High-Speed Stamp Soldering

This article examines stamp soldering, a solution that provides consistent high quality by repeatedly applying accurate amounts of molten solder onto a printed circuit board using static volumetric solder stamps guaranteeing total flatness during the through-hole soldering process.

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The increased use of double-sided reflow, widely utilized for high density SMT and through-hole mixed-technology assemblies, makes these boards susceptible to warpage that adversely affects their planarity during subsequent through-hole soldering. This article looks at stamp soldering, a highly engineered solution that produces consistent high quality results by repeatedly applying accurate amounts of molten solder onto a circuit board using static volumetric solder stamps while guaranteeing total flatness throughout the entire through-hole soldering process.

Board Warpage

The most frequent defects associated with through-hole soldering are insufficient through-hole fill, excessive solder, solder bridging and the formation of solder balls. All of these conditions are directly affected by the contact between the circuit board and the molten solder. Lack of parallelism between the board and the solder surface, as well as non-uniform flux deposition, improper preheating or an uneven solder wave height can result in any of these defect conditions.

Insufficient through-hole fill is commonly linked to wave soldering with aperture pallets since boards are exposed to excessive conditions including board lifting, uneven or entrapped fluxing, inadequate preheat or insufficient wave height. At the same time, an excessive solder condition can occur with either wave soldering or selective soldering if the board is exposed to uneven fluxing, contaminated solder or an uneven height of the molten solder.

Typically the root cause of solder bridging is either insufficient fluxing, excessive preheat that burns off flux activators, excessively high soldering speed or contamination of the molten solder. Solder bridges can often be eliminated through adequate design practice since its occurrence is directly affected by the pitch of the through-hole connectors, the lead length of the component and the type of flux that is used.

In many high-reliability applications there is a zero tolerance toward the presence of solder balls which have to be 100% removed to avoid a catastrophic field failure in a mission critical environment. There is a common misconception that solder balling is affected by glossy versus matte solder mask finish of the printed circuit board. In reality the formation of solder balls is a phenomenon that is the direct result of uncured solder resist that leaves tacky plasticizers on the surface which inhibits solder de-wetting.

The propensity of solder balling is also affected by non-uniform flux deposition since this has a direct influence upon solder de-wetting. Some flux formulations minimize the formation of solder balls but these should not be used at the expense of activity. Prior to changing fluxes, it is best to have a good working knowledge of the actual flux deposition in terms of volume, uniformity and board-to-board repeatability. In most cases it is better practice to reduce flux consumption to a highly uniform minimum volume to avoid components of the flux from being absorbed by the porous solder resist.

Point-to-Point and Multi-Nozzle Systems

For high density SMT and through-hole mixed-technology assemblies, typically either point-to-point or multi-nozzle selective soldering is employed that utilizes a re-circulating supply of molten solder to form the through-hole solder joints. However, these methods can be problematic due to inconsistent or unstable wave height caused by molten solder flowing through nozzle openings of various sizes in conjunction with excessive board warpage.

Point-to-point selective soldering systems are highly flexible since maximum control can be exerted over the soldering angle, contact time and fluxing volume. Then again point-to-point processing can be effected by maintaining control over the solder wave height. Maintaining parallelism between the board surface and solder nozzle of a point-to-point system often requires continuous adjustment of the Z-axis coordinate in order to compensate for board warpage.

Multi-nozzle selective soldering systems typically have faster throughput than point-to-point systems but the process is determined by the most thermally challenged component. The wave height of multi-nozzle systems can often prove to be less than consistent or unstable since molten solder is flowing through various size nozzle openings. Dross contamination is also an important consideration since it can further limit the stability of the wave height within multi-nozzle systems. When combined with board warpage as a result of two heat histories of the double-sided reflow process, this unstable wave height can result in inconsistent contact and a higher tendency for solder defects such as insufficient hole fill, excessive solder or solder bridging.

A selective soldering method that is highly effective at minimizing the frequency of solder bridges when soldering boards with a high degree of warpage are non-molten systems. These systems utilize either solder wire, solder paste or a solder pre-form that becomes molten as the through-hole solder joint is formed. A significant drawback of these systems however is that they are relatively slow and require more expensive solder materials making them less cost effective for most production applications other than prototyping or low-volume assembly.

Volumetric Control

Stamp soldering is a selective soldering process that combines the high throughput and minimal bridging of multi-nozzle and non-molten systems together with a high tolerance for board warpage. It achieves a low level of solder bridging because it encompasses an extremely stable solder height along with volumetric control of the molten solder. This high degree of control over both the solder volume and solder height results in consistently high quality levels with low defect rates.

The stamp soldering process comprises several basic process steps. The printed circuit board assembly arrives at a fluxing station where it is held securely between top and bottom contour plates negating any warpage. Flux is applied at predetermined locations on the board by means of flux stamp application brushes that utilize surface tension to apply a uniform and consistent volume of flux irrespective of solids content. Preheating is then carried out to dry the flux solvent and make active the flux activators.

Printed circuit board assemblies are then transferred to the soldering location where they arrive above a stationary solder pot and are held securely between top and bottom contour plates eliminating all board warpage. The top surface of the molten solder is skimmed with an automatic solder skimmer removing all oxides and a door is opened above the solder pot which is contained in a nitrogen atmosphere. Solder stamps then rise above the surface of the solder transferring the volumetrically controlled molten solder to specific locations on the board with the entire soldering process carried out in a completely flat and uniform plane.

