EFFECT OF DIFFERENT CONCENTRATION OF CARBON NANOTUBE (CNT) IN SAC305 SOLDER ALLOY ON THE HARDNESS, WETTABILITTY AND RESISTIVITY UNDER THERMAL AGING

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DECLARATION

I hereby declare that this project entitle "Effect of Different Concentration of Carbon Nanotube (CNT) in SAC305 Solder Alloy on the Hardness, Wettability and Resistivity Under Thermal Aging" is the result of my own work except for the one with the citation.

Signature :……

Name :……

Date :…….

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature :……

Supervisor's Name:……..

Date :……

DEDICATION

I would like to dedicate to my mother and father, my siblings, my friends and my supervisor, Dr Nor Azmmi bin Masripan for their full support and encouragement during the research.

ABSTRACT

Today, as in this new era, the need of a metal bonding with another metal is high. It is because it is the heart for the electronic industry as it is used a lot in the electronic devices. The metal with the metal bonding can be achieve by the process called soldering. Therefor this project is focusing on finding the best solder paste for the electronic where the solder paste is analysed to find out the most conductive, high resistance in heat and long lasting when there are electric current run into it. For this project, the SAC305 and MWCNT are used as the solder paste that undergoes thermal aging for three hour with four different wt% of CNT (0, 0.01, 0.02, 0.03 and 0.04). The CNT is choose because it have a great electrical properties where it has high conductivity, while SAC305 has a high joint strength and high wettability. Thus the CNT that are mixture with the SAC305 can improve solder properties greatly. The solder paste will undergoes, cold mounting and will be grind to get the cross section part. The cross section part of the solder paste will be analysed using the image analyser, four point probe, nano indenter and ImageJ software. Based on the data, it shows that the solder alloy with 0.04 wt% has the highest result on the electrical conductivity and the wettability where it shows the value of resistivity of 0.2 mΩ/□ and it show the contact angle of 20.979˚. For hardness, the solder alloy with 0.0 wt% has the higher hardness with 17.4 HV and for the IMC thickness, the solder alloy with 0.01 wt% show the closest value to the ideal thickness of IMC layer which is 2.3164 μm.

ABSTRAK

Pada zaman era baru ini, keperluan untuk ikatan antara logam dengan logam yang lain adalah sangat tinggi. Ini kerana ia merupakan kunci utama di dalam sesebuah industri elektronik di mana ia banyak digunakan oleh alat-alat elektronik. Ikatan antara logam dan logam yang lain dapat dilaksananakan melalui satu proses yang dipanggil pematerian. Oleh itu, projek ini memberi tumpuan dalam mencari pes solder yang terbaik untuk elektronik dimana pes solder tersebut dianalisis untuk mencari pes solder yang paling konduktif, rintangan yang tinggi terhadap suhu dan tahan lama di mana arus elektrik dapat mengalir melaluinya dengan lancar. Untuk projek ini, SAC305 dan CNT telah digunakan sebagai pes solder dan telah memalui penuaan haba selama tiga jam dimana setiap pes mempunyai empat wt% CNT yang berbeza (0, 0.01, 0.02, 0.03 dan 0.04). CNT telah dipilih kerana ia mempunyai ciri-ciri elektrik yang bagus di mana die mempunyai kadar konduktiviti yang tinggi. Manakala SAC305 pula mempunyai kekuatan joint yang tinngi dan tahap basah yang tinggi. Oleh itu gabungan antara CNT dan SAC305 ini dapat meningkatkan ciri-ciri pes solder secara mendadak. Pes solder tersebut akan melalui pemasangan sejuk dan akan dikisar untuk mendapapatkan bahagian tengahnya dan bahgian tengah pes solder tersebut akan dianalisis menggunakan penganalisis imej, four point probe, nano indenter dan ImageJ software. Berdasar kan data, ia menunjukkan bahawa pes solder yang mempunyai 0.0 wt% mempunyai nilai yang paling tinggi dalam elektikal konduktiviti dan tahap kebasahan nya dimana ia menunjukkan nilai rintangan sebanyak 0.2 mΩ/□ dan ia menunjukkan sudut sentuhan sebanyak 20.979˚. untuk kekerasan, pes solder dengan 0.0 wt% mempunyai nilai kekerasan yang paling tinggi iaitu sebanyak 17.4 HV dan untuk ketebalan lapisan IMC, pes solder dengan 0.01 wt% menunjukkan nilai yang paling dekat dengan nilai ideal untuk ketebalan lapisan IMC dengan bacaan 2.3164 μm.

