PAPER • OPEN ACCESS

The Influences of Silver Content in Lead-Free Solder Sn-0,7CuxAg (SAC) in Physical and Mechanical Properties

To cite this article: Erwin Siahaan and Abrar Riza 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **1007** 012025

The Influences of Silver Content in Lead-Free Solder Sn-0,7CuxAg (SAC) in Physical and Mechanical Properties.

Erwin Siahaan, Abrar Riza
Mechanical Engineering Department, Faculty of Engineering Universitas Tarumanagara
Email address: erwins@ft.untar.ac.id

Abstract. *As an increment of soldering technology that SnPb has been banned since 2006 as Pb a toxic chemical content. The usage of Copper and silver has been found that can be alloyed to Sn as Sn-Cu-Ag (SAC). The characteristic of a new alloy such as Sn-Cu-Ag has to be achieved as Physical and Mechanical Properties SnPb. In this research is carried out of vary percentage of Copper and Silver has been adding to Sn-Cu-Ag. The method of this research was used Mass Balanced of 1,1.5 and 2 % of Silver is heated at 600 º C as solder alloy SnCuAg. The results have shown that shear strength is increasing in the increasing percentage of Silver on SnCuAg alloy Lead-Free Solder. The lowest of Melting temperature is 182 ºC of 1% Silver content on Sn-0,7Cu x Zn*

Keywords: Material solder Sn-Cu-Ag, physical properties, mechanical properties, Melting Point

1. Introduction

Soldering is Metallurgical connection processes low temperatures which are generally reversible, are method incorporation by using filler metals namely solder metal which has a melting temperature below 315 ° C. In splicing solder the wetting process occurs followed by a chemical reaction. Wet ability is a function of solder material, fluxes, and materials to be joined, such as Cu. The chemical reaction that follows the wetting process is between the liquid solder and the material which are joined to form an intermetallic phase region at the interface.
The composition of the solder used in electronic fabrication must have the ability to be wet which is good and has a minimum one component. The intermetallic form conductive, temperature-stable, non-brittle, and plastic with a base material. For this reason the most common solder alloys are Pb-based alloys, for example Pb-Sn. There are several historical reasons for the extensive use of Pb-Sn alloys as solder alloys.
These reasons include low solidus temperatures, good formability, and forms intermetallic Cu-Sn at wide temperature intervals, as well as cheaper equipment and processes. However, Pb is a

dangerous heavy metal (toxic) and there are regulations limiting the use of Pb in developed countries. Therefore, various attempts have been made in these countries to replace solder Pb based or alloys containing Pb greater or equal to 0.1% by weight (ASTM B32-96 and ISO 9453) with other environmentally friendly alloys.

2. Method and Materials

The materials in the alloys of composition Sn-0.7Cu of purities of 99.8% were weighted by a liquid metallurgy route. The alloys were melted solidified in cast-iron in the form of 8 mm diameter x 2 mm thick. The casting was a graphite mould 150mm x 200 mm x 10 mm in dimension at temperature of 600^{o}C and thermally agitated to perform the homogenization. The resulting alloys was cold rolling into long sheets of about 3 mm in width and I mm in thickness. The alloy samples as illustrated in Table 1. X-Ray diffraction analysis was performed on the flat surface of all alloys using an X-ray diffractometer (Dx- 30, Shimadzu, Japan) of Cu-Kλ radiation and Ni-filter in the range from 20^{o} to 100^{o} of 2θ value (λ = 0.154056 nm, 4.5kV and35mAThe method was heat treated of Sn0.7Cu as base material and Pure Silver (Ag) at temperature 600^{o} C in Maple Furnace to achieved homogenised material by using Materials Balanced Processes.