After the soldering is complete, the solder stamps are lowered to their original position beneath the surface of the solder and the nitrogen sealing plate is closed maintaining the nitrogen atmosphere. Afterward, the printed circuit board assembly is released and proceeds to exit the machine. All of these actions are carried out with tooling that is specially coded to ensure the correct tools are loaded with a given program. All flux stamp, contour plate and solder stamp tooling has the ability to be quickly changed over in 30 minutes or less (Figure 1).

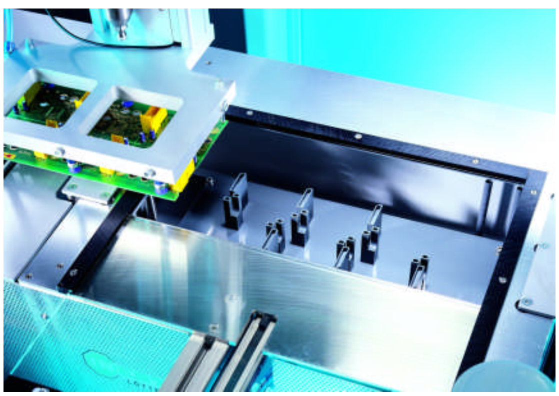

Figure 1. Stamp soldering process is carried out in nitrogen atmosphere to ensure consistent solder joint formation

The solder stamps have fully wetted surfaces to ensure uniform solder flow and excellent thermal transfer properties. The solder stamps are always maintained below the surface of the molten solder and are therefore continuously tinned. These solder stamps use a still pool of molten solder to transfer solder to the board and form the through-hole solder joints (Figure 2).

Figure 2. Solder stamps with volumetric control of molten solder minimizes solder bridging and reduces solder ball formation

A major advantage of the stamp soldering process is that its volumetric control of the molten solder minimizes solder bridging and significantly reduces the formation of solder ball defects. The reason for this is that the elimination of solder bridges is to process a board at as slow of a soldering speed as possible thereby reducing overall contact length between the boards and solder resulting in improved peel back conditions. The formation of solder balls is also significantly minimized with the stamp soldering process since its high uniform flux deposition optimizes solder de-wetting.

Narrowing the Gap

The stamp soldering technique offers several quality and operational benefits. Stamp soldering produces boards of a consistently high quality level with high yields and extremely low defect rates making it ideal for high reliability, mission critical applications. It also guarantees board flatness during the through-hole soldering process irrespective of warpage from previous reflow processing.

Stamp soldering operates with a fast cycle time and high throughput with rates as fast as 25 seconds for as many as 1 to 10,000 solder joints per board assembly. However, a major advantage of stamp soldering is that it is highly tolerant of any amount of board warpage and has the ability to solder either bare boards or solder boards into housings by means of top and bottom contour plates (Figure 3).

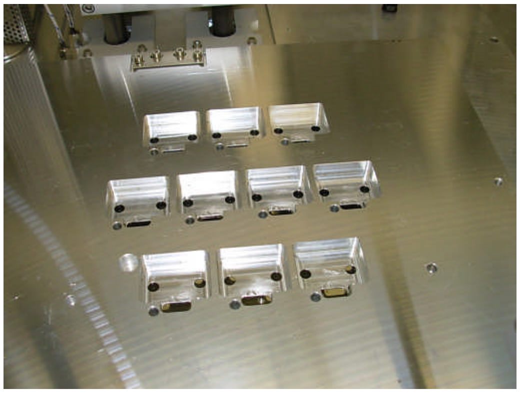

Figure 3. Quick change contour plates assure board flatness during through-hole soldering process

When comparing stamp soldering and multi-nozzle selective soldering, several key factors can be noted. Stamp soldering has a highly stable solder height, guarantees board flatness, reduces dross formation, eliminates solder balling and has greater process repeatability (Table 1).

Table 1. Comparison of stamp soldering and multi-nozzle selective soldering		
Selective soldering type:	Stamp soldering	Multi-nozzle selective
Wave height	Well defined, highly stable solder height	Unstable wave height caused by pumping solder through various size openings
Board flatness	Top and bottom contour plates eliminates board warpage	Use either grippers or conveyors that does not control warpage
Solder dross	Static solder pot without solder pumps generates less dross	Constantly flowing nozzles cause turbulence and generates more dross
Solder ball formation	Static solder helps to eliminate formation of solder balls	Fluctuating solder wave height promotes solder ball formation
Solder contamination	Solder is skimmed prior to each stamp minimizing contamination	Constantly flowing solder can promote solder contamination
Repeatability	Repeatable to ± 0.01mm	Repeatability is typically between ± 0.10mm and ± 0.30mm

Stamp soldering systems are typically available with either a turntable or in an inline configuration to support batch or continuous operation, as well as special configurations to meet the needs of various applications. Each machine can be configured with convection preheat, infrared preheat, or various combinations of preheating for water-based or alcohol-based fluxes.

Conclusion

To obtain high throughput rates while maintaining consistently high quality levels, several high-volume manufacturers of safety related management electronics systems have employed stamp soldering. It is a widely accepted solution for repeatedly forming accurate solder joints and is the only system available that can guarantee total board flatness during through-hole soldering.

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