Practical Technical Information

Procedures for Handling Solder Paste

The following guidelines are recommendations from the Indium Corporation on appropriate handling procedures for solder paste from receipt until use.

General Handling Guidelines

- Solder paste is shipped cold, approximately -5°C to 10°C.
- Refrigerated storage will prolong the shelf life of solder paste; -5°C to +20°C is common.
- Storage temperatures should not exceed 22-25°C.
- Syringes and cartridges should be stored tip down.
- Solder paste is a shelf life item and should be managed in a FIFO manner (FIFO = first in, first out).

Ideal Handling Procedures

- Upon receipt at the customer's shipping area, solder paste cartons must be immediately placed in an area which is temperature controlled to <= 22°C.
- Cartons not scheduled for immediate use should be stored in a controlled environment where the ambient temperature is maintained below 22°C. Refrigerated storage, -5°C to 10°C, is ideal.
- Older solder paste batches should be used prior to newer batches. Batch age can be identified by the manufacturing date on the box and jar labels. Use before expiration date on label.
- If solder paste must be transported between facilities, care must be taken to ensure that the solder paste is kept at a moderate temperature, approximately 22°C or lower.

Handling Immediately Before Printing

- Prior to use, paste should be allowed to reach room temperature. Consequently, paste must be removed from refrigeration at least two hours before printing. Frozen and large containers may take up to four hours to reach room temperature.
- Removing paste from storage one day before use is highly recommended.
- Rapid warming of paste on top of ovens or by any other method is not recommended.
- A temperature controlled water bath may be used if the temperature is at or below 25°C.
- Stirring or pre-conditioning of solder paste is acceptable, but usually unnecessary.

Process Impact of Excessive Heat Exposure

- Storage of paste in temperatures in excess of 30°C may result in significant flux separation and chemical decomposition.
- Heat damaged solder paste may be high in viscosity which could result in poor printing performance. Chemical decomposition could reduce tack and reflow performance.
- Contact Indium Corporation to discuss disposition of heat damaged solder paste.

In-Process Handling

- Reduce solder paste exposure to air and humidity by replacing lids on open jars and removing paste from stencil during down time in excess of 2 hours.
- Paste removed from stencil for future use should be placed into a separate jar reserved for used paste.
- Jars or cartridges should be labeled with date and time of opening.
- Excessive mixing prior to placement on stencil is acceptable, but should not be necessary.

Eliminating Solder Paste Hang-Up on Squeegee Blades

This discussion is of possible and proven causes for solder paste hang-up. Paste hang-up is discussed with limited consideration for other process requirements.

Definition

Paste hang up is when solder paste adheres to the squeegee blade after lift-up from stencil.

Process Impact

Paste hangup may cause insufficient deposition.

Printer Parameters

- **Print speed** may affect amount of shear. A faster print speed will result in greater shear thinning and consequently better drop-off.
- **Print pressure** will affect squeegee blade's flex angle and consequently the blade's surface area interacting with paste. Lower print pressure will result in less interaction between the paste and blade giving the paste less of an anchor and enhancing drop-off.
- **Blade angle** will affect the paste-blade interface. Greater blade angle (more vertical) will result in less of the blade's surface area contacting paste. The more paste coats the blade the more likely the paste bead will hang-up.
- **Blade composition (squeegee type)** may also affect hang-up. Old worn blades will provide a surface which allows for mechanical hang-up.
- **Blade wings or stoppers** on blade edges keep paste within the blade's path. These wings may provide an anchor site for paste hang-up. However, by preventing bead thin-out, the likelihood of hang-up is reduced.
- **Release method** will also affect drop-off. A blade lifting straight up after a print will allow paste to flow down and off the blade. A blade that flips back off the paste does not facilitate flowing and requires the paste to release simultaneously along the paste-blade interface.
- **Lift height** may affect paste release. If the blade is not lifted high enough off the stencil, the paste will not flow completely off the blade. However, too much lift height will exacerbate problems caused by hang-up and the swinging release of paste.

Paste Parameters

- **Viscosity** will affect paste release. If viscosity is too high, the paste may not flow off the blade resulting in hang-up. Paste viscosity also increases with decreasing temperatures. Consequently, adequate time is required for paste to reach ambient conditions after refrigerated storage.
- **Shear thinning** (thixotropic index) can compensate for high viscosity. If a paste is worked (mixed) thoroughly, the shear will cause a reduction in viscosity and consequently better release. The thixotropic index is primarily determined by the flux vehicle.
- **Tack** can also affect release. If tack is too great, the paste will stick to the squeegee. Tack is determined by the flux vehicle.

Reducing Solder Beads and Solder Balls

Solder beads and solder balls are related, but distinct, problems. They are presented together because causes and solutions are the same for both.

Definitions

Solder beads are large solder spheres which form aside components during reflow. They are most common with low stand-off resistors and capacitors.

Solder balls are small, widely scattered solder particles found within the flux pool.

General Causes for Beading

- Paste printed or pressed onto solder mask
- Stencil aperture design
- Large overlap between pad and component
- Excessive paste volume due to thick stencil
- Switch from rubber to metal squeegee
- High component placement pressure
- High flux activation temperature
- Flux and moisture outgassing
- Fast ramp rate
- Excessive solder powder oxides or contaminates
- Low metal load
- Fine powder; type 4 or 5
- Paste slump; hot and cold

Process Impact

Solder beads and balls may cause electrical shorts immediately or in the future if the balls roll around the PCB. Beading and balling could also cause insufficient solder joint volume.

