International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 2 Issue: 11
ISSN: 2321-8169
3784 – 3787

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

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Abstract : Scientific and systematic study has lead to an increased knowledge of variety of materials and their different properties. For the development of semiconductor materials, nano technology has played a significant role. This has made it possible to offer tremendous innovation in semiconductor industry. The present paper discuss about a latest and novel soldering techniques using reballing process known as BGA & CGA technique. Also, requirement and selection criteria of different components used for this process and its applications are discussed.

Keyword s: *BGA, VLSI, PGA, Rework Station, Stencils*

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1. INTRODUCTION :

With the advent of VLSI technology, package miniaturization and the density of surface mount interconnects and other components continued to advance. The technology of surface mount area arrays (SMAA) have been in existence for decades and are increasingly becoming more important as printed circuit board (PCB)assemblies became complex. Efficient soldering is still an evolving technology As advances in electronics continue to yield more efficient packages and smaller components, this technique is very important and must be widely used to meet the changing demand of the electronic industry. In the First and Second part of this paper different techniques of soldering viz. Simple soldering using Solder Gun[1], Wave soldering, Reflow soldering[2] processes were discussed.

The modern electronic instruments uses PCB's in which components used are based on surface mount technology and Pin Grid array technology (PGA).The most recent era now a days uses instruments containing compact multilayer printed circuit boards in which large number of integrated circuits and components are used based on Ball Grid Array (BGA) techniques for better performance.

For many SMT components, in meeting the density requirements, traditional SMAA solder attachment methods-Ball Grid Array (BGA) and Charge Grid Array (CGA) have been challenged with reliability, automatic processing and difficulties associated with its inspection.

This paper discusses mainly the Rework process using BGA Technique known as BGA Rework Station, its importance and General problems involved with this technology.

2. ELECTRONICS OF REWORK PROCESS :

The word Rework (or re-work) is used for the repair or refinishing operation of an electronic printed circuit board (PCB) assembly[3]. This normally involves process of de-soldering and re-soldering of SMT (Surface Mount Technology) devices / components. For single device repair or replacement, Mass processing techniques are not applicable. Therefore, it is required to replace defective components using specialized manual techniques by expert personnel using appropriate equipment. Particularly, Area array packages such as ball grid array (BGA) devices require appropriate tools and expertise.For this, hot air station or hot air gun is used to heat devices and melt solder. Specialized tools are used to pick up and position often tiny components.

A rework station is a place to do all this type of work- the tools and supplies for this work, typically on a work bench.

2.1 WHY REWORK IS REQUIRED ?

The most common causes and reasons for voids in joints which requires rework of electronic components are-

(i) Faulty Components.
(ii) Up gradation or changes in Engineering parts.
(iii) Solder joints are poor because of thermal cycling or faulty assembly.
(iv) Solder bridges - Formed because of unwanted drops of solder that connect points that should be separated from each other.
(v) Chemistry of solder paste.
(vi) Shape of joint , Termination of geometries.
(vii) For components and boards – Metallization of finishes.
(viii) Effect of surface tension.
(ix) Thermal profile.
(x) Outer surface oxidation of solder joints.

(xi) During reflow – Component board out-gassing.

3. REWORK PROCESS :

For different components, Re-work may involve i.e. de-soldering / re soldering can be done without damage to surrounding parts or the PCB itself. The parts/components which are not being worked on are protected from heat and damage[4]. To prevent unnecessary contractions of the board which might cause immediate or future damage, thermal stress on the electronic assembly is kept as low as possible.

To avoid health and environmental hazards, most soldering is carried out with Lead-free solder, both on manufactured assemblies and in rework. Tin-Lead solder melts at a lower temperature and is easier to work with, where this precaution is not necessary.

The first step for this process is to heat a single SMD with a hot-air gun to melt all solder joints between it and the PCB. The second step is to remove the SMD while the solder is molten. Using pad array, the old solder is cleaned off on the conductor board. Normally, it is much more easy to remove these residues by heating them to melting temperature. With de-soldering braid, a soldering iron or hot air gun can be used.

The next step is to place precisely the new unit on to the prepared pad array. This requires skilful use of a highly accurate vision-alignment system with high resolution and magnification. Fig.1 and Fig.2 shows PGA and BGA ICs respectively.

