Improvement of the microstructure of Sn – Bi lead free solder alloy

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Improvement of the Microstructure of Sn – Bi Lead Free Solder Alloy

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Abstract. Different composition of (Sn –Bi) powder of (800-100) μm, grain size were achieved. Three types of alloy were fabricated by melting under (350°C) in inert atmosphere. X-ray diffraction indicated the formation of (Sn-Bi) alloys. Melting points were conducted. Optical micrographic investigated to study the main structure characterization for all fabricated alloys. Hardness test reflect the ductile form for all the three alloys with a remarkable value of 26 HRB for the alloy 40 wt.% Sn- 60 wt.% Bi.

Keywords: Sn –Bi alloy; Microstructure; Melting point.
PACS: 75.47.Np

INTRODUCTION

The damage in solders generally arises from the thermal mismatch of the element in a package. Many manufacturers are implementing less expenses components and circuit materials in product an assembly in order to reduce production costs. The most common alloy used in reflow soldering is eutectic Sn-37Pb. Since this alloy has a melting point of 183C0, they are practical lower limits to the solder – reflow temperature. Alternative solder alloys with lower melting points than those of eutectic Sn-37Pb are often considered for application such as those described, the alternate alloy most frequently considered is Sn-43Pb-14Bi. This solder has several attributes that are not desirable for all applications .According to the European Union Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction of Hazardous Substances Direction (RoHs) much interest in lead – free solders. These contain tin, copper, silver, bismuth, indium, Zinc antimony, and other metals in varying amounts [1]. Tin – Bismuth alloy, (Eutectic) having very low melting points and used in some low temperature application [2]. These are uniquely used for lapping thin film magnetic heads, its advantage that they produce less smearing across the magnetic sensor which results in a cleaner magnetic and electrical signal. In general tin and its alloy are a class of materials which have recrystallization temperature bead room temperature. They has good wettability and low proneness to whiskers, however it is brittle. Sn-Bi alloys one in compatible with lead containing materials become of formation of ternary eutectic with extremely low melting point 204F0(96C0) locating along the grain boundaries [2].

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MATERIALS and METHODS

The samples used in the work were melted form pure elements (99.9) of (80-100) µm, grain size in a resistance furnace under inert atmosphere (obtained by constant flow of Nitrogen), and casted in alumina boat. Three alloys were prepared for sake of comparison with its properties obtained in the studied systems, Sn 42 wt.% - 58 wt.%, Sn 40 wt.% - Bi 60 wt.% and Sn 30 wt.% - Bi 70 wt.%, respectively. The alloys were examined by X-ray diffraction to determine the phases, optical microscopy were used to characterize the microstructure feature. Melting point were measured for all the three alloys. In the cast alloys the hardness were tested by hardness measurements. The load was 30Kg and loading time was 20S. It was recognized that the indentation of Brinel hardness was large enough as compared.

RESULTS and DISCUSSION

The X-ray diffraction results of the specimens after casting were tested. Figure 1 which represent the alloy Sn 42 wt.% - Bi 58 wt.% shows the formation of the alloy with a little phases as indicated by latter (a): while after increasing the Bismuth amount to be 60 wt.% and Sn 40 wt.% , the alloy formation can be observed as dominate phase (a) as shown in Figure 2. While the 3rd alloy Sn70 wt.% - Bi 30 wt.% shows a very little phase (a) formation Figure 3 compeers with the previous types. As a result we can considered that the Sn 40 wt.% - Bi 60 wt.% it the best structure obtained due to the thermal diffusion temperature range (250-350)°C, That Sn is melted and diffused in the molten of Bi homogenizing forming the eutectic composition [3], to eutectic microstructure of specimens.

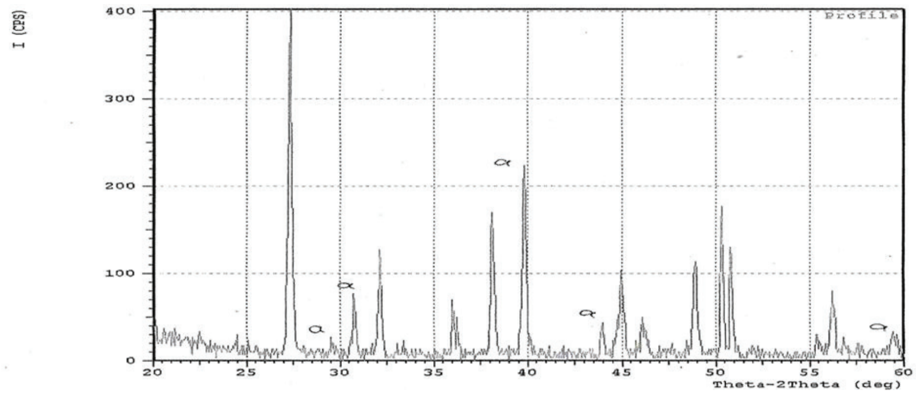

Figure 1. X-ray diffraction pattern for the alloy Sn 42 wt.% - Bi 58 wt.%.

