

Method and Apparatus For Assembling Surface Mount Devices

Background and Field of the Invention

- 5 This invention relates to a method and apparatus for assembling surface mount devices, particularly but not exclusively, for assembling such devices on flexible printed circuit boards or thin rigid circuit boards.

In the specification, the following abbreviations will be used:

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ASIC - Application Specific Integrated Circuit.

CCD – Charge Couple Device

COB - Chip on board

COF - Chip on flex

15 FPC - flexible printed circuit

PCB - printed circuit board

SMT - surface mount technology

SMD - surface mount device

SOC- System on chip

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Further, the following definitions should be considered:

Pads - an SMT feature used for electrically interconnecting a component to a printed wiring board,

Thin rigid PCB – Rigid printed circuit board having thickness of less than

25 0.5mm.

SMD – a functional component and/or part that is attached to a printed wiring board package through a surface mounting.

5 In the past decade, there have been increasing applications of FPC and Thin rigid PCB as portable/handheld electronic products reduce in size while maintaining or increasing their functional capabilities, primarily due to user demands for smaller, light weight and thinner designs. Such electronic products include mobile phones, digital cameras, MP3 players, PDA, VCD, DVD, Laptop
10 computers, etc. Due to constraints on space and problems associated with mounting SMD on FPC, circuit designers usually use ASICs (for example, COB, COF and SOC) to lower component count on the FPC board and avoid mounting too many components on the FPC board by allocating bulk of the components to the main circuit board of a product. Thus, conventionally FPCs
15 are usually mounted with very few components, having extremely low component count, typically less than ten SMDs per single piece FPC board.

To assemble a FPC board, it is known to use the rigid PCB SMT component assembly method. In such a method, the process begins by placing a FPC
20 board having a plurality of identical circuits marked thereon and supporting the board on a hard baseplate so as to give the board the necessary rigidity to resemble a conventional rigid board so that the FPC sheet is suitable for undergoing the In-Line SMT mounting process (i.e. transporting the circuit board through conveyors, to print solder paste, perform component mounting
25 using SMT mounters and passing the entire FPC board with the baseplate

through reflow oven to solder components on the FPC). After the reflow, the FPC board soldered with components is then placed in between a cutting mold and by using a press machine to cut off the cavities of each circuitry to obtain singulated forms of the circuitry. However, such assembly technique of mounting SMDs on FPC board has several problems. For example, a typical board of FPC is mounted with far fewer components relative to conventional larger rigid PCBs and thus, the total mounting time taken by a SMT mounter to mount the surface components can be shorter to the conveying/transporting of the FPC board in and out of the SMT mounter machine. Large period of time is therefore wasted for transporting the boards (i.e. non-value adding activity) instead of mounting components to the boards (i.e. value adding activity) and thus, this is inefficient. For example, a typical SMT machine speed is 0.01 second per mount. It takes a total of 0.8 seconds to mount a sheet of FPC that contains 8 cavities (i.e. each cavity representing one circuit) with each cavity having 10 components. While it takes approximately 3 seconds to transport the sheet in and out of the SMT mounting machine and another 0.2 seconds for Bad Mark inspection of reject FPC cavities. Thus the value adding time is only 20% (i.e. $0.8 / (0.8 + 0.2 + 3) \times 100\% = 20\%$). As the result, the productivity of the SMT machine is very low when mounting low component count FPC boards.

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A sheet of FPC or Thin rigid PCB placed on a rigid base jig often results in slippage and/or warping, especially a sheet of FPC that has been punched out with outlay cuts. Any slippage or warping results in dimensional changes on the FPC sheet and thus affect the accuracy of solder paste printing and component mounting during the SMT assembly process. This kind of dimensional and

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position changes often cannot be compensated using a pair of fiducial checks available in SMT machines equipped with machine vision. With the slippage or warping, fine pitch connector and/or IC tends to be shifted from the designated positions which is not acceptable and rework is required to align the component to its intended position and this would incur additional cost and affect the quality of the assembly. Fiducial checking every cavity within a sheet using machine vision increases process time thus reduces mounting productivity.

The yield of up-stream manufacturing of FPC is often lower with the increase in density of the circuitry with fine printing wiring lines and number of layers. In order to avoid mounting components on rejected cavities within a sheet of FPC or Thin rigid PCB that contain many cavities, SMT mounting machine is equipped with Bad-Mark detection that the machine would scan and check each cavity to identify the specific reject cavities. Bad-Mark checking activity waste machine utilization time (i.e. during bad-mark checking, SMT machine cannot perform mounting concurrently) thus further reducing the productivity of the SMT mounter.

