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Advancement in Soldering Technology Main Issues and Its Perspectives - Part 1

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Abstract: The advancement of electronics and related instrumentation would be possible in mass production of electrical and electronics components/equipments with accomplishment and advances in soldering technology. With the advent of different components like resistors, capacitors, diodes, transistors and especially integrated circuits have changed the electronics world completely. As there is an intensive demand for package miniaturization and the density of surface mount components and other interconnects continues to advance, the technology for solder attachment methods must also improve and continue to evolve. This paper discusses the evolvement of soldering techniques, its applications and the criteria to select proper soldering techniques for specific applications.

Keyword s: *Solder, Component , Interconnection, Techniques, Solder Iron*

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1. Introduction

The technical advancement in science has introduced more and more sophisticated compact electronics instruments and miniaturized components. The modern electronics instruments are very compact, light weight and with versatile facilities. This electronic instruments /devices contains multi layer printed circuit board in which one or more number of integrated circuits are used for the better performance.

The assembling of integrated circuits are very important for the function of any devices. In early days , integrated circuits were used in Dual in line package (DIP) or Metal can packages type. It requires more space. It has wide & Thick pin connection thereby having more complexity in PCB. So overall size and weight of Instruments was increased. Since few decades there is an existence of surface mount area arrays and are extensively becoming more and more important as printed circuit board (PCB) mounting and assemblies became further complex with package miniaturization and density. As surface mount area arrays (SMAA) solder joint technology is advantageous and necessary for PCB space savings i.e. package miniaturization, it is also extremely important that the solder joints formed when using SMAA technology are reliable and robust.

During the development of this new SMAA technology much attention was given to existing SMAA structures such as Ball Grid Array (BGA) and Column Grid Array (CGA) [1].

Soldering technology is a never ending story for more than 5000 years.

People had scarcely learned how to use different metals for different purposes when need arise to join them. Number of tools, jewellery and weapons [2] we know from the early Bronze age were given their utility and beauty of soldering.

Soldering ‘came of age’ when tin was discovered as a soldering metal- before 4000 years ago ! The most advent and impressive achievements can be attributed to the ancient Romans. They soldered 400 km long water pipes made of lead and conjured up stoves and tubs made of bronze.

During last few decades, particularly in last century, not only witnessed an increased improvement in the craft man’s soldering skill, but also our understanding was refined in respect to the scientific interactions which take place during soldering.

Consequently, soft soldering developed into an independent field of production engineering in the electronics industry. Thus, it combines the disciplines of Physics, Chemistry, Metallurgy and Mechanics to an equal extent.

In 1921, Ernst Sachs developed the first electric and mass produced soldering iron for industry.

With the introduction of the circuit board in 1950’s, new soldering techniques were needed and the first ‘wave soldering system’ was introduced.

Further, with the advancement of SMT technology, reflow soldering systems were introduced to serve the growing SMT market.

This paper discusses mainly the issues evolved and its perspectives with the advancement of soldering techniques / technology.

2. Soldering Methods / Techniques

The soldering techniques used today be mainly classified as ,

(1) Electrical Method (Mainly using rosix flux)
(2) Non Electrical (Mechanical) Method (using acid flux)

With the advancement of discrete components like resistors, capacitors, diodes, transistors and especially integrated circuits have revolutionized the whole world. These devices are of very little value when used as an individual components. For the effective use of these devices, they should be electrically connected with each other and to the mechanical devices. The majority of these electrical connections are made by soldering. Also it is used to provide a physical connection between the components and its supporting printed circuit board.

Throughout the years solder has been used in various applications. However, in the latter part of this century it was the invention of electronic devices that led to rapid advances in soldering technologies. Table 1 Summarizes soldering techniques and corresponding equipment used.

Table 1:Soldering techniques & equipment used

Sr. No.	Technique of Solder	Equipment Used
1	Solder joint	Solder Gun
2	Electronic contact wave soldering	Solder pot with automation using conveyor belt, pump and sprayer arrangement
3	Re-flow soldering	Re-flow oven
4	BGA	BGA Rework Station

Without the soldering technology, mass production of electronic equipment would not have resulted.

3. Materials

Soldering is a method of making a permanent electrical and mechanical connection between metals. Glue, which forms a solely physical adhesive bond , solder chemically reacts with other metals to form a different alloy. While there are so many different advanced processes utilized in soldering, virtually all of them involve four basic elements : Base metals, Flux, Solder and Heat.

3.1 Base Metals:

A base metal is any metal that contacts the solder and forms an intermediate alloy. When electronic components like Resistors, Capacitors , IC's etc. are connected to a printed circuit board , the component's leads or pins and board's metallic circuitary are the base metals that will contact the solder. Number of metals like silver , brass , copper , bronze and some steels , readily react with solder to form strong chemical and physical bonds. Other metals , such as cast iron, aluminium , high alloy steels and titanium form very difficult to solder.

It is true that there are metals that do not react with solder is important , that they are useful in fabrication of soldering machinery. Also these metals can be used as temporary covers for components that are not to be soldered . It is important to mention the fact that ceramics do not react with solder. This draw an attention and allows a manufacturer to draw liquid solder over a ceramic circuit board without having any chemical reaction between the solder and the board itself.

There are chances of surface oxidation on the base metal and how quickly solder can react with it. If oxidation is more, solder bond will be weaker. It is fact that most metals when heated oxidize at a very greater rate which ultimately creates a specific problem, because the chemical reactions associated with soldering require high temperatures. Flux is the basic and elemental material use to overcome problems caused by oxidation.

3.2 Flux :

Prior to soldering , often flux is applied as a semi liquid paste to the surface of the base metals. Although, flux has a number of perspectives /purposes.

