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Selective Reflow Soldering - Solder Thickness and Flux Control

By David Steinmeier

Selective Reflow Soldering

Selective reflow soldering is the localized heating of two solder plated parts to a temperature level that permits the solder plating on each part to melt and flow between each part. Cooling the solder creates a common electro-mechanical bond between each part.

Selective reflow soldering requires precise control of the heating rate, reflow temperature, time-at-reflow temperature, cooling rate, solder thickness, flux type and thickness, and heat sinking effects. Hold down force is an additional variable normally associated with hot bar reflow soldering. Hold down force is generally not necessary when using non-contact heating sources such as hot gas or diode laser selective reflow soldering.

Typical Applications

Selective reflow soldering applications include bonding flexible printed circuits to flexible or rigid substrates, bonding individual components to the same substrate, and attaching connecting jumpers or tabs between multiple substrates.

Problem Number One

In an effort to reduce production costs, Vendor "A" redesigns his flex-to-PCB joint by replacing the solder plating on the flex with an organic coating. Since the organic coating prevents the bare copper contact pads from oxidizing, Vendor "A" also assumes that he can eliminate the use of flux.

Subsequently, Vendor "A" finds his solder joint failure rate has increased and the peel strength between the parts has substantially decreased. Rework costs eat up any savings produced by substituting the organic coating in place of the solder plating and the elimination of flux residue cleanup. Vendor "A" is forced to ask what has gone wrong?

Two events conspired against Vendor "A". One, he decreased the total solder thickness by half compared to his previous design. Two, he eliminated the flux.

Problem Number Two

Vendor "B" uses a low cost PCB source that skimps on the solder plating to save production costs. However, unlike Vendor "A", Vendor "B" uses the proper type and thickness of flux in his reflow process. However, Vendor "B" also experiences increased failures and poor peel strength. The common denominator between Vendors "A" and "B" is the solder thickness reduction and the lack of solder thickness consistency.

Selective Soldering Equipment

Modern selective soldering equipment provides excellent control over the previously mentioned reflow soldering variables. However, the lack of solder thickness control and no or insufficiently active flux can prevent the best reflow soldering equipment from achieving parts with strong and consistent peel strength.

Peel Strength Factors

The following factors strongly affect the solder joint peel strength.

- Solder alloy.
- Solder plating thickness.
- Solder plating thickness consistency.
- Degree of solder and substrate oxide buildup.
- Solder attachment strength to the substrate.
- Solder wetting action.
- Level of flux activity.
- Flux heat carrying capacity.
- Solder cooling method.

This remainder of this microTip focuses on effects of solder thickness, solder thickness consistency, flux activity and flux heat carrying capacity.

Application Example

A solder plated copper tab was reflow soldered to a solder plated metalized glass substrate using Hot Bar reflow soldering equipment operating in a constant power mode. A Tungsten hot bar was used for its long life characteristics and for its ability not to bond to either solder alloy. A cool time of 4 seconds ensured solder solidification.

The copper tab plating was a high content tin solder alloy, ranging in thickness from 11.8 microns (.00047 inches) to 13.2 microns (.00052 inches). The metalized glass substrate plating was a high content Indium solder alloy, ranging in thickness from 10 microns (.0004 inches) to 65 microns (.0026 inches). A low clean, quick drying, flux was applied to selected portions on the Indium solder plating using a manual dispensing tool and allowed to dry.

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Flux or No Flux?

Flux does several very important things. One, flux removes surface oxides, allowing the solder plating on each part to bond. Two, flux reduces the surface tension on the parts, allowing the solder to rapidly wet and flow across the part surfaces. Three, flux carries the soldering heat and solder into minute air gap spaces between the parts.

Flux Study Results

A Design of Experiment (DoE) was set up to investigate the effect of flux, hot bar power, heating time, and force on the copper tab peel strength.

The results showed that flux, hot bar heating time squared, and the power level were the key input factors in predicting peel strength. Hot bar force was insignificant as a predictor of peel strength. Power level consistency was the key input factor in predicting standard deviation. Solder plating thickness on both the copper and the glass substrate was held as uniform as possible during the DoE. Figure 1 shows the effect of flux and reflow soldering time on the peel strength.

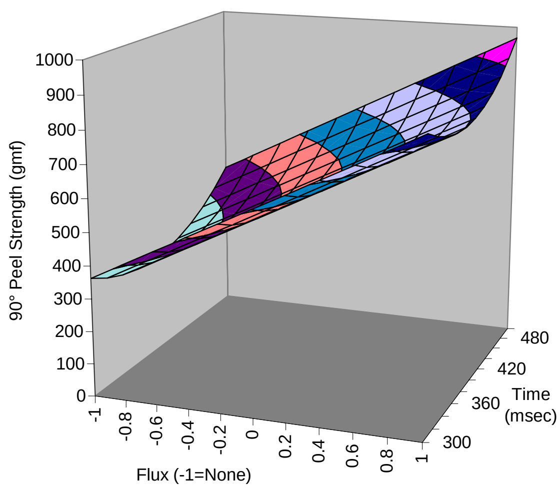

Figure 1 - Peel Strength vs Flux & Time

Without flux, the average peel strength is less than 400 gmf (.88 lbs). With flux, the average peel strength is over 800 gmf (1.76 lbs). The difference is two to one!

Indium Solder Plating Study

A second DoE study was performed to determine the effect of the Indium solder thickness, hot bar power, and heating time on peel strength. Flux was used throughout the experiment and the hot bar force was kept constant.

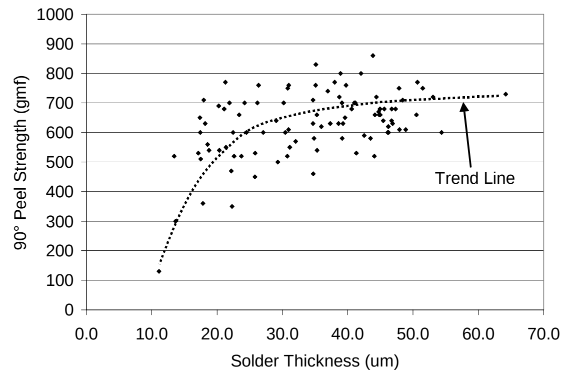

Figure 2 - 90° Peel Strength vs Solder Thickness

The results showed that Indium solder thickness is the second major predictor of peel strength, as shown in Figure 2. Note: Once the solder thickness is greater than 30 microns (.0012 inches), there is little peel strength to be gained by adding more Indium.

Part of the large variance observed surrounding the Trend Line can be attributed to a 30% variation in solder thickness over the 6 mm (0.24 inches) length of the copper tab reflow solder joint. The remaining variance was most likely caused by unknown factors controlling the Indium adhesion to the metalized glass substrate.

The visible peel pattern also supports the data in Figure 2. An Indium plating thickness of 20 microns (.0008 inches) or less results in the Indium peeling completely off the metalized substrate. As the Indium thickness increases beyond 20 microns, more of the Indium remains on the metalized substrate. At 50 microns (.0020 inches), about half of the Indium remains on the metalized substrate and half on the tin-plated copper tab.

Summary

Reflow soldering peel strength depends on the proper flux to remove the oxides, increase surface wetting, and spread the flowing solder. Peel strength also depends on achieving a minimum, consistent solder thickness.