Further, a sheet of FPC mounted with components subjected to heat in the reflow oven and subsequently cooled to room temperature would result in non-uniform shrinkage and deformation in dimension. This may cause the cutting mould of the press machine to over and/or under cut into the interconnecting area and/or circuit line when separating out the cavities after reflow oven process. The consequence is non-repairable defect boards created and costly

scrapping of the piece of circuit board in addition with the components mounted on it.

Another problem associated with reflowing the entire FPC board in the reflow oven is when the FPC board is mounted with stiffeners using adhesive glue this results in deterioration or damage of adhesive glue quality (e.g. adhesive strength) and warping of the stiffeners. This situation worsens with recent years introducing of lead-free soldering that requires higher melting temperature (typically 240 degrees C). In addition, other sensitive areas on the FPC board and component sensors are exposed and/or contaminated with evaporated solder paste flux in the heat chamber inside reflow oven (for example, Optical Pick-up IC for CD and DVD, CCD sensor for Digital camera, Contact area on the FPC for mounting Dom Switch with adhesive tape). The conventional reflow oven process therefore lowers the overall quality of assembled FPCs.

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Another problem is the mounting of SMDs on conventional thin rigid PCB. As the Rigid PCB gets thinner than approximately 0.5mm, it begins to behave like or have the characteristics resembling FPC boards. Unlike thick rigid PCB, thin rigid board tends to sag/bend when placed in between conveyor edges of a SMT machine. Special treatment/handling is required in order to allow thin rigid PCBs to be subjected to conventional In-Line SMT component mounting process. Specifically, a sheet of thin rigid PCB cannot placed on the conveyor edge of SMT machine directly without the use of hard base supporting jigs. Warping and deformation of thin rigid PCBs after reflow oven process can be significant and if the deformation goes outside user's specification, then the

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board becomes a defect. In addition, separating a sheet of Thin rigid PCB into individual cavities after reflow oven process often resulted in significant warping due to stress created after FPC sheet mounted with large components cools to room temperature. Thus, conventional assembly arrangement of mounting

5 SMDs on Thin rigid PCB board share the similar problems described above.

It is an object of the invention to provide a method and apparatus for assembling surface mount devices which address at least one of the disadvantages of the prior art and/or to provide the public with a useful choice.

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Summary of the Invention

According to a first aspect of the invention, there is provided a method of assembling a flexible printed circuit board or a thin rigid circuit board, each

15 circuit board including a number of independent cavities/circuitries, the method comprising the step of singulating the circuit board to produce individual panels for each independent cavity/circuitry prior to mounting components on each individual panel.

20 According to a second aspect of the invention, there is provided a method of soldering components on a flexible printed circuit board or a thin rigid circuit board, each circuit board including at least one component to be soldered, the method comprising the step of selectively directing heat to solder that at least one component but not other areas of the circuit board that does not require

25 soldering.

The circuit board may be an individual panel having an independent cavity or circuitry, or has a plurality of independent cavities or circuitries.

According to a third aspect of the invention, there is provided an apparatus with
5 means for performing the method of the second aspect.

According to a fourth aspect, there is provided a modular apparatus for mounting surface mount components onto printed circuit boards, the apparatus comprising

- 10 a receptacle for receiving at least one printed circuit board,
a pick-and-place device for picking and placing components onto the at least one printed circuit board,
a rotary device or an indexer for alternating the receptacle between a first position for receiving the at least one printed circuit board and a second position
15 which enables the pick-and-place device to place components onto the at least one printed circuit board.

In a fifth aspect, there is provided a method of assembling SMDs on singulated or multiple singulated FPCs and Thin rigid PCBs, such method comprising the
20 steps of

- separating a sheet of FPC or thin rigid PCB that content one or more pieces into singulated pieces of circuit boards,
using a set of precision jig or pick-and-place machine, the singulated circuit boards are placed and arranged on a rigid base rectangular jig coated with
25 adhesive material or attached with vacuum,

solder paste is selectively dispensed or printed on the selected area of connecting pads on the circuit boards,

SMD components are mounted on each singulated circuit boards using pick-and-place machine,

- 5 the area with connecting pads that content deposited solder paste are selectively soldered using precise guided stream of spot hot air (or focused UV lights or LASER beams),
- each singulated FPC or Thin rigid PCB soldered with SMDs is then taken out from the based jig.

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In a sixth aspect, there is provided a set of mounting assembly jig having a based assembly and a movable part, said mounting assembly jig comprising at least one supporting based member with at least two guide pins inserted from the surface of the based member,

- 15 a flat sheet of base plate to be attached with adhesive material that can withstand high temperature in part or all surface where printed circuit board is placed,
- a thin metal sheet plate with shape of cavity openings for which pieces of circuit boards can be guided to intended position,
- 20 at least one top plate to hold the pieces of circuit boards on the baseplate while allows the metal sheet plate to be release from the jig assembly.