1. When the base metals are being heated to soldering temperature, it prevents it from oxidizing.

2. Flux covers the surface to be soldered , Shielding it from oxygen and thereby preventing oxidation during heating.

It can be possible to virtually completely clean off the oxidation layer using a strong acid. However, this causes a serious problem by damaging the electronic components. Even mild acids leave a residue that continues to corrode after the soldering process is complete which ultimately lead to future failure.

When the liquid solder is applied , the flux must readily move out of the way so the solder can come into direct contact with the base metal, which in turn inevitably combines with the solder. This lowers the surface tension of the solder upon contact, thereby allowing a more efficient wetting.

Flux is made up of by mixing chemicals and solvents. The chemical part normally includes the active components. The solvents is primarily the carrying medium which determines the cleaning method to be employed to remove the flux residue. Fluxes can be removed with simple water

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treatments or by some cleaning agents such as alcohol , organic solvents , terpenes and chlorinated flurocarbons .

3.3 Solder :

There exist variety of metal and metal alloys that can be used as solder. The selection is primarily based on its properties such as brittleness, ductility, heat conduction, expansion at high temperatures , electrical resistance , toxicity , wetness ,tensile strength etc and of course its cost.

The most commonly used solder in the electronics is a tin-lead alloy. These alloys have a relatively low melting point and having low cost in comparison with other alloys with similar properties. Lead is a very cheap and abundant metal, so the cost of a tin- lead solder is primarily controlled by the cost of the tin.

However there are certain health hazard problems with lead which needs attention and therefore lead free techniques are evolved now a days.

Different Tin-Lead ratio is used for solder [3] such as

A : Lead Bearing alloys (Commonly Used) :

(i) 63% Tin (Sn) and 37% Lead (Pb) – 361^0F/183^0C Known as eutectic tin-lead alloy can be applied as a liquid just above the melting point, and then as it cools it will transform directly into a solid. This makes it possible to form solid solder joints very quickly.

(ii)60 % Tin (Sn) and 40% Lead (Pb) – 361^0F-374^0F /183^0C-190^0C : This alloys exhibits a nearly eutectic change from solid state to a liquid state.

It is extremely important to keep the solder, free of impurities. Otherwise other metals in a tin-lead alloy results in drastic changes in surface tension, poor wetting and thereby poor solder, change in melting temperature etc. Oil, vapors, dust and other non-metal impurities imposes weakening of solder bonds.

Common forms of solder include Chips, Bars, wire(Often with a core of flux), each is having advantages in specific process of soldering.

(iii) 62 % Tin (Sn) and 36% Lead (Pb) + 2 % Silver(Ag)– 354^0F-372^0F /179^0C-189^0C :Non-Eutectic Solidus/Liquidus Temperatures.

B : Lead Free Alloys (Proposed for Hand soldering Applications):

(i)Sn 96.5/Ag3.5 – 430^0F / 221^0C (Eutectic)

(ii)Sn96.5/Ag3.0/Cu0.5 – 423^0F -428^0F / 217^0C – 220^0C (Non-Eutectic Solidus / Liquidus Temperatures)

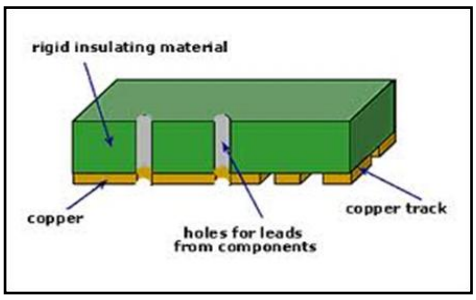
(iii)Sn 99.3 / Cu 0.7 – 441^0F / 227^0C (Eutectic)

4. Solder iron

Along with an increase in melting points of the new alloys, advancement in the ways that hand soldering tools perform are critical as well.[4] The requirement to transfer heat to the application without significantly increasing the working temperature of the soldering tool being used can only be achieved by increasing the thermal capacity of the tool. An increase in the thermal capacity accompanied by the direct transfer of energy from the soldering iron's heating element to the tip.

To join electrical parts together to form an electrical connection using a molten mixture of lead and tin is with the use of a soldering iron[5]. A large range of soldering irons are available.

Certain factors one should keep in mind while choosing soldering gun are – Voltage (Iron runs from 230V,12V,24V etc. with special controller), Wattage (low power rating between 15-25 W), Temperature control , Anti static protection , Bits etc. Fig.1 shows history of Integrated circuits and printed circuit board.



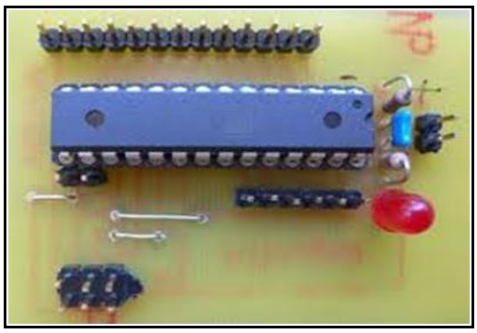


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Fig. : 1 History of Integrated circuits and printed circuit board.

Soldering irons are best used along with a heat resistance bench – type holder so that the hot iron can be safely parked in between use. Soldering stations already have this feature, otherwise a separate soldering iron stand is essential, preferably one with a holder for tip-cleaning sponges.

Conclusion

For good performance of any electronic circuits / sophisticated Instruments it is extremely important to have good interconnection between desecrate components in the PCB which should have low contact resistance, high resistance to chemical attack, Good thermal heating, Rapid cooling after heating to a melting point etc.

The various soldering techniques and corresponding equipment used are summarized. The main problems, selection of good solder and related parameters are discussed.

The following part in the series of this paper will discuss further advancement of solder technology and related Instrumentation and control developed.

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Author Profile

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 60 International/National conferences/ Seminars/Workshops. She has presented and published about 40 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..