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DESIGN AND DEVELOPMENT OF LABORATORY BASED MODEL OF REWORK SYSTEM FOR BGA SEMICONDUCTOR DEVICES

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ABSTRACT

With the evolvement of new technology in semiconductor science, most of the sophisticated instruments contains compact multilayer printed circuit boards with large number of small size components and integrated circuits. These integrated circuits are mounted on the PCB by Ball Grid Array (BGA) technique. This paper contains new design approach for the development of a system for making and removing contacts of BGA semiconductor chips on PCBs by using ferromagnetic balls. The developed system includes Top heater coil with fan assembly and special regulated power supply, Bottom Infrared Heaters, Temperature sensor attached with Temperature controller, relays and supporting mechanical assembly with Rack and Pinion arrangement for top heater movement. The design and development approach of BGA rework system is having high density, good conduction and low induction leads. The development stages of different sections for BGA system are discussed.

Key Words : Solder, Infrared Heater, Ball Grid Array(BGA), Thermocouple, Controller.

INTRODUCTION

In recent years, with the technological advancement in electronics science and engineering have resulted in development of more compact sophisticated Gadgets/Instruments and components having reduced size. Since there is an extensive requirement for compact packages, density of surface mount components and other interconnecting joints, the solder attachment techniques and methods must also modify and continue to evolve.

In last decade, most electronic instruments used PCB 's in which components were based on Surface Mount Technology (SMT) and Pin Grid Array (PGA) Technology. The advancement in soldering technology and related processes are discussed.[1-7]

The most recent era now a days uses instruments having multilayer printed circuit boards which contains large number of components like Integrated Circuits (ICs) based on Ball Grid Array (BGA) techniques for Improved performance.

The assembling of integrated circuits are very important for the function of any devices. To get the density requirement for many SMT components, the Ball Grid Array (BGA) technique have been evolved with reliability. In the BGA technology instead of pins, for the contacts it uses metal balls which are soldered on to the surface of the printed circuit board.BGA can provide more interconnection pins that can be put on a DIP (dual in line or PGA)Package. In PGA technique, instead of using perimeter all bottom surface of the devices can be used. The leads are shorter which gives better performance for high speed device applications.

The BGA technique known as BGA Rework station/system is used for the repair or refinishing i.e. solder/desolder operation of BGA semiconductor chips/devices in an electronic printed circuit board (PCB).[8]

In the present era of computer and mobile technology and their tremendous use in routine day to day life, there are more possibilities for the failure / damage of these devices. In particular there are more chances for the damage of Integrated circuits - Surface mount device package(SMD). In order to repair these kind of electronic instruments/gadgets, replacement of the SMDs can be done more easily & conveniently compared to other methods by means of BGA rework method.

The main aim of BGA rework system is to produce high-quality, high density effective Soldering. With the use of BGA rework streamline operation can be carried out which gives improvement in the success rate of soldering and also reduces the overall Soldering costs.

OBJECTIVE OF THE DEVELOPMENT OF BGA SYSTEM :

For numerous SMT components, to meet the required density, conventional SMAA soldering techniques i.e. BGA have been challenged with reasonable reliability, automatic processing and difficulties associated with its inspection.

Technology of mass processing is not effectively and easily applicable for repairing or replacement of single device. Therefore, it is necessary to change the faulty/damaged components using special manual methods by experts using proper equipment. In particular various area array packages such as BGA devices require appropriate tools and expertise.

A rework system is a system to do all type of work. The word rework is used for the mounting and demounting of BGA ICs on an electronic printed circuit board. (PCB).

Many hardware Users have been involved in handling scientific sophisticated research instruments, computer maintenance, repair of medical equipment, communications equipment maintenance, video game maintenance, training teaching, and in variety of such other fields.

BGA rework system existing in the market are very costly. In this context, it is of high demand to develop such type of BGA rework system for the technical persons who are involved in repairing of such kind of the electronic instruments/gadgets.