General Causes for Balling

- Print smearing
- Stencil aperture design
- Large number of fines in powder
- Excessive humidity
- Insufficient flux activity
- Excessive solder powder oxides or contaminates
- Solder mask and paste interaction
- High flux activation temperature
- Flux and moisture outgassing
- Fast ramp rate
- Component outgassing
- Low metal load
- Paste slump; hot and cold

Solutions

- Modify the stencil apertures and thickness. Reduced apertures are recommended.
- Different pad designs or metallizations may also reduce beading and balling.
- Evaluate component and board metallizations for solderability and contaminates.
- Adjust the reflow profile. A slow steady ramp (≤1°C/sec) permits moisture and solvents to evaporate gradually prior to rosin/resin softening. Hot slump is minimized. Pastes with long stencil life and tack time generally require a slow ramp so environmentally stable solvents can evaporate.

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Understanding Flux Vehicle Chemistry

Solder paste flux vehicles are generally resin based and are comprised of solvents, activators, and rheological additives. A description of each is provided below.

Resin

- Is a modified rosin with a softening point of 100° to 125°C.
- Is a benign inert substance which is electrically non-conductive and non-hydroscopic.
- Is a favored material for soldering because it liquefies during soldering, attracts the metal salts, and then solidifies when cooled, entrapping and immobilizing the contaminants.
- Protects the surface from reoxidation before soldering occurs.
- Acts as a thermal blanket to spread heat evenly during soldering.
- Provides paste tackiness.

Solvents

- Dissolve all the constituents of the flux.
- Evaporate during the preheat portion of the reflow profile.
- Assist in controlling viscosity and rheology characteristics.
- Enhance stencil life & tack time when they have high boiling points.

Activators

- Dissolve oxides & prepare the surface for wetting by the molten solder.
- Can be one or several chemicals (referred to as an activator package).
- Are slightly active at room temperature, but the activity increases dramatically as the temperature rises.
- May be a combination of halides, amines, and acids.

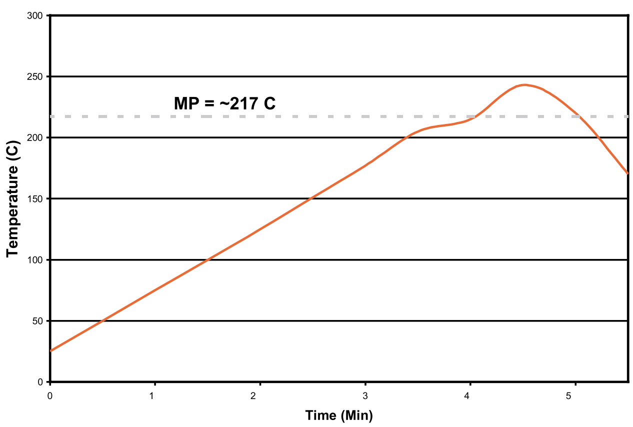
Rheological Additives

- Effect tack, viscosity, printability, dispensability, & overall solder paste rheology.
- Assist in keeping the solder powder in suspension minimizing flux separation; solder powder and the flux/vehicle have a natural tendency to separate due to the large difference in densities.
- May also serve other specialized functions.
- May act as a surfactant to reduce foaming in a closed loop cleaning system.

Optimizing Reflow

A typical reflow profile consists of four stages: preheat, soak or dryout, reflow, and cooling. Understanding these four stages is essential when designing an effective thermal profile.

Recommended profile:



Preheat — The objective of the preheat stage is to elevate the board and components to a temperature between 120° and 150°C. This drives off volatile solvents in the paste and attempts to minimize thermal shock on components. A ramp rate of 0.5° to 2°C per second is recommended. Too fast a ramp rate can result in solder balls due to spattering caused by rapid outgassing of volatile solvents. Wicking, skewing and additional defects may occur during a fast preheat. Faster ramp rates may be evaluated with respect to process requirements. Contact component suppliers for their recommended ramp rate and observe reflowed boards closely for any defects mentioned above. If a faster ramp rate is required, a compromise may be reached by increasing the peak temperature and/or time above liquidus.

Soak or Dryout — This stage serves to activate the flux and stabilize temperature across the board before entering the reflow zone. The forced air convection reflow ovens of today offer more uniform heat transfer than the infrared ovens commonly used a few years ago. The uniform heating allows a more linear ramp rate right up to liquidus temperature depending on board size, density & oven efficiency. This eliminates the hump or shoulder profile of the past where the board was held at around 150°C for 1 to 2 minutes.

Reflow — Actual soldering occurs in this stage. As the profile moves into the reflow zone, the ramp rate should increase to 2.5°-3.5°C/second up to a peak temperature of 30°-40°C above the liquidus temperature. The time above liquidus should be 30-90 seconds to reduce excessive intermetallic formation which can weaken solder joints. Thermal damage and charring of the post reflow residue can also result from excessive time above liquidus and/or too high a peak temperature.

Cool Down — A cooling rate of <4°C is recommended to allow the board to cool quickly, solidify the solder joint and minimize intermetallic growth. Cooling also prevents discharge of flux fumes into the work area and allows manual handling of the boards. A fast cooling rate produces a small, tight grain structure which is desired. Too slow a cooling rate can result in a large grain structure and a weaker, less reliable solder joint.