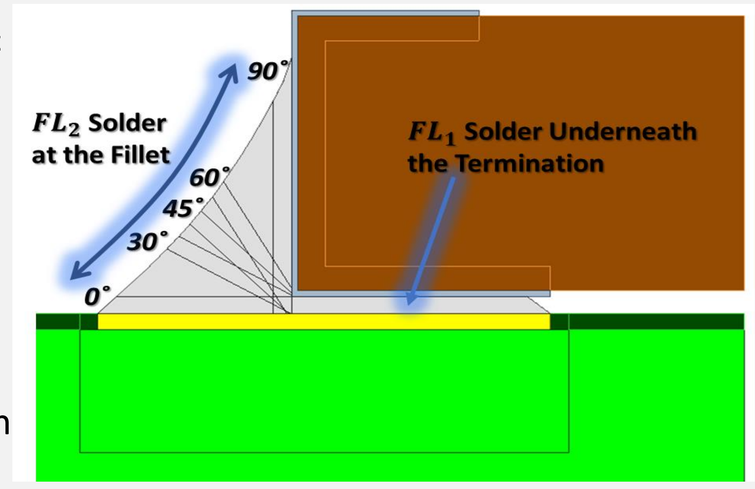
- Boundary condition: Quarter or half symmetry model for the chip resistor assembly
- Load: Free thermal expansion under thermal cycling



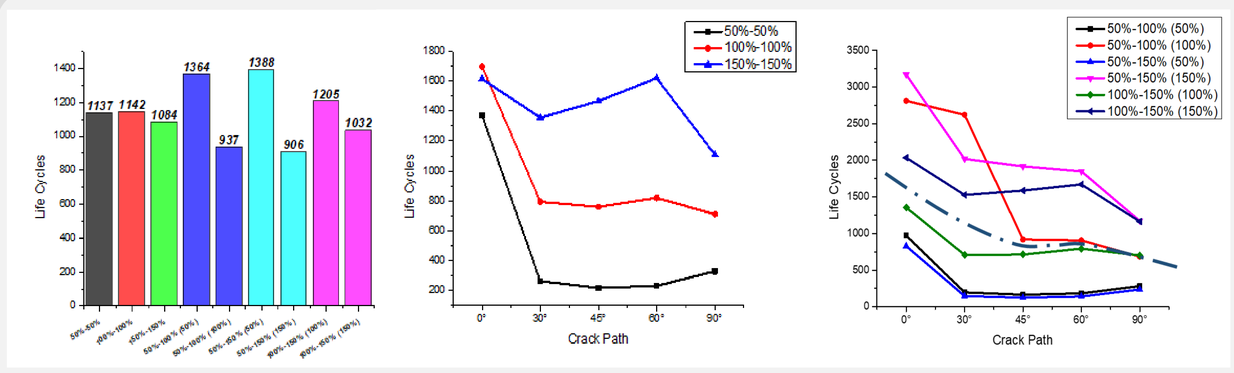
Finite Element Model



- Volumes for average plastic work calculation
  - Solder underneath the termination fatigue is calculated as FL_1
  - Remove the underneath portion solder and run thermal cycles again to calculate the fillet portion fatigue life FL_2



Results

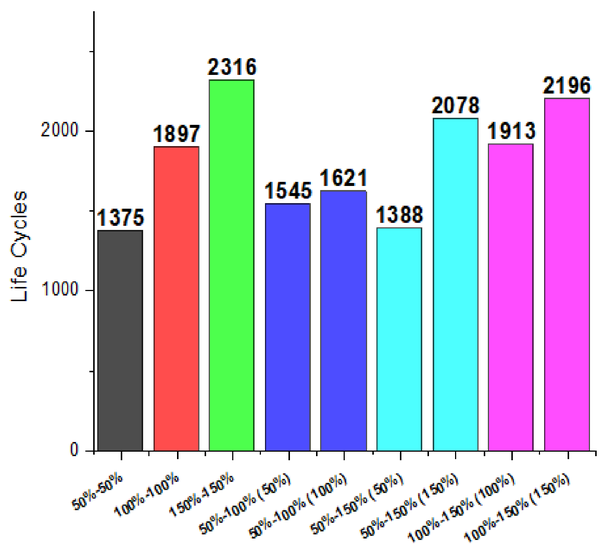


Life cycles for solder underneath the termination

Life cycles for balanced model fillet solder

Life cycles for unbalanced model fillet solder

- The balanced model has similar FL_1 despite the different solder volume
- The unbalance model always has higher FL_1 on the less solder side
- All cases are not likely to crack through the 0˚ path at the fillet portion
- Less solder always lead to a less FL_2 due to short crack path length
- **Total solder fatigue life**



- For the balanced model, the solder fatigue life increases as the applied solder volume increases
- For the unbalanced model, the less solder side always has a higher crack risk, and its fatigue life is determined by the less solder side solder volume

Conclusion

- For the balance model, the solder joint fatigue life increase as an increasement of the solder volume
- For the unbalanced solder volume cases, the crack happens at the less solder side.
- Unbalance solder volume cases have less solder fatigue life than the balanced cases.
- Severe unbalance cases should be avoided.
- Thermal cycling on actual chip resistor will be conducted to confirm the simulation prediction.

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