Since very few companies are involved in developing the BGA Rework Station, the main aim and objective of this work was to design and develop Ball Grid Array rework system where for BGA integrated circuits temperature profile is calibrated to assemble and disassemble it from various circuit boards having different sizes.

With this view, It was initiated and attempt was made to design and develop low cost, profile based, more reliable laboratory based model of BGA rework system which is having high density, good conductor and low inductance leads.

The developed model includes Infrared Heaters, Heater coil with fan assembly and special regulated power supply, temperature controller, contactors, relays and supporting mechanical assembly with Rack and Pinion arrangement for the Heater movement.

THE MAIN OBJECTIVES ARE

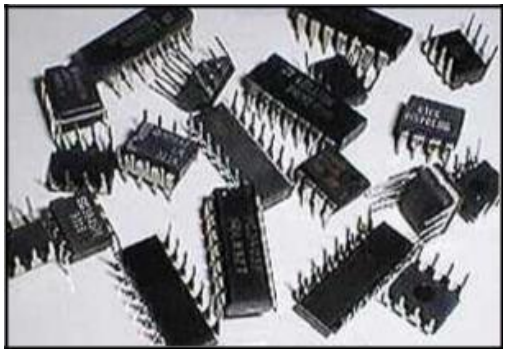
(i) Design and Development of BGA rework system for technical persons involved in repairing of sophisticated Instruments/Gadgets in which mostly BGA Integrated circuits are used.

(ii) To focus on awareness about the latest technological development i.e. GRID technology among students of electronics science, physics and electrical engineering discipline.

(iii)To impart hands on Practical / Project training at chip level for assembling and disassembling SMD based components in multilayer PCB's which is now a days widely used in computers, laptops and other sophisticated instruments to generate technical manpower /Hardware technician

TECHNOLOGICAL BACKGROUD AND ADVANCEMENT :

(i) Early days, Integrated circuits used were of



DIP or Metal can packages having,

- Increased Size of IC's.
- Wide and Thick pin connection.
- More space & More complexity in PCB.
- Big size and weight of Instruments.

Ex: Big Computers – occupied more space.

Demand for Miniaturization

(ii) Surface Mount Devices (SMD) :

(a) Pin Grid Array (PGA) :

Less Pin Thickness, More pin allocation in small size IC's

(b) Ball Grid Array (BGA) :

1. Less distance between IC and PCB. Therefore low thermal resistance between IC package & PCB. Soldering of IC through metal Balls (Leaded and Lead free)
2. Avoids overheating of PCB
3. High Density, Good conduction which leads to the better performance for high speed devices.

EXPERIMENTAL AND DISCUSSION :

DETAIL DESCRIPTION OF INSTRUMENTATION AND HARDWARE DEVELOPED FOR BGA REWORK SYSTEM

This is an advanced new design approach for the development of low cost BGA rework system.

This developed BGA rework system gives joining of SM components easier than normal bench top techniques. It also makes mounting of IC's perfectly. The advantage of this system is it minimizes thermal stresses due to difference in temperature during rework and mounting.

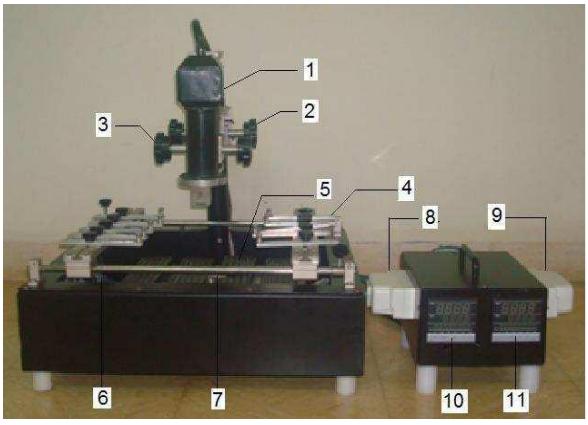
BGA Rework system is composed of Heater Assembly which consist of Top Heater and Bottom Infrared Heaters. The function of Top Heater is to blows hot air directly on the BGA IC. This ensures that the IC gets enough heat so that the required melting point is achieved thus the IC soldered/desoldered well. The Bottom IR Heaters are connected in series

which covers more heating surface at the bottom. This is required to pre heat the Printed Circuit Board uniformly so that it can not crack because of differential temperature.