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I would like to take this opportunity to give my thanks to Allah SWT who give me strength to finish this project. Without His help I would be unable to finish this research project.

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PCB	Printed circuit board
SAC305	96.5Sn-3.0Ag-0.5Cu
CNT	Carbon nanotube
UV	Ultra violet
E	Young's modulus
Fe	Iron
Pb	Lead
Ag	Silver
Cu	Copper
UTS	Ultimate tensile strength
IMC	Intermetallic compound layer

CHAPTER 1

INTRODUCTION

1.1 Background

In this new era, the need for the bonding metal to metal or metal to other substance is high because it is the foundation technology for the electronic industry. It can be done by welding, brazing and soldering. The difference between these methods are the processing temperature and the melting temperature of the metal. In comparison between these methods it show that soldering is the best way that enables electronic assembly. Solder by mean is a mixture of alloy with melting point of 90° to 450° use in a process called soldering and soldering is the process that used the filler metal to joint apparent material. Soldering is used in many thing like in television, personal computer and even in our smart phone that we cannot live without. It is used in almost every electronic device that we have nowadays.(Rahn, 1993)

There is two type of solder which is the wire solder and the solder paste. For the wire solder, it comes in easy, medium and hard. When soldering a piece for example likes bezel it will have a multiple step begin with the hard solder where it has the highest melting temperature. Then it will move to the medium solder where it will flow before the hard solder and lastly the easy solder where it flow the quickest. For the paste solder it come with soft, medium and hard. It used the same step like the wire solder but for the solder paste, the paste

have already contain flux, so there is no need to apply extra flux when using it thus making the work easier.

Soldering is very important in our live and why do we have to learn about the soldering come with many reason. Without soldering we will not have this technology like our personal computer, mobile phone and others. A single missed connection will make the electrical appliance from stop working. Quality in the soldering works is needed to create a firm joint between different pieces of metal used to make a single item. It is essential to create a good connection between the wires so that the appliance can work like it should be. Therefore, this project will increase the reliability of the soldering by study on the effects of aging temperature towards solder paste when adding with different concentration of carbon nanotube (CNT).

1.2 Problem Statement

Soldering is the process that used the filler metal to joint apparent metal and it is used mainly in all of our electrical appliance. Soldering has a lot of advantages in this era of development where nowadays human cannot live without the electrical appliance. For example the mobile phone. Recently, researcher is focusing on finding the best method to do the soldering with high conductivity without disturbing the functionality. In this project we used the SAC305 solder that are mix with carbon nanotube (CNT) in order to improve the reliability of the soldering process.

However before we find the most suitable material or ways to do the soldering, there will be a lot of failure. Most of the soldering material that they used in the previous study have a lot of disadvantages same goes with the soldering process. Some of the disadvantage of the soldering are the connection between the material is weak unless its reinforced with

other material to change the properties of the solder paste and increase the solder performance so it will be suitable to use in electrical appliance and lead free.

Therefore to overcome this problem, this project will be focusing on to find effect of different wt% of CNT in SAC305 solder alloy on the hardness wettability and resistivity under the same thermal aging. In this project we will investigate the characteristic of the solder paste when it is subjected with different concentration of CNT that has undergoes the same thermal aging temperature.

1.3 Objectives

i) To study the microstructure of the composite solder subjected to different percentage of CNT after undergoes the same thermal aging temperature.

ii) To determine the hardness and the electrical conductivity of the composite solder with different percentage of the CNT after thermal aging temperature process.

iii) To investigate the relationship between morphological of the composite solder with hardness of the composite solder.

