DfR Solutions
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Case Study

Supplier Intervention – Flex Circuit

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Situation

A DfR customer recently requested a supplier intervention. Extremely low yields at a contract manufacturer was leading to unacceptable delays in maintaining supplies in the field and was preventing the OEM from initiating numerous projects, causing severe financial hardship. Numerous problems were identified, including

- Excessive solder balling (numerous components and site)
- Frequent tombstoning
- Solder joint degradation on large components during the second reflow process

On short notice, DfR dispatched two experts for an onsite assessment of the current contract manufacturer and a capability review of a potential alternate contract manufacturer. DfR immediately identified several opportunities for improvement at the contract manufacturer. The production question was assembled on a flex circuit.

For solder balling, DfR identified solder paste printing off the bond pads and excessive solder paste on the bond pads were identified as the primary drivers. For corrective actions, DfR recommended revising the stencil design to improve registration and reduce aperture size. Specifically, the contract manufacturer was asked to position paste 50um (~2 mils) inside of each side and inside edge of pads. Note: this recommendation was based on the assumption that the inside edges of pads were correctly designed to be 5-10 mils beyond inside edges of component metallization

For tombstoning, DfR educated the OEM and CM that small parts have less loading mass and cylindrical MELF Packages provide less "Part to Board" adhesion force than rectangular parts. As a result, these parts can be overwhelmed by unbalanced end surface tension forces if one side melts before the other or if there is offset placement. To help ensure that both sides go liquid at the same time, DfR recommended using a ramp-hold-ramp profile instead of current continuous ramp soldering profile. Specific reflow parameters in terms of time and temperature were provided to the contract manufacturer. DfR personnel remained onsite through several iterations until tombstoning was eliminated. In addition, DfR recommend calibration on pick and place equipment to improve placement offset.

Solder joint degradation was being driven by the subjecting a large mass component to two reflows. During the second reflow, gravity over comes liquid solder's hydrostatic forces to pull the solder away from the pad. In addition, the large mass of solder being applied for soldering purposes (stencil + syringe) was also playing a role. The value of the syringe was questionable as the paste was being applied on the sides of the component, not under the component where it was needed. Instead of a syringe, DfR recommended considering a solder perform as an alternate method for applying additional solder under the part.

After the onsite review, DfR personnel reviewed their notes and discussions with the OEM and CMs and made the following recommendations. The unique capability of DfR was in not only identifying manufacturing issues, but also providing the OEM with a list of design for manufacturability (DfM) changes that needed to be made to the product to make it more sourceable and less sensitive to process variations.

Immediate Process Improvements for Current Design

- Evaluate reversing the build order to resolve solder degradation under the large component
- Continue to optimize the Ramp-Hold-Ramp Soldering Profile for Yield improvements.
- Continue to optimize the stencil design for yield improvement.
- Enhance documentation of the manufacturing process
    - Include the rational of what each feature does or why a process step is required so that the consequences/risks of future revisions can be anticipated in advance.
    - Keep process documented up to date with any changes to the baseline procedure.
- During a new product launch establish weekly information exchange meeting between the CM and OEM on first pass yield, Pareto of assembly defects and corrective action investigation and implementation activities.
- After new product launch, during continuous production, establish monthly or quarterly reviews of manufacturing yield, field feedback and corrective actions to improve first pass yield (FPY) and field quality.

Medium Term Process Improvements for Current Design

- Evaluate the use of solid solder preforms as a better solution to the solder degradation under the large component
    - Preforms may apply a lower mass of solder than the current approach.
    - Preforms may be a better solution to the solder degradation problem that could allow the process flow to return to the original sequence
- Evaluate if the large component could be attached by automated glue dots instead of the OEM-specified epoxy.
    - CM hand mixed the epoxy, then removed the pallet from the line to manually apply the epoxy while hand placing the large device. This was a costly, slow process that allowed the solder paste to dry out and subjected the pallet to extra handling that may damage/displace other components.

Design Issues Long Term

- Replace the cylindrical MELF components with rectangular SMD components and adjust pads as needed
- Revise layout to place large components on the same side so that that side can be soldered only once during the second reflow cycle.
- Relocate the small resistor away from the edge of the PCB and replace the cut out under it with a circular hole. This should reduce local flex circuit warping that contributed to tombstoning.
- Insure that components pads are symmetrical and correctly sized and placed for their components.
    - Do not allow pads to be misshapen by the exit path of circuit traces.
    - Design in component keep out regions in area where to flex circuit needs to bend to reduce bending/breakage stress damage to components and solder joints.