“FlashSoldering” – A New Opportunity for Diode Lasers

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Background –

The electronics industry effectively uses mass reflow soldering techniques to bond the majority of through-hole and surface mount components to their printed circuit board (PCB) assemblies. However, some temperature sensitive electronic components can not tolerate the high temperature peak of 230°C for one minute that is typically encountered in the mass reflow soldering process without suffering damage. These components are soldered off-line using hand or other semi-automated soldering techniques. This process is commonly known as “Odd Form Soldering” or “Selective Soldering” and constitutes as much as 10% of all electronic assembly work.

Hand soldering is slow and highly dependent on operator skill level to achieve a good solder joint. Attempts to use semi-automated forms of selective soldering have been partially successful. Semi-automated selective soldering techniques include hot bar, the common soldering iron, and micro-flame. All three heat sources require intimate contact with the components to create a solder joint. These heat sources are typically paired with a solder wire feed system for controlling the wire solder feed rate.

Hot bar reflow soldering utilizes a temperature controlled metal heating element that can be pulsed to the desired reflow soldering temperature or maintained at a constant temperature. Hot bar reflow soldering suffers from several major drawbacks which include mechanical deformation of the electronic component surface and reduced thermal transfer due to warping and flux build up on the heating element surface. In some cases, the hot bar contact surface must be cleaned as often as every 500 to 1,000 cycles.

The soldering iron also uses a metal heating element for a constant temperature heat source. Solder in the form of solder wire is hand or semi-automatically feed into the joint area. To prevent a reduction in heat transfer, the soldering iron heating element or tip must be constantly wiped by a mechanical scrubbing mechanism to remove flux and solder oxide buildup. This repeated oxidation removal process eventually results in the replacement of the heating element.

Micro-flame heating employs a miniature gas feed flame to create the necessary soldering heat. Micro-flame is capable of generating very high temperatures with a large amount of heat, sufficient to melt a variety of metal alloys. This process works well with more continuous applications like brazing, which utilizes brazing alloys that typically melt above 450°C, compared to soldering in the range of 180°. The micro-flame is generally turned on by using an electric discharge. This arc-discharge mechanism can potentially damage sensitive electronic components. Moving the micro-flame in and out of the joint area provides a rough way to “turn on” and “turn off” the heat source without having to extinguish and re-light the micro-flame.

The Need –

As electronic components become smaller and the space between the components decreases to less than 0.5 mm, the opportunity for creating solder “bridges” or short circuits between adjacent contacts increases. What is needed in the realm of miniature and micro-miniature selective soldering is a more precise method of applying and controlling both the heat and the solder volume. Diode laser heating technology, coupled with solder bearing lead technology offers the electronic assembler a new tool for success.

The Future –

“FlashSoldering”, using diode laser technology, is a new, non-contact, selective soldering process that offers the electronic component assembler a highly controlled method for soldering a variety of temperature sensitive miniature and micro-miniature components.

FlashSoldering applications include: making miniature magnetic components such as single and multiple toroidal transformer packages; LAN filters; low power DC-DC converters; single or multiple form coils and inductors; and joining fine magnet wires to high-speed data connectors. PCB applications include joining flexible printed circuits and other miniature electronic components to flexible or rigid mounting surfaces.

Four components comprise the FlashSoldering system. In the case of the magnet wire application, the first component is an “electronic contact” that locates and retains very fine insulated copper magnet wires during the soldering process. For flex circuit and other electronic component applications, the “electronic contact” is the mating surface, which could be another flex circuit or a rigid PCB.

The second component is the insulated magnet wire for the magnet wire application, the flex circuit pads for the flex-to-PCB application, and the component leads or feet for the electronic component application.

The third element is a precise amount of solder. The solder is plated on one or both contacts or mechanically attached to one contact in the form of a solder bearing “nugget” which may also contain flux. Solder can also be applied in the form of dispensed solder paste, but requires more volume compared to a solid soldering bearing “nugget”.

The fourth and final component is a diode laser heat source. The growth of commercially available, low cost, highly controllable diode lasers with wavelengths in the 810 to 980 nm infrared range and self contained programmable power supplies makes non-contact, selective soldering economically feasible.

Pulsed YAG lasers with an operating wavelength of 1024 nm have not proved very successful for soldering miniature electronic components due to their high peak power and short pulse duration. These characteristics cause solder plating or solder paste expulsion and vaporization. The base materials tend to become pitted and covered with tiny solder balls that can cause shorting in the final assembled product.

To illustrate the diode laser as a reliable, controllable soldering heat source, consider the magnet wire application previously mentioned. In this application, the diode laser simultaneously removes the insulation and solders the wire to the contact without damaging or contacting the wire.

Figure 1 shows the results of FlashSoldering a 100 micron diameter, polyurethane-nylon insulated copper magnet wire to a surface mount SMT) contact without using any flux. The low peak power (less than 11 watts) nature of the diode laser and the short heating time (under 0.25 seconds) prevents the copper wire from being dissolved by the tin, thus ensuring a reliable solder joint.

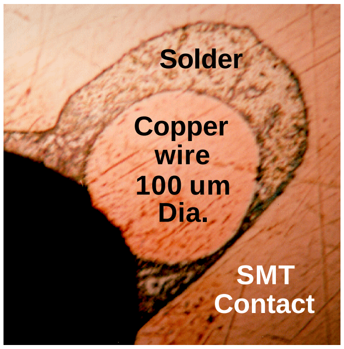

Figure 1 - Cross-section of SMT Contact containing a 100 micron diameter copper wire.

Figure 2 is a backscatter, scanning electron microscope view of another FlashSoldered joint, taken by Sandia National Laboratories. An analysis by Sandia showed no embedded carbon particles from the insulation material. Additionally, the copper-tin intermetallics surrounding the copper wire and the SMT contact were less than 1 to 2 microns thick, which is indicative of a strong bond.

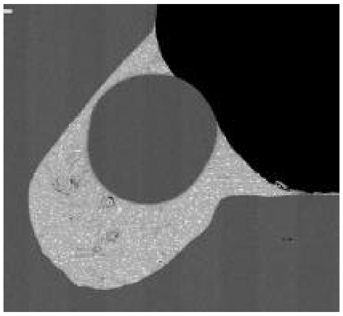

Figure 2 - SEM photo (350x) of SMT Contact cross-section.

Summary -

The diode laser offers the electronics industry a new, non-contact, selective soldering process for producing and assembling a variety of miniature electronic components and interconnection systems. “FlashSoldering” with diode lasers improves process reliability by preventing shorts caused by solder bridging. The short soldering time afforded by FlashSoldering improves joint integrity by minimizing copper dissolution by tin. And finally, FlashSoldering can reduce the labor and maintenance costs associated with other forms of selective soldering.

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About the Author -

David Steinmeier of microJoining Solutions is an internationally recognized expert in the field of micro-joining miniature metal components. He is the author of many metal joining articles that have been published in leading industry journals such as *MD&DI* for the medical industry and *AWS* for the American Welding Society. David can be reached at 626-444-9606 or by email at mjs@microjoining.com.