1.4 Scope of Project

i) This study is focusing on the composited solder which is a mixture of the solder paste (SAC305) with MWCNT subjected to different percentage of the MWCNT (0.01, 0.02, 0.03 and 0.04) with the thermal aging of 200℃.

ii) The composite solder without MWCNT but still undergoes with 200℃ thermal aging will be a baseline of this study.

1.5 General Methodology

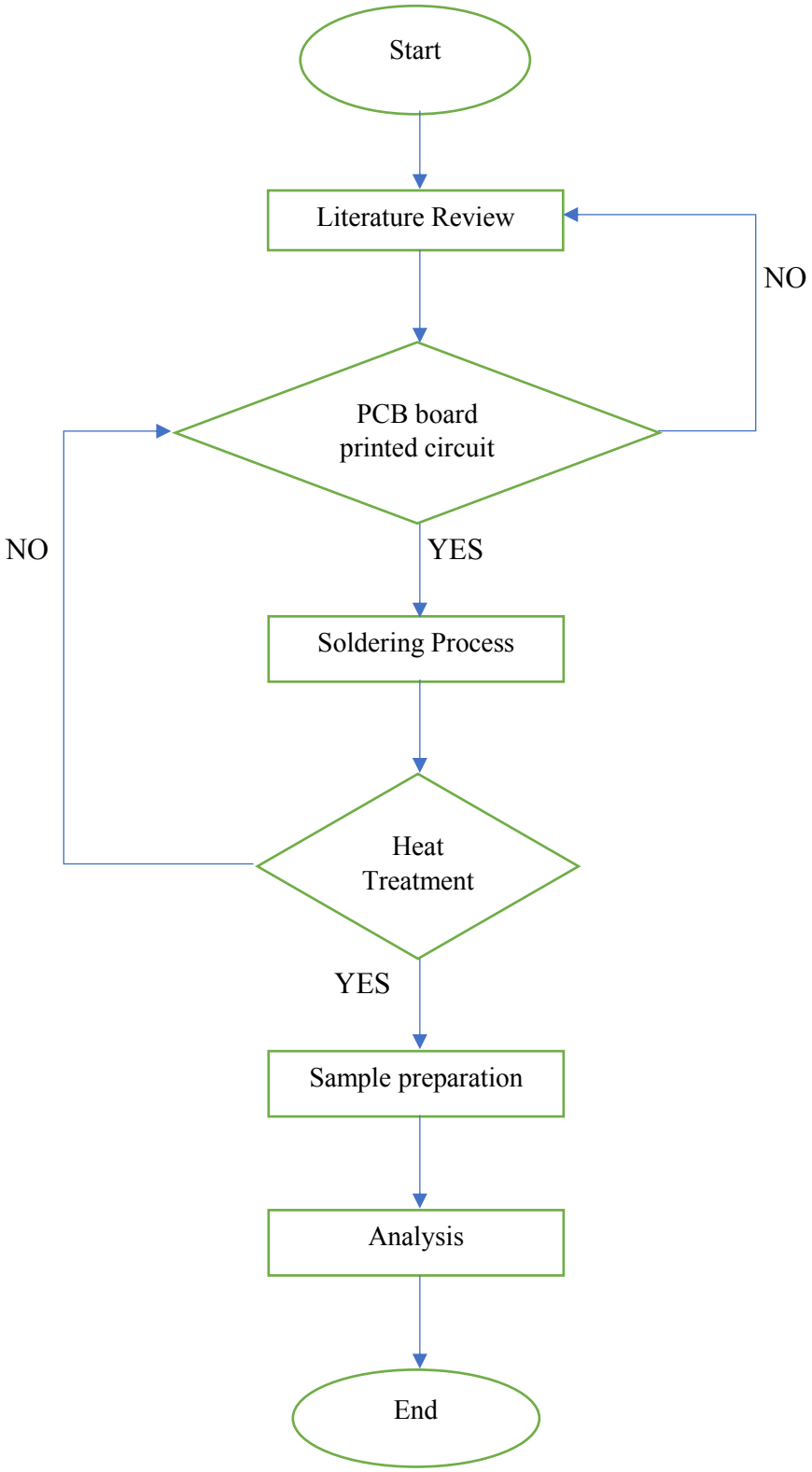


Figure 1: general flow chart of the experiment process

For the methodology. First we have to find some information from the journal that we can found in the internet or in the library to give us the general knowledge and guide us in this study. Next is the PBC board printed circuit progress where it has a several step begin with print out the accublack paper then do the ultraviolet curing (UV curing) process where the ultraviolet light is used to instantly cure or dry the inks, coating or adhesives. After that we will develop the PCB and enter the etching process where it used a strong acid to cut the unprotected part of the metal surface. Then lastly we do the Photoresist Stripper Process where it is done to neutralize the acid.

After that is the soldering process, which is the process of joining the metal with other material. Heat treatment is where the sample is put in the oven repeatedly for a different amount of time. Then the sample is cooled down at the ambient temperature. Next is the sample preparation. The sample is prepared by cold mounting, where the resin is mixed with a hardener to provide the mounting compound. The mixture is mixed in the mounting cup. After cold mounting process, the specimen is cut so it has a cross section.