BGA Rework Station also uses PCB Table with cooling Fan and Locking handle seat / Temperature controller which controls the upper and lower heater assembly.

Fig 1 Shows the develop BGA system with its parts name indicated.

Fig.1 : Developed BGA rework system
(Top) Upper Heater



1. X-axis Regulator
2. Y-axis Lifting Regulator
3. PCB Table and locking handle seat
4. Cooling Fan
5. Bottom Infrared Heater (Pre-Heater)
6. Temperature Sensor

7. Main RCB switch

8. MCB switch for Heaters

9. Upper Profile based Temperature Controller

10. Bottom Profile based Temperature Controller

DETAIL DESIGN, ARRANGEMENT AND ASSEMBLY OF INDIVIDUAL PART :

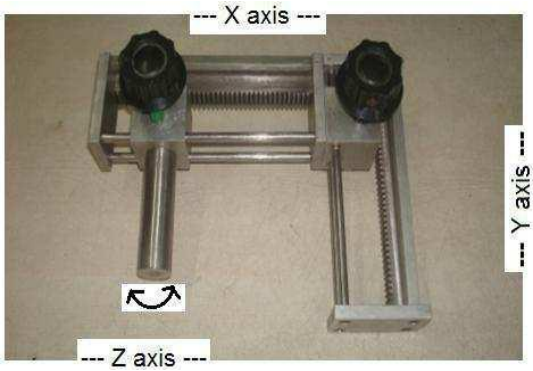
1. **(Top) Upper Heater Assembly :** The function of Top Heater is to blow Hot air to the SMD IC for Soldering, Disoldering and Reballing purpose

Fig.2 Development of Top Heater Assembly

2 and 3. X-axis and Y-axis Lifting Regulator :

This is used to move the Top heater in X,Y and Z direction to adjust the Printed circuit board to obtained best position for hot air to blow.

Fig.3 Development of Rack and Pinion Arrangement



4. PCB Table and locking handle seat :

This is used to hold the Printed circuit board from which IC is to be replaced or reballing is to be carried out.

Fig.4 PCB table and Locking handle seat

5. Cooling Fan : (fig. 5)

It is used to cool the bottom Infrared Heater. Rating of the Fan is 12V DC, 0.60A.

Fig.5 Cooling Fan

6. Bottom Infrared Heater (Pre-Heater) : (fig.6)

This is used to produce uniform temperature to the Printed Circuit Board. Total five IR heaters are used.

3 IR heaters used with capacity : 600W and
2 IR heaters used with capacity : 300W

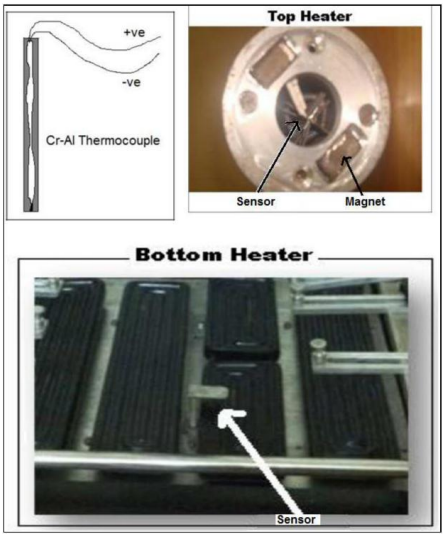
IR Heater having Ceramic coating.