In a seventh aspect, there is provided a mounting assembly apparatus having a based portion and conveying mechanism, said mounting assembly comprising

- 25 a pick-and-place assembly,

at least one rotary turn-table fixture and/or fast indexer to transfer.

at least one IC tray and/or IC discharge module,

at least one component feeder to discharge SMDs,

- 5 In an eight aspect, there is provided an assembly apparatus having a based portion and a moving part, said mounting assembly comprising
- at least one supporting based member to support heat source.
- a driving motor or pneumatic piston,
- a moving block movable in top and/or down directions to varying heights,
- 10 varying heating source, varying timing periods, varying blow direction and varying blowing air speed and patterns.
- at least one guided heat source attached on the movable block,
- at least one printed board.
- 15 The described embodiments provide an efficient and cost effective manufacturing process of assembling SMDs on FPC and/or Thin rigid PCB that addresses the problems in the prior art.

- The described embodiments also provide an assembly apparatus to enable
- 20 placing and arranging singulated FPC and/or Thin rigid PCB precisely on a vacuum or adhesive flat based plate.

The described embodiment also discloses a mounting assembly includes rotary turn-table fixture and/or fast indexer (loading/unloading fixture) to reduce the

time for conveying the singulated FPCs and Thin rigid PCBs to the mounting assembly and out from the mounting assembly.

The described embodiments also provide an assembly apparatus that allows
5 selectively soldering of SMDs on the singulated FPCs and/or Thin rigid PCBs that prevent heating unwanted areas within a printed wiring board that is not mounted with SMDs such as areas attached with stiffener and/or double-sided adhesive tapes or Opening area for attaching Dom Switches.

10 The described embodiments describe a method for assembling SMDs on FPCs and Thin Rigid PCBs with the accompanying assembly apparatus. In particular, the method enables singulated form of large quantity of flexible printed wiring boards and/or thin rigid printed wiring boards being assembled with low component count SMDs with great efficiency and the method allows selectively
15 soldering of SMDs on singulated FPCs and/or Thin rigid PCBs effectively. The method achieves its maximum effectiveness when applied in assembling FPCs and Thin rigid PCB having very low component count (typically less than 20 components per singulated circuit/cavity) and high production volume requirement with short assembly lead time.

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The above and other objects, features and advantages of the invention will become more apparent from the following description of preferred embodiments thereof taken in conjunction with the accompanying drawings.

25 Brief Description of the Drawings

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which,

- 5 Figure 1 is a flow chart illustrating a process for assembling SMDs on FPC and/or Thin rigid PCB according to a preferred embodiment of the invention; Figure 2 shows a Singulated FPC Mounting Assembly used in the process of Figure 1;
- Figure 3 is a mounting assembly apparatus used in the process of Figure 1;
- 10 Figure 4 is a selective soldering apparatus used in the process of Figure 1; Figure 4a shows the apparatus of Figure 4 in greater detail;
- Figure 5 shows a sheet of FPC having a plurality of cavities/panels; and Figure 6 shows the cavities/panels of Figure 5 in singulated form, and after removal of the defective cavities.

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Detailed Description of the Preferred Embodiment

- Unlike known methods where the entire sheet/board 304 is subjected to in-line SMT process, at step 10 of Figure 1, the FPC board 304 is first cut into
- 20 singulated panels 300a-300g with each panel having an independent circuitry/cavity and rearranged as shown in Figure 6. The cutting process is achieved by using conventional cutting metal mould utilizing press machine. In this way, the defective cavities are discarded even before being subjected to the SMT process. This is to prevent printing solder paste on the defects and to

avoid subsequent process for Bad Mark checking by the SMT mounting processes.

At step 20 of Figure 1, each of the singulated cavities/panels 300a-300g is
5 hence placed in a base plate 80 using a jig as shown in Figure 2. The base plate is attached with a full coat of adhesive material or on certain selected areas. A template of rigid sheet (for example stainless steel sheet which is cut with laser having high precision to form shapes corresponding to the singulated panels such that it enables the panels to be placed in exact positions) is then
10 placed on the jig through guide pins. Each of the singulated panels are then placed on the jig as arrays and attached by the adhesive on the based jig. A top cover jig is attached to enable the template to be removed from the based jig.

After the singulated panels are precisely placed on the base plate, the panels
15 are placed or transferred to a solder paste printing/dispensing machine during which solder paste is printed on the solder pads of the component side of the FPC, at step 30. As the number of pads is relatively less due to very low component count per board, it is efficient to use solder paste dispensing method and any conventional solder paste dispensing or printing method may be
20 applied at this stage to place the solder paste on the pads of the singulated panels.