Lastly is the analysis part. From the cross section, the specimen is analyse using the image analyser to find out the microstructure of the solder alloy. The specimen then will be tested for its hardness where the specimen is put under the nano indenter machine to undergo the hardness test and the data will be displayed on the computer to see toughness of the specimen. Same goes to the conductivity test that the specimen is tested to find out the electrical conductivity of the solder past of different concentration of CNT that undergoes thermal aging at 200℃.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

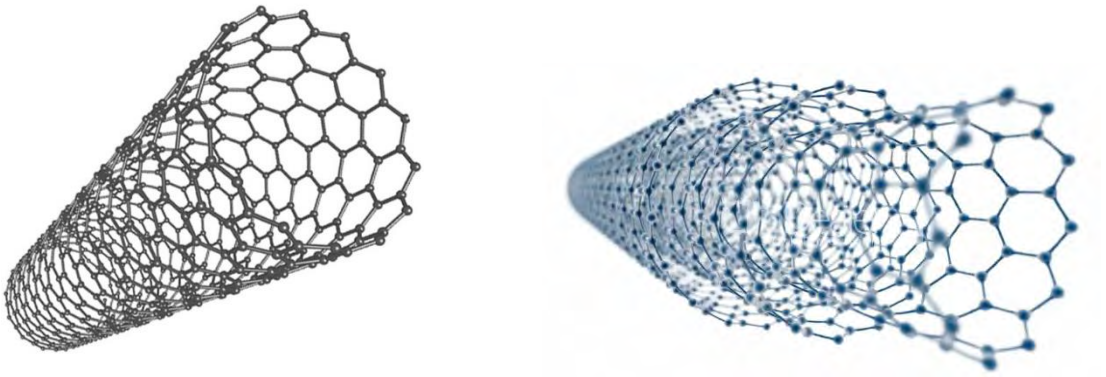
In this chapter the past review of the wetting characteristic of the Solder paste of the carbon nanotube (CNT) that are mixed together with 96.5Sn-3.0Ag-0.5Cu (SAC305) is studied where the type of CNT used is the multiwall CNT (MWCNT). This chapter also studied about the behaviour or the change of in the microstructure of the solder paste that undergoes thermal aging with different concentration of CNT. This chapter collects data of from the past journal and reference book of the same area of study to understand more and related the topic area of the project. The comparison from the past study are also study so that the best method or the data can be obtained and can be used in this project.

2.2 Solder Paste

Solder paste is usually used in the electronic component where it is used in manufacture of printed circuit boards where it connect the printed circuit boards with other electrical components. Before heating, the solder paste will behave like an adhesive components. After the heating process the solder will melt and it will forming a mechanical bonding with the board as well as an electrical connection. The types of solder paste used in this project is SAC305 added with CNT mixing together to form the best type of solder paste.

