Advancement in Soldering Technology Main Issues and Its Perspectives – Part II

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Abstract : In recent years , the technological advancement has revolutionized the semiconductor industry. The production of electronic components and products based on these components are spread all over the world and have deeply penetrated into the daily routine life of human being. It has governed tremendous innovation in semiconductor technology. The present paper discuss about advanced soldering techniques viz wave soldering and reflow soldering its uses and importance in electronics history.

Keywords : *Reflow oven, wave soldering, flux, solder paste.*

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1. Introduction

The advancement of electronics and semiconductor industry have resulted in mass production of electronic instruments/equipments because of advances in soldering methods / technology. To understand how well soldering is used in the electronics industry, one should be familiar with the materials used in soldering , how actually solder bond is formed at macro level, and the process by which soldering is accomplished .

The first part of this paper [1] discusses about forming the solder joint using tin –lead solder with conventional Solder Gun.

The tin makes chemical reaction with the base metal when tin – lead solder is used. This forms an intermetallic alloy. This intermediate layer of metal ranges from a very high concentration of the base metal on the top side to a very high concentration of tin on the solder side. These intermetallic alloys may be brittle & weak which forms weak solder joint. This causes mechanical failure due to excessive vibration or stress.

To minimize this failure, the intermetallic alloy is made to be as thin as possible. This intermetallic layer is dependent on temperature. At low and room temperature its growth rate is negligible which increases with increase in temperature. Therefore it is advisable to solder at the lowest possible temperature, just above the solder melting point. A thinner intermetallic layer results by a shorter time of contact between the solder and base metal at elevated temperature. The other way to get a thinner intermetallic layer is to slow its growth by using lower tin contentent [2].This paper presents the details about new soldering techniques –Wave soldering and Reflow soldering with its applications and perspectives.

2. Wave Soldering

Early attempts with soldering large number of electronic contacts at the same time involved simultaneously putting /dipping into a pot of solder complete printed circuit board (PCB),or moving and dragging the PCB across the top surface of solder in a pot [3]. These processes of Soldering were modified and improved by a technique known as Wave Soldering. The idea of wave soldering was given by an Englishman name of Strauss. He used this technique to coat cookies with chocolate[4]. In this method, Liquid solder is pumped up through a nozzle and out the end. Gravity then causes the solder to fall back down, which creates a parabola shaped 'wave'. The PCB, with the electronic components already inserted, travels over the apex of the wave. As the wave of solder comes in contact with the bottom side of the board, which is already flux with metals, chemically bond with the solder. The process of wave soldering and wave soldering machine is as shown in Fig.1.

The process of wave soldering can be automated easily with the use of a conveyer belt system to move the board. This system is constructed of a material such that it cannot bond with solder .The conveyer moves the board into fluxing area through a preheating process and then over the solder wave. Conveyer systems can move boards by the use of finger conveyers or flat pallets.

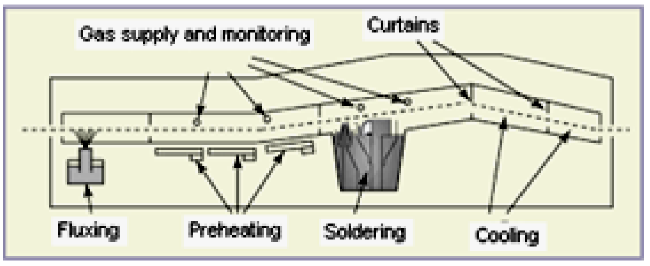

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Fig:1 The process of wave soldering and wave soldering machine.

2 (i) How to apply flux ? :

There are number of methods by which flux can be applied. In early days board was dipped into a liquid flux or brushing the flux onto the board with rotating bristles but in this case, the flux that is applied could not be controlled. Large quantities of flux are very harsh on electronic components. Also, the brittle brushes had a tendency to dislodge the electronic components before even they arrived at the solder wave.

The second method to apply the flux is using a flux wave. In this technique, the flux contains a mesh which removes ripples as flux is propelled upwards. Flux is applied as the board leaves the wave, an air knife is then used to blow excess flux off. Even though, this technique is very efficient and effective way of applying flux, it requires continuous maintenance and cleaning to keep it operating.

The third method to apply flux is by spraying it on. Since, the spraying has basic inherent problem of depositing flux all around the target area, the amount of flux applied can be controlled precisely.

Similar to that of paint sprayers used in industries, flux can be sprayed by using a compressed gas process. Some flux sprayer uses a compressed air and revolving drum. As the drum rotates, the underside comes into contact with a tank of flux. The drum has a mesh like outer surface that allows it to pick up small amounts of flux as it passes through the liquid. Then air blows liquid flux particles off the upper side of the drum onto the circuit board. [5]

The most common and widely used method of applying flux in a wave soldering process is foam fluxing. Here, the flux is aerated with extremely fine bubbles of compressed gases that causes it to foam up. This foam is allowed to climb up a chimney and spill out over the top, creating a foam head over the chimney. The PCB then moves across the top of the foam head, picking up some of the flux [6].