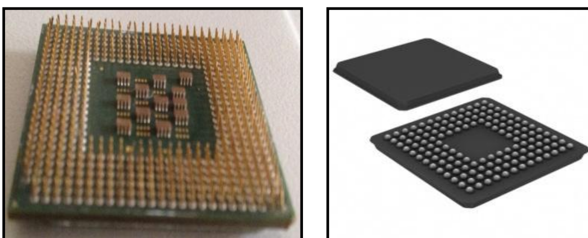

Fig : 1 PGA IC Fig : 2 BGA IC

Lastly, the newly placed SMD is soldered onto the board. With the use of solder profile, reliable solder joints are possible, which preheats the board, heats all the connections between the unit and the PCB to the melting temperature of the solder used, then properly cools them.

Before soldering and positioning the unit, specific design of SMDs or demand require the precise application of solder paste. The surface tension of the molten solder , which is on the board's solder pads , tends to pull the device into precise alignment with the pads if not initially positioned correctly.

4. REBALLING :

In this process one uses a high quality technology , that uses a bottom heat source to help heat the bottom of the chip. While at the same time an infrared lamp/heater is shined on top of the chip. with both heat sources on the chip, the solder under the chip becomes liquid and chip is then remove. one can uses the flux and a solder braid to remove the solder on the chip and on the mother board where the chip was sitting very carefully, so that solder pads can not be damaged. Then new solder balls that are lead - based are replaced. Again the chip is placed on mother board and solder it back on, making it permanent fix. Lead- based solder holds lot stronger and is more flexible then the lead-free solder. Therefore, solder balls will not crack or move around, when the chip is heated up and cooled down.

5. BALL GRID ARRAY :

A Ball grid array (BGA) is a type of surface-mount packaging[5] used for integrated circuit. These packages are used to permanently mount devices such as microcontrollers /microprocessors. A BGA can provide more interconnection pins that can be put on a flat package or dual-in-line package. Instead of just the perimeter, the whole bottom surface of the device can be used.

A BGA device is never mounted in a socket in use. Soldering of a BGA devices requires precise control.

5.1 ASSEMBLING BGA IC'S ON A PCB :

The BGA is descended from the Pin Grid Array (PGA), which is a package with one face covered fully or partly with pins in a grid pattern. These pins conduct electrical signals from the integrated circuit to the printed circuit board (PCB) on which it is placed. In BGA, the pins are replaced by balls of solder struck to the bottom of the package. After fabrication of the BGA package, tiny balls of solder are glued to the pads on its underside, manually or with automated equipment. The solder spheres are held in place with a flux until soldering occurs. The device is placed on a PCB with copper pads (stencils)in a pattern that matches the solder balls. Fig.3 and Fig.4 shows different types of stencils and solder balls.

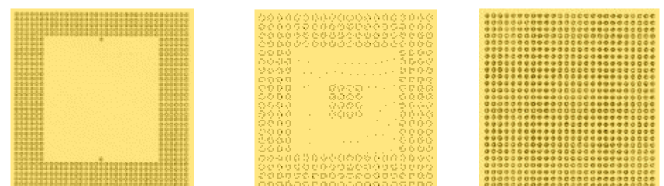

Fig : 3 Different types of Stencils

Fig : 4 Solder Balls

ISSN: 2321-8169
3784 – 3787

The assembly is then heated, either in a reflow oven or by an infrared heater, causing the solder balls to melt which connects each pad on the device to its mate on the PCB without any extraneous solder bridging between adjacent pads. Surface tension causes molten solder to hold the package in alignment with the circuit board at the correct separation distance, while the solder cools and solidifies.

5.2 ADVANTAGES OF BGA:

(i) Heat Conduction :
An important advantage of BGA packages over packages with discrete leads (i.e. packages with legs) is the lower thermal resistance between the PCB and the package. This allows heat generated by the integrated circuit inside the package to flow more easily to the PCB, preventing the chip from overheating.

(ii) High Density :
BGA is a solution to the problem of producing a miniature package for an integrated circuit with thousands of pins. Dual-in –line Surface Mount (SOIC) and pin grid array packages were being produced with more and more pins and with decreasing spacing between the pins. But this pauses difficulties for the soldering process. As package pins got closer together, the danger of accidentally bridging adjacent pins with solder grew.

(iii) **Low Inductance Leads** :
Lower Inductance because of shorter electrical conductor. This property causes unwanted distortion of signals in high speed electronic circuits BGAs, with their very short distance between the package and the PCB, have low inductance and therefore have for superior electrical performance to leaded devices.