At step 30, the base plate together with the singulated boards are subjected to a mounting assembly apparatus 100 as shown in Figure 3. This apparatus is
25 designed to have very low board indexing (loading/unloading) time for

transferring the base plate with singulated FPCs in and out from the mounting machine. This low indexing time enables higher component mounting that results in higher productivity of utilizing the SMT pick-and-place machine.

- 5 After the SMD are mounted on the FPC, the next step (step 50) requires using a selective soldering apparatus 200 of Figure 4 to carry out selective soldering of the SMD on the FCP. This may be achieved by way of precise guided streams of spot hot air, guided rays of Ultra Violet (UV) lights or LASER beams but in this embodiment, spot hot air is used.

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- To carry out the spot soldering, the machine must first be programmed with the X-Y coordinates of each or a group of the components to be soldered. By varying the height between the nozzle of the hot air and the component to be soldered on the singulated boards and/or the direction of the blowing of the hot
- 15 air and/or the time periods of blowing and/or the temperature settings of each blowing periods and the blowing patterns of the hot air, an optimum temperature profile can be created to meet the requirement for each component or a group of components in close proximity.

- 20 With the above processes, at step 60, after the base plate with FPC boards cool to room temperature, the singulated panels are removed from the base plates to complete the process.

Having now fully described the invention, it should be apparent to one of ordinary skill in the art that many modifications can be made hereto without departing from the scope as claimed.

CLAIMS

1. A method of assembling a flexible printed circuit board or a thin rigid
5 circuit board, each circuit board including a number of independent
cavities/circuitries, the method comprising the step of singulating the
circuit board to produce individual panels for each independent
cavity/circuitry prior to mounting components on each individual panel.
- 10 2. A method of soldering components on a flexible printed circuit board or a
thin rigid circuit board, each circuit board including at least one
component to be soldered, the method comprising the step of selectively
directing heat to solder that at least one component but not other areas
of the circuit board that does not require soldering.
- 15 3. A method according to claim 1 or 2, wherein each circuit board is in the
form of an individual panel having an independent cavity or circuitry.
4. A method according to claim 1 or 2, wherein each circuit board is in the
20 form of an individual panel having a plurality of independent cavities or
circuitries.
5. An apparatus for performing the method according to any of the
preceding claims.

6. A modular apparatus for mounting surface mount components onto printed circuit boards, the apparatus comprising
a receptacle for receiving at least one printed circuit board,
a pick-and-place device for picking and placing components onto the at
least one printed circuit board,
a rotary device or an indexer for alternating the receptacle between a first position for receiving the at least one printed circuit board and a second position which enables the pick-and-place device to place components onto the at least one printed circuit board.
7. A method of assembling SMDs on singulated or multiple singulated FPCs or Thin rigid PCBs, the method comprising the steps of
separating a sheet of FPC or thin rigid PCB into singulated pieces of circuit boards,
arranging the singulated circuit boards on a jig coated with adhesive material or attached with vacuum,
dispensing solder paste on selected connecting pads on the circuit boards,
mounting SMD components on each singulated circuit boards,
and selectively soldering the connecting pads having deposited solder paste.
8. A method according to claim 7, wherein the selectively soldering is performed using precise guided stream of spot hot air, focused UV lights or LASER beams.

9. A method according to claim 8 or 9, further comprising the step of removing each singulated FPC or Thin rigid PCB soldered with SMDs from the jig.
- 5 10. A mounting assembly jig having a based assembly and a movable part, said mounting assembly jig comprising
at least one supporting based member with at least two guide pins inserted from the surface of the based member,
a flat sheet of base plate at least partially coated with adhesive material
10 where printed circuit board is to be placed,
a thin metal sheet plate with shape of cavity openings for which pieces of circuit boards can be guided to intended position,
at least one top plate to hold the pieces of circuit boards while allows the metal sheet plate to be release from the jig assembly.
- 15 11. A mounting assembly apparatus having a based portion and conveying mechanism, said mounting assembly comprising
a pick-and-place assembly,
at least one rotary turn-table fixture and/or fast indexer to transfer.
20 at least one IC tray and/or IC discharge module,
at least one component feeder to discharge SMDs,
12. An assembly apparatus having a based portion and a moving part, said mounting assembly comprising
25 at least one supporting based member to support heat source.

a driving motor or pneumatic piston,
a moving block movable in top and/or down directions to varying heights,
varying heating source, varying timing periods, varying blow direction
and varying blowing air speed and patterns.

5 at least one guided heat source attached on the movable block,
at least one printed board.