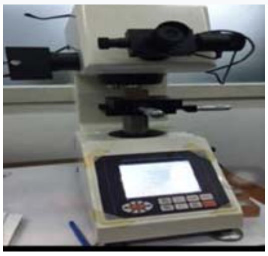

Fig.1. Shimadzu Micro hardness

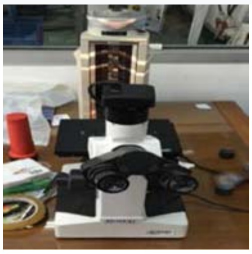

Fig.2. Optical Electron Microscope

Fig.3. Sn0.7Cu

Fig.4. VD 1100 Shear Strength

Fig.5. Pure Silver (99.9 % Ag)

IOP Conf. Series: Materials Science and Engineering 1007 (2020) 012025 doi:10.1088/1757-899X/1007/1/012025

3. Result and Discussion

Table 1. Materials Balance

No	Free Lead Solder Alloys	Weight of mass (grams)		
		Total wgh (gr)	Sn.07Cu wgh (gr)	Ag wgh (gr)
1	Sn.07Cu1Ag	58.4	57.8	0.6
2	Sn.07Cu1.5Ag	58.4	57.5	0.9
3	Sn.07Cu2Ag	58.4	57.2	1.2

Table 2. Melting Point

Samples Code	Melting Temperature (^{o} C)
SnPb	183
Sn0.7Cu1Ag	182
Sn0.7Cu1.5Ag	191
Sn0.7Cu2Ag	198

Table 3 Hardness Number

Samples Code	Hardness Number (VHN)
SnPb	40
Sn0.7Cu1Ag	15
Sn0.7Cu1.5Ag	18
Sn0.7Cu2Ag	20

Table 4 Shear Strength (N/mm^2)

Samples Code	Shear Strength (N/mm^2)
SnPb	18.80
Sn0.7Cu1Ag	30.33
Sn0.7Cu1.5Ag	32.67
Sn0.7Cu2Ag	36.48

IOP Conf. Series: Materials Science and Engineering 1007 (2020) 012025 doi:10.1088/1757-899X/1007/1/012025

The result has shown that an addition of Ag elements is influential with respect to the melting temperature of the Sn-0.7Cu alloy shows that the greater the addition of Ag, the melting temperature of the Sn-0.7Cu alloy increases. This is because Ag has a higher melting point compared to Sn-0.7Cu that has shown alloy that the greater the addition of Ag, the melting temperature of the Sn-0.7Cu alloy increases. This is because Ag has a higher melting point compared to Sn-Cu.

From the results of the hardness test set forth in Table 4 then changed into the form graph, as described in table 3 shows that the addition of the element Ag influences against the hardness of a binary alloy Sn-0.7Cu. The greater it is the addition of Ag, the hardness value of the Sn-0.7Cu binary alloy is increasing. From the results of shear strength testing as outlined in Table 4 then converted into graphical form, as described in table 4 shows that the addition of Ag elements affects the shear strength of the Sn-0.7Cu alloy. Strength shear increase on Sn-0.7Cu alloy containing Ag1% is 30.33 %, whereas in Sn-0.7Cu alloys containing Ag 2% experienced an increase in shear strength of 36.48 %. This shows that the increase in shear strength is obtained from the addition of Ag.