5.3 MAIN ISSUES WITH BGA :

As with all surface mount devices, bending due to a difference in coefficient of thermal expansion between PCB substrate and BGA (thermal stress) or flexing and vibration (mechanical stress) can cause the solder joints to fracture.

Thermal expansion issues can be overcome by matching the mechanical and thermal characteristics of the PCB to those of the package. Fig.5 shows typical thermal profile normally used to solder BGA Ics.

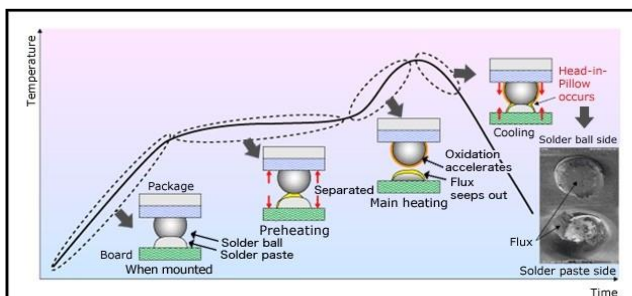

Fig : 5 Typical Thermal Profile

Mechanical stress issues can be overcome by bending the devices to the board through a process called " under filling ", which injects an epoxy mixture under the device after it is soldered to the PCB effectively gluing the BGA device to the PCB.

5.4 INSPECTION DIFFICULTY:

Once the package is soldered down, it is difficult to identify the soldering faults. For this x-ray machines, special microscopes and industrial CT scanning machines have been developed to overcome this problem.

If BGA is found to be not properly soldered, it can be removed in a rework station. Fig.6 shows performance of good solder joint using BGA.

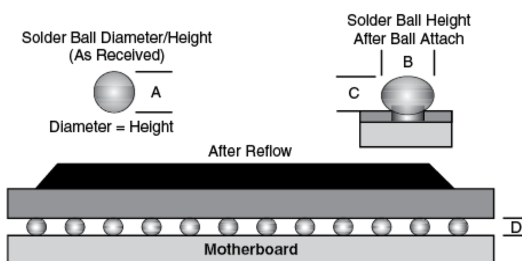

Fig : 6 Performance of good solder joint using BGA.

Intel used package designated BGA for their Pentium II and early Celeron mobile processors.

The micro-FCBGA (Flip Chip Ball Grid Array) is Intel's current BGA mounting method for mobile processors that use a flip chip binding technology. Fig.7 shows typical PCB which consists of SMT components and BGA IC. Fig.8 shows BGA rework station used to solder/de solder BGA ICs.

Fig : 7 PCB with BGA IC

Fig : 8 BGA Rework Station

5.5 FIELD OF APPLICATIONS :

BGA rework station can be used for [7],

- Mobile and Radio systems devices

ISSN: 2321-8169
3784 – 3787

- Medium and large scale service centers
- Cellular phones, PDAs, Handhelds, Notebooks and Motherboards
- LAN devices, Network nodes and Military Communication Equipments
- Portable medical equipment

Conclusion:

BGA Rework Stations are used in different industries and service stations for rectifying and repairing varied types of computers and laptops known for their effective performance, these products help in the work quality of the user. PCB space savings is possible with BGA solder joint technology which is advantageous and necessary. The solder joints formed when using this technology are reliable and robust. As BGA devices and applications continue to evolve, solder attachment methods must also evolve to meet the need of these more advance and dense electronic packages and applications.

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Shahera Patel received her B.Sc. and M.Sc. degree in Electronics from Sardar Patel University, V.V. Nagar, Gujarat, India in 1989 &1991 respectively. She obtained her Ph.D. degree in Electronics in 2005 from Sardar Patel University. She has joined as Technical Officer-I in University Science Instrumentation Centre (USIC), Sardar Patel University in 1991. At present she is working as an Assistant Professor at Department of Electronics, Sardar Patel University. Her area of interest is in Instrumentation, Nano Science, Microprocessor and Microcontroller based automatic control and automation. She has attended more than 62 International / National conferences / Seminars / Workshops. She has presented and published about 42 research papers in conferences/seminars/journals. She was honored by Hari Ohm awarded for best research paper. She is a member of ISTE, IPA, Instrument Society of India of India. She has offered her services as a reviewer for various journals. Also, she has worked as a visiting faculty and given Invited talks in conferences and in various training programmes.