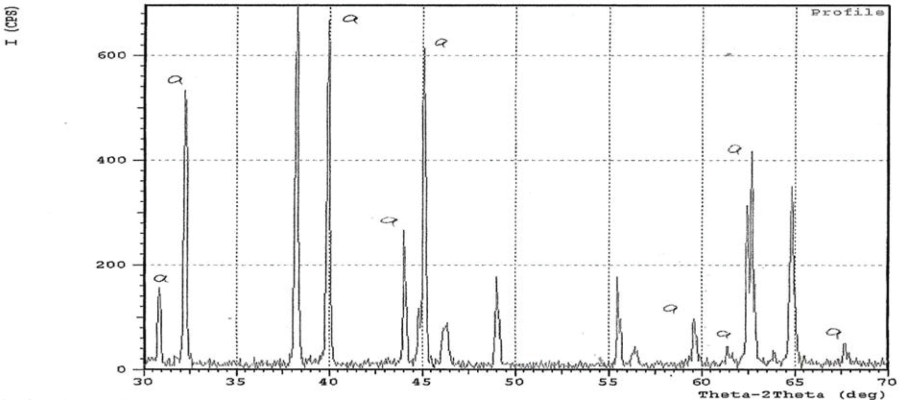

Figure 2.X-ray diffraction pattern for the alloy Sn 40 wt.% - Bi 60 wt%.

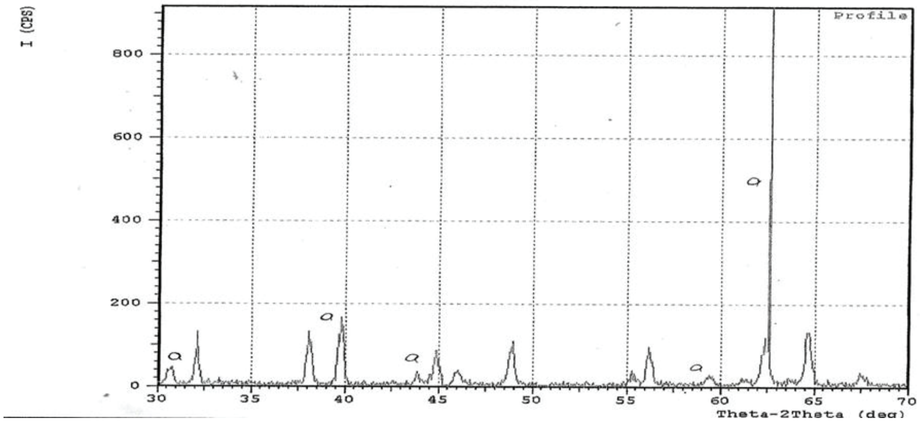

Figure 3. X-ray diffraction pattern for the alloy Sn 30 wt.% - Bi 70 wt.%.

The microstructure of Sn 42 wt.% - Bi 58 wt.% alloy in Figure 4, reveals the unhomogenates between the mixture at fine Bi-rich and Sn-rich solid solution (dark colored area). From Figure 5 the optical micrograph of the alloy Sn 40 wt.% - Bi 60 wt.% shows the remarkable microstructure after completely melting and homogenate (Bright colored area) was achieved. While the microstructure of Sn 30 wt.% - Bi 70 wt.% consisted of both on acicular structure, formed as primary crystal (Black Spot), Sn – solid solution Figure 6. For that the microstructure of Sn 40 wt.% - 60 wt.% alloy reflect the remarkable one due to the completely melting and diffusion accrue between both Sn and Bi [4]. From the melting point measurements at the alloys Sn – Bi, were found that the Sn 40 wt.% - Bi 60 wt.% having a lowest melting point at 165°C, and for the alloy Sn 30 wt.% - Bi 70 wt.% is 190°C while the alloy Sn 42 wt.% - Bi 58 wt.% is 173°C. The inconsistency in these results because of the bismuth weight percentage in the three types [5].

Alloys and the lower melting point was achieved at Bi 60 wt.% which was consistence with all other results. The Brinel hardness of value (26HRB) for the alloy Sn 40 wt.% - Bi 60 wt.% and (15HRB) for the Sn 30 wt.% - Bi 70 wt.% and (10HRB) for the alloys Sn 42 wt.% - 58 wt.% .From all those results we can considered that the alloy Sn 40 wt.% - Bi 60 wt.% having desirable hardness because the harding of microstructure was caused by solid-solution of Bi into Sn-rich solid solution and by precipitation of Bi in the Sn-rich solid solution. It was assumed the hardening over comes softening [6, 7].