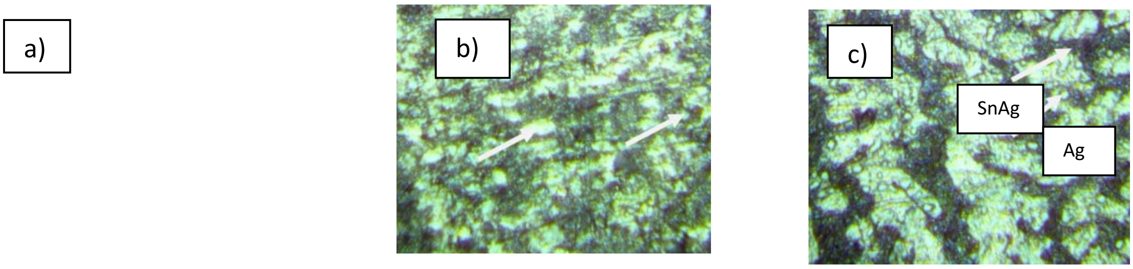

Figure 6 . Micro Structure Alloy (a) Sn-$_{0.7}$ Cu-$_{1}$Ag, (b) Sn-$_{0.7}$Cu-$_{1.5}$Ag and Sn-$_{0.7}$ Cu-$_{2}$Ag Magnification of Photo 500 × Etching: Acid Nitrate 2%, Akohol 98%

4. Conclusion

1. The effect of adding Ag on Sn-Cu-Ag alloys can increase specific gravity, ie on Sn-0.7Cu-1Ag obtained 7.36 gr / ml, on the material Sn-0.7Cu-1.5Ag obtained 8.9 gr / ml, and Sn-0.7Cu-2Ag material was obtained 9.45 gr / ml.

2. The effect of adding Ag in Sn-Cu-Ag alloys can increase melting temperature, 182 ° C in Sn-0.7Cu-1Ag material, 191 ° C in Sn-0.7Cu-1.5Ag material and 198 ° C in Sn-0.7Cu- 2 Ag.

3. Effect of adding Ag on Sn-Cu-Ag alloys increase the value of hardness, the Material Sn-0.7Cu-1Ag obtained 15.36 VHN, on the material Sn-0.7Cu-1.5Ag obtain 17.87 VHN, and Sn-0.7Cu-2Ag material was obtained 19.91 VHN.
4. Effect of adding Ag on Sn-Cu-Ag alloys can increase shear strength on the materiasl Sn-0.7Cu-1Ag obtained 30.33 N / mm2, Sn-0.7Cu-1.5Ag material as achieved 32.67 N/mm2, and in Sn-0.7Cu-2Ag material, 36.48 N / mm2 was obtained.

References

[1] Lee, Ning Cheng.Getting Ready for Lead Free Solders. USA: Indium Corporation of America Utica NY (2007)

[2] Yanfu, Yan et al. Influence of Temperature on Creep Behaviour of Ag Particle enhancement SnCu based Composite Solder . Tsinghua Science and Technology ISSN 1007-0214 10/18 pp 296-301, Volume 12, number 3, June (2007)

[3] K.S. Bae, S.J. Kim, J Mater Res 17, 743 (2002)

[4] K. Suganuma, Curr Opin Solid State Mater Sci 5, 55 (2001)

[5] Lin, J.K.; DeSilva, A.; Frear, D.; Guo, Y.; Jang, J.;Li, L.; Mitchell, D.; Yeung, B.; Zhang, C Characterization of lead free solders and under bump metallurgies for flip-chip package. Proc ECTC, Orlando, FL, IEEE: Piscataway, NJ, May 2001; 455-462.

[6] David E. Weisberg. “Chapter 14 : Intergraph” p. 14-8, 2008.

[7] Cho, M. G., Lee, H. M. Effects of Minor Additions of Zn on Interfacial Reactions of Sn-Ag-Cu and Sn-Cu Solders with Various Cu Substrates during Thermal Aging. *Journal of ELECTRONIC MATERIALS*, 36(11), 1501 -1509, 2007

[8] Mayappan,R. Wetting and Intermetallic Study between Sn-3.5Ag-1.0Cu-xZn Lead-Free Solders and Copper Substrate (x = 0, 0.1, 0.4, 0.7). *Advanced Materials Research*, 501, 150-154, 2012.

[9] Mohd Salleh, M. A. A., Hazizi, M. H. Z., Ahmad, Z. A., Hussin, K., & Ahmad, K. R . Wettability, electrical and mechanical properties of 99.3Sn-0.7Cu/Si 3N4 novel lead-free nanocomposite solder. *Advance Materials Research*, 277, 106-111, 2011.