2.(ii) Preheating:

During Preheating, in order to increase the base metals to their soldering temperature, the PCB with its components is heated. When the solder is introduced, if these metals are already at or near the required temperature, the amount of time that the solder, in its liquid form, must be in contact with the board is minimized. This gives a much stronger intermetallic layer.

The commonly used preheating techniques are using

(a) Electric heaters that work on the same principle of a household toaster are used.
(b) Convection Heating.
(c) Infrared Heating Processes.

Each method has some advantages and disadvantages.
In case of infrared heating it has the advantage of being able to heat up the assembly quickly, but the equipment employed is more expensive.

3. 3. Re-flow soldering process

While surface mount components can be wave soldered, they must first be attached to the circuit board with some type of adhesive or cement in order to keep them in place during soldering. This introduces another step in the assembly process. Since the whole SMT components immersed in the wave, it must be constructed in such a manner to withstand the high temperature of the liquid solder. There is also a problem of gases being trapped between the component and the board[7]. Because of these difficulties with wave soldering, reflow soldering is the preferred method of soldering surface mount components.

The development and increased use of surface mount technology has led to the use of other soldering methods like reflow soldering which is not a new manufacturing process. For many years the electronics industry has used and modified the process of reflow soldering. However with the advent of Surface Mount Technology (SMT),reflow soldering has expanded in the number of types and has been studied, refined and explored as never before. The best or optimum process which resulted in meeting the goals of reflow soldering for the SMT application.

The process of using a source of heat – heat gun, heat lamp-heating up the GPU (Graphic Processing Unit) candle to a point where the solder balls also known as video card that hold the chip to the mother board melt into a liquid state and any cracks or moved solder balls are removed creating a complete circuit making that a temporary fix.

There are many advantages using SMD component sover through-hole components. some of the major advantages are size and cost.The smaller size means the circuit boards are smaller. Also,smaller components and smaller cicuit boards means lower cost.

3 (i) Goals :

The goals for reflow soldering are categorized in two main types.

The first type includes,

(i) Solder joint should be uniform.
(ii) There should be minimum repairs and part replacement.
(iii) Requirement of minimum solder skips,solder balls and part movements.
(iv) Complete assembly should be cleaned.
(v) Maximum flexibility to allow soldering a large number of circuits with minimum changeover time.

The second types of goals includes,

(i) To reduce solder grain growth by fixing minimum time above the liquidous solder temperature.
(ii) Minimum damage and stress to the printed circuit board (PCB)
(iii) Minimum stress and damage to the SMT parts.
(iv) Minimum "leaching" of part termination materials.
(v) Optimum conditions to minimize movement of parts.

To achieve these goals, it is important to understand the process, to modified it if required to ensure the product is protected.

3(ii) Detail Description of Reflow Solder Process :

The basic steps of reflow solder process includes :

(a) Applying a solder paste to the desired pads on a printed circuit board (PCB)
(b) Placement of the parts in the paste.
(c) Applying heat to the assembly which causes the solder in the paste to melt (reflow),wet to the PCB and the part termination resulting in the desired solder fillet connection.

(a)Applying Solder Paste : As the demands of reflow soldering for SMT increase, the solder paste mixes are improving. Selection and Specification of the optimum paste plays a key role in the solder process. There are numerous methods in use to apply the solder paste to the circuit board. One way of doing this is to dispence a slightly pressurized solder paste through the end of a tube. This is similar to the operaion of a syringe. This type of application has many advantages over other methods. First, it employs a closed tank of solder paste that allows little opportunity for solder contamination. The syringe can reach into odd shaped places which is of particular use in reflow soldering SMD components onto a board after through-hole components have already been wave-soldered on . Use of disposable syringes is also a relatively inexpensive process. The main difficulty with this method is to control the precise amount of solder paste that is applied to the board. Adequate control can only be achieved with complicated and expensive Hi-tech control systems. Additionally, dispencing takes place on only one pad at a time, making this method relatively slow.

Screen printing is a more common way of dispensing the solder paste onto the circuit board. This is essentially the same process that is used in applying paint to clothing and street signs. A screen stencil is placed slightly above the board, and a squeegee manually drawn over the stencil, forcing solder paste through the screen on to the board. The alignment between the board and screen is very important otherwise solder will not be deposited in the right place.

Another technique used is to dip dull pins into the solder paste, and then dab the end of the pin onto the board. The amount of solder applied is directly related to the size and shape of the pin. This method is fast. A whole array of pins can be lowered onto the board at the same time[8].

(b) Placement of the parts in the paste :

This is not difficult if the pad design considers all the applicable tolerances. One should take care during transportation of the PCBs not to smare the solder paste or move parts.

(C) Heating :

Application of heat to result in the eventual solder joint must consists of the following. (i) Before the flux begins to work, Preheat cycle is intended to drive-off most of the volatile solvents contained in the paste. This assist in initiating fluxing action on the solder powder and the metal surfaces to be joined. (ii) Additional preheat time to elevate the temperature of the PCB, Solder paste and Terminations to a temperature near the melting point of the solder. (iii) Additional Heat Transfer to elevate the temperature over the liquidous point of the solder. (iv) Temperatures to be achieved are the liquidous melting point of solder.