Fig.6 Bottom Infrared Heater

7. Temperature sensors used with Top and Bottom IR Heater :

This is used to sense the heat produced by the Top and Bottom IR Heater. Sensors used Chromel – Alumel (Cr- Al) K-type temperature sensor. Range of the maximum temperature measurement used is about 350^0C

Fig.7 Temperature Sensor



8,9,10,11. Profile based Temperature controller (PFY 700) along with Main RCB Switch and MCB Switch for Heaters :

This is used to control the profile based temperature of Top and Bottom IR Heater. It is having Solid State Relay based output. 16 steps of Temperature Profile can be controlled. Here the calibration of Temperature measurement profile was carried out to get proper melting of solder balls.

Technical Specification of Model PFY 700 :

Input Supply voltage : AC 230V

Frequency : 50 HZ

Power consumption : Approx : 3 VA

Accuracy : 0.2 % FS ± 1digit

Sample time : 250ms

Thermo Couple : K type

Facility : Output 1 and Output 2 :

For heating and cooling control use.

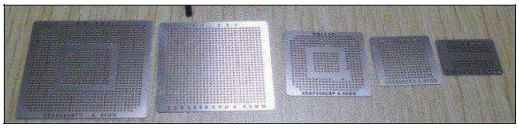
Fig.8 Profile based Temperature Controller with MCB and RCB switches

ACCESSORIES USED :

(i) **IC Stencils and Solder Balls** :

IC Stencils and Solder Balls of Different sizes are shown in Fig.9. Depending on the sizes of BGA IC and number of pins used proper selection of stencils can be done.

Fig.9 IC Stencils and Solder Balls of Different sizes



BALL SPECIFICATIONS :

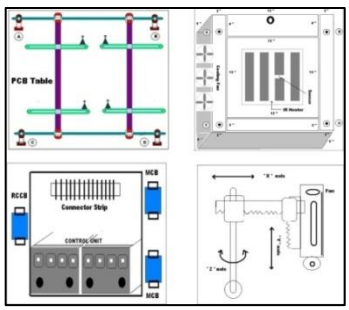
- **Ball Diameter** (mm)
- 0.76mm
- 0.635mm
- 0.50mm
- 0.45mm
- 0.406mm
- 0.35mm
- 0.30mm
- 0.25mm
- 0.20mm
- 0.15mm
- 0.10mm

(ii) **Ultrasonic Cleaner :**

It is used to clean the PCB and Stencils. Also, the function of ultrasonic cleaner is to remove the stencil from the Printed Circuit Board after Re balling operation. This is done because suitably vibrating the sensor probe .

Fig.10 Ultrasonic Cleaner

COMPLETE SCHEMATIC DIAGRAM OF BGA REWORK SYSTEM :



OPERATING PROCEDURE :

Once the faulty IC is detected it is required to replace/ reball the IC with the help of BGA system which includes the following steps.

1. Fill the Faulty IC with BGA flux.
2. Place BGA IC in PCB Table and locking handle seat of BGA rework system. Heat the IC up to 230^0C to 260^0C by Top Heater and give 200^0C temperature by Bottom IR Heater (Take due care while placing PCB)
3. Remove IC from the Printed circuit board. Clean it properly with NC Thinner and Flux
4. Clean the IC and their appropriate Stencils with NC Thinner.
5. Paste flux on both IC and Stencil.
6. Spread the solder ball on both the components.
7. Again follow the step 2 to heat both the IC and Stencil.
8. To separate the stencil form the IC both the arrangement are to be dipped in the tray filled with NC Thinner proper vibration is given by Ultrasonic Cleaner to the thinner solution.
9. In this way the BGA IC is reballed .
10. The PCB with reballed IC is used to test for its proper functioning.

PARAMETERS OF BGA :

(i) Upper Heating IR : 600W
(ii) Bottom Heating IR : 2400W
(iii) Total Power Consumption of the instrument 3000W

CONCLUSION :

Laboratory based model of rework system for BGA semiconductor devices is designed and developed. This is a new design approach in

which Infrared heaters are used. These are used because it has special feature of local heating and good penetration power which avoids damage and overheating of nearby components. The developed system is reliable, simple and easy to operate. The reballing work with this system is done effectively and efficiently. It provides accurate and precise temperature control which is the demand of recent advance IC packages. The temperature profile for the system is calibrated.

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