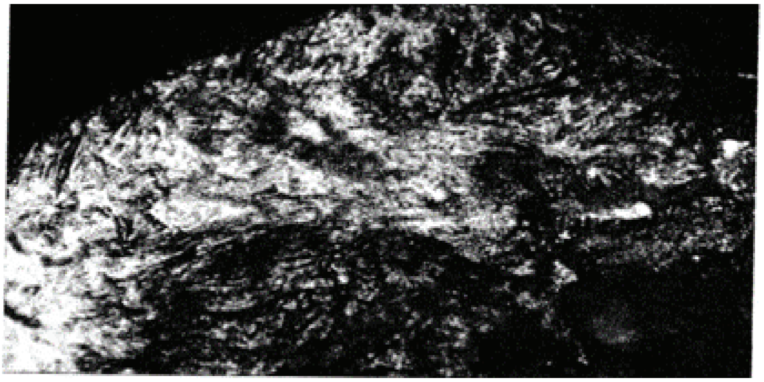

Figure 4. Photomicrograph for the alloy Sn 42 wt.% - Bi58wt.% (Magnification 1600X).

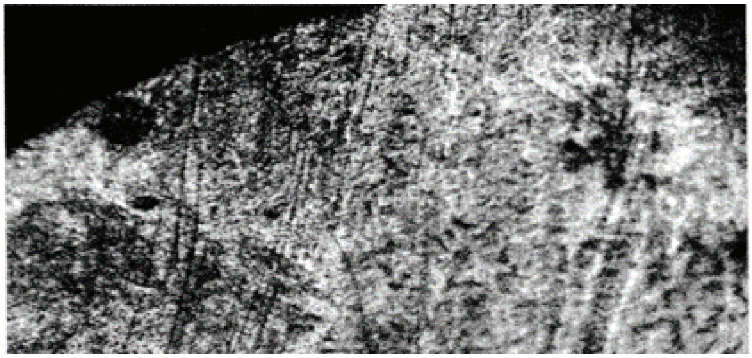

Figure 5. Photomicrograph for the alloy Sn 40 wt.% - Bi 60 wt.% (Magnification 1600X).

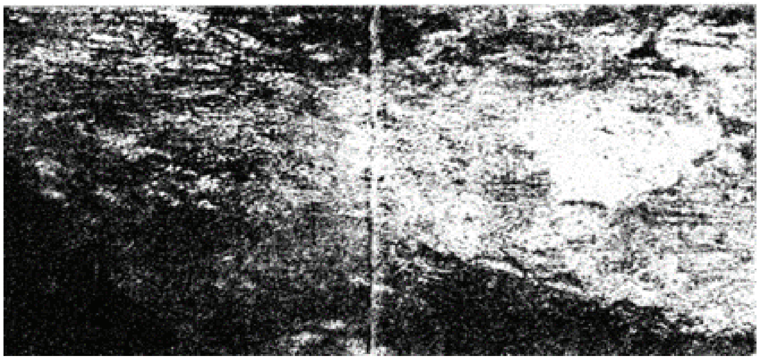

Figure 6. Photomicrograph for the alloy Sn 40 wt.% - Bi 60 wt.% (Magnification 1600X).

CONCLUSION

The alloy Sn 40wt% - 60wt% having the remarkable crystal structure, micro structure ,lowest melting point 165°C.The microstructure changes of Sn – Bi eutectic alloy solder were observed after completely melting and homogenization . Having a softening microstructure.

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REFERENCES

1. M. T. M. C. Cormark et al., *J. Jom.*, **485**, 54-56 (1996).

2. Y. Mnyazawa, T. Arige, ECO Design Apos, (*First International Symposium*), **3** (3), 616-619 (1999).

3. T. B. Massalski, H. Okamoto, P. R. Subramanion, L. Kacprzak, Binary Alloy phase Diagram, (*Materials Park*), 94-97 (1999).

4. M. Kitajma et al. FUSITSO Sci. Tech. J., **41** (2), PP225-235 (2005).

5. T. Yamamoto et al., *FUSITSU Sci. Tech. S.*, **43** (1), (2007).

6. T. T. Issa, K. M. Donya, *Research J. of Social Science & Management*, **2** (05), (2012).

7. T. T. Issa, F. T. Mohumad, *AIP Conf. Proc.*, **1569**, 315-354 (2013).