Liquidous points for
63 Sn/37 Pb solder is 183^{o}C
60 Sn/40 Pb solder is 188^{o}C
62 Sn/36 Pb 2Ag solder is 179^{o}C. (v)Assisted temperature cool down to the solder solidification temperature followed by gradual(Static) cooling to temperature near cleaning temperature.

3(iii) Preparation :

To ensure good reflow solder results, the following items should be considered. the temperature profile and equipment choices are important .

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(a) Printed Circuit Boards :

Bake boards at elevated temperatures prior to application of solder paste. This eliminates excessive moisture from the board. Circuit boards are of two types. (i) Bare Copper pads (With a protective sealer to prevent oxidation). (ii) PCB with solder coated pads.These boards are usually fused or reflowed to increase the coverage of the solder to the edge faces of the copper and to prevent further chemical processes in the board. Keep all pads, traces and parts away from the board edges.

(b) Solder Paste :

It is important to select a good solder paste. Two important variables are viscosity and slump tests. Understanding the effect of premixing and test temperature on viscosity is important.

(c) Rheology :

Rheology of solder paste is one of the important characteristics as the flow and deformation behavior of solder paste directly affect the quality of paste deposition on the solder pad.

(d) Purity :

Solvent purity and metal particle cleanliness (Oxides,Carbonates etc.) are very important in minimizing solder balls and voids and in improving solder wetting and shapes of solder fillets.

(e) Stencils :

Selection of the optimum solder paste stencil is a trial and retrial situation**.**

(f) Solder Masks :

The best solder mask is no solder mask. PCB's with no solder mask, have only mounting pads on the outside layers.

4. 4. Typical Reflow Solder Temperature Profile :

The optimum method of obtaining a thermal profile is through the use of Thermocouple. A typical reflow solder profile is as shown in Fig.2. The Fig. shows a typical temperature versus time curve for the reflow process.

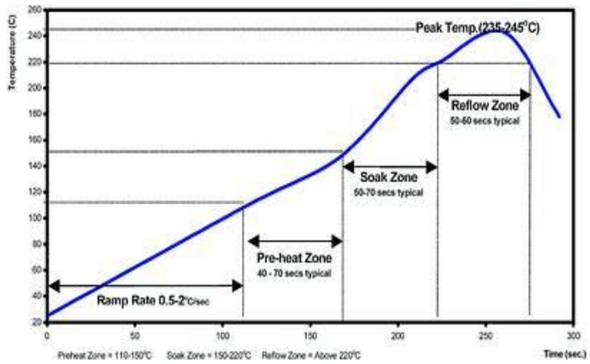

Fig.2. A Typical Reflow Solder Profile

The actual time and temperature requirements is dependent on the type of the solder paste used. Either longitudinal profiles or lateral profiles are used. To ensure adequate soldering conditions, the minimum peak temperature should be 205°C. The maximum recommended peak soldering temperature should be 220°C. However, Many reflow solder profiles have been established with profiles as high as 240°C to 260°C.

5. Process Specifics

The main differences in reflow soldering process lie in heat transfer methods. Heat transfer for reflow soldering is of many types. In Practice, some methods are combined. Radiation, Conduction, Convection and Condensation –all are used. With the growth of SMT, the reflow industry concentrated on Infrared (IR) and Vapor Phase (VP) reflow soldering methods. Fig. 3 shows these methods.

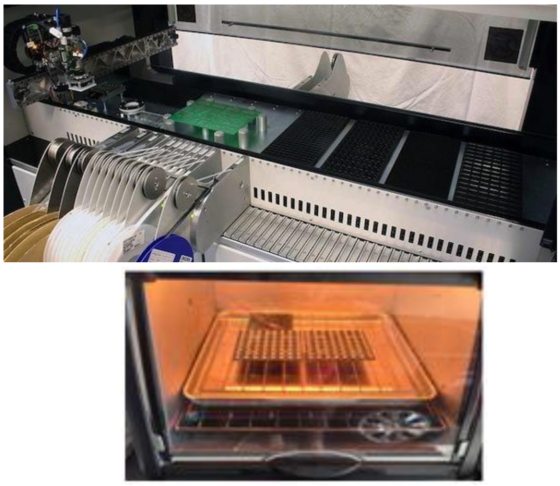

Fig.3 Reflow Process : Convection and IR.

6. Conclusion

The reflow solder process used depends on its ability to consistently deliver the ideal temperature profile for each product. Some people use lasers to reflow solder in less than a second. Others have heating times of 20 minutes or more. Most fall in between these two limits. The only thing required is to match the heating process and solder product to the soldering need.

The SMT Manufacturer will work to approach the ideal temperature profile for each product. Using suitable profile will result in the attainment of all goals and a nearly trouble free process.

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