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# Effects of sintering temperatures on microstructures and mechanical properties of Sn4.0Ag0.5Cu1.0Ni solder alloy

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**Abstract**

This research was carried out to investigate the effects of sintering temperature on the properties of Sn-4.0Ag-0.5Cu-1.0Ni solder alloy by varying the temperatures. The Sn-4.0Ag-0.5Cu-1.0Ni solder alloy was prepared by using powder metallurgy method by press and sinter routes. 99.9% of pure Sn, Ag, Cu and Ni powder were used in this research where the pre-mixed powder undergoing milling process for 6 hours using a planetary ball machine. Hydraulic press machine was used to compact the solder powder at identically 5 tons(125 bars) for all samples. Five different temperatures of sintering specifically at 120℃, 150℃, 180℃, 220℃ and 250℃ were used. Characterizations on the microstructures such as grain size, thickness of intermetallic compound and, wettability angle were carried out using Scanning Electron Microscopy. Meanwhile, properties of the solder alloy were also evaluated through hardness and tensile test. It is expected that sintering process could be able to improve the strength of the solder joint by decreasing the intermetallic compound grain size. So far, most papers commonly used 180℃ as their sintering parameter without anyone providing the promising findings and various effects of the temperature onto solder. Therefore, this work is conducted to make a clarification and be the pilot study for the next sintering works for soldering. This paper reports experimental results of properties of Sn-4.0Ag-0.5Cu-1.0Ni solder alloy at different sintering temperatures.

## 1.0 Introduction

Electronic industries are booming the world market as the technology and gadget being the most crucial part in human life in this 21st century onwards. While these sector growing rapidly, it has driven a high demand of superior quality of electronic devices from the consumers across the world at any applications. As a matter of fact, soldering is one of the most necessity electronic systems to ensure the favourable performances of the devices to fit with basis or extreme environment applications such as military and oil production. To fulfil the work, solder with significant properties had to be carefully chosen.

Previously, Sn-Pb solder is widely accepted to the electronic system owing to its low melting point and better mechanical properties but due to health and environment concerns by Waste Electrical and Electronic Equipment(WEEE) and Restriction of Hazardous Subtances(RoHS), all range of Pb solder have been extensively banned since July 2006[1, 2]. Termination of Pb solder from industry has brought the cumulative studies of Pb-free solder as a new initiative solder today. The ranges of SnAgCu solder have been appointed as the most promising substitute for the previous Sn-Pb solder as it has the closest melting point to the SnPb solder and other effective properties[1-3].

Since heat and temperature is the major discussion in this work, conventional sintering process from Powder Metallurgy(PM) method has been used to study the effects of different sintering temperatures on the microstructure and mechanical properties of Sn4.0Ag0.5Cu-1.0Ni solder as no one reported before. Sintering is one of the heat treatment processes that purposely use the heat to enhance the strength of a compacted body by forming bonds(necking mechanism) between the particles, usually to a 60%-90% of the melting point of the main material in an amount of time[4-6].

As the sintering temperature increasing, speed oxidation will happen and form numerous pores between particles and this situation may lead to weaker mechanical properties but not if supported by protective gas such as inert hydrogen and argon gas[7]. Therefore, this study is conducted to enlighten the research area on the effects of different sintering temperatures on the microstructure and mechanical properties of Sn4.0Ag0.5Cu-1.0Ni solder without any precautionary gases.

## 2.0 Experimental procedures

Sn-4.0Ag-0.5Cu-1.0Ni solder alloy was prepared using 99.9% of pure powder. They were then pre-weighted according to the wettability percent and preceded throughout the stages of Powder Metallurgy routes. Using a planetary ball-mill machine with 1400rpm, the pre-alloy solder was milled for 6 hours non-stopped to achieve a uniform distribution powder. It was then taken out to re-weight into 1.5g for microstructures, hardness, SEM, EDX, IMC thicknesses and wettability angle analyses while 0.7g for lap-shear test, a set for each sintering temperatures. Compaction process were then took place using a hydraulic press machine (Specac-UK model of GS15011). A constant pressure of 5 tons was exerted onto all weighted powder and waited for 2 minutes to set the pellet. They were then sintered according to 120℃, 150℃, 180℃, 220℃, 250℃