2.2.1 Carbon Nanotube (CNT)

Carbon nanotube (CNT) have a shape of a tube like material where it is made from carbons. CNT is very special because it has a very strong bonding between the atoms and has a high strength and stiffness (Schadler et al., 1998). There are many types of CNT like junction and crosslinking, extreme carbon nanotubes, single-walled, multi-walled and others. But the most used types of CNT is either single-wall nanotube (SWNT) or multi-wall nanotube (MWNT) as shown in Figure 2.1. It is said that a perfect CNT is CNT that the carbons are attached or bond in a hexagonal lattice but not at the end. The CNT is defected if the atoms are bond in the form of other shape like pentagons and heptagons.(De Volder et al., 2013)



a b

Figure 2.1: (a) Single-wall nanotube; (b) Multi-wall nanotube (De Volder et al., 2013)

CNT has been a worldwide commercial where the production of the CNT have achieved a several thousand tons in a year. One of the most production for CNT is where it is used in the thin films and bulk composite material. The MWNT is used as a fillers in the plastic as it is electrically conductive. For a high quality SWNT, it is usually used in the transistor because of its low electron scattering.

For the mechanical properties, the levers nanotube in the MWNT will vibrate caused by the thermal excitation and blurred the observer. The vibration amplitude is measured, and the value of the Young's modulus (E) gets is high. For the electrical properties, the carbon nanotube acts as a giant molecular wires where the electron inside it can move almost freely in any direction. It has the same properties as the ordinary metal. The molecule of the CNT are usually insulators and it can become a conductors when it is heavily doped.(Schonenberger et al., 2001)

2.2.2.1 SAC305

SAC305 is one of the lead-free alloy that contain 96.5% tin, 3% silver and 0.5% copper. SAC305 has a very high fluidity where it shows that the SAC305 can flow easily compared with the other alloys. SAC305 also have a really high joint strength and have a high copper dissolution rate. It also have a high wettability. That is why SAC305 is usually used in the electrical device.

Based on Cheng Nishikawa et al. (2008) Sn-Ag-Cu alloys had been considered as the most promising solder paste in electrical industry compare to the other as it has low melting temperature and suitable for the commercial components as it is compactible. The fact that SAC305 has been the industry standard for lead free solder alloy in Japan show that SAC305 was the most used solder paste compare to the other. Shnawah et al. (2012) state that a Sn-

Ag-Cu solder paste will have a good temperature if it contain high silver concentration where it is desirable in the electrical component.

SAC305 that are added with the high quantity of silver (Ag) is primarily used in the industry as the Pb-free solder alloy. This is because SAC305 has a very low melting temperature. Nai et al. state that, based on his studies, the Sn-3.5Ag-0.7Cu solder that has been added with carbon nanotubes with the range of 0.01-0.07 w% has shown that it did not lower or downgrade the resistivity of the Sn-3.5Ag-0.7Cu. It also show that the Ag content that added with iron (Fe) will gradually increase the electrical resistivity.(Amin et al., 2014).

2.3 Wetting Characteristic

Wetting has three phases of material, which are gas, liquid and solid. If the liquid has a high surface tension, it will have a low wetting ability and vice versa. But if the liquid has a medium surface tension, it can have a high wetting ability if it is added with the wetting agent. To find the contact of the angle of the wetting, the coloration between cohesive and adhesive force is needed. Wetting ability is also about the strength of the intermolecular interaction between solid and liquid.

Based on Chantaramanee et al. (2013), the Ag-coated single walled carbon nanotubes (Ag-coated SWCNTs) is used as the solder that mixed together with 96.5Sb-3.0Ag-0.5Cu in it. The solder paste with 0.01-0.10 wt% nanotube reinforcement were prepared. The 0.01wt% of the Ag-coated SWCNT improved the solder's wetting ability and it reduce the contact angle by 45.5% while with the 0.10% wt% it degraded the wettability. They have study about the effect of multi-walled carbon nanotube on Sn-Ag-Cu composite solder and it show that the wetting and mechanical properties were improved. The effect of the coated nanotube loading on wettability is shown on the Figure 2.2 below.