Lower Melting-Point Lead-Free Solder Alloy

درجة ذوبان اقل لسبيكة اللحام – خالية من عنصر الرصاص

Tarik T.Issa ,Farah T.Mohamed ,Nadia A.Ali
University of Baghdad, College of Science , Physics Department

Abstract:-

A lower –melting – point solder alloy composition Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ has been studied by Differential Scanning Calorimetric (DSC), a large portion of the alloy melts sharply at a approximately 136˚C, the melting point of Sn-Bi , Sn- Zn eutectic alloy .The produce alloy was analyzed by XRD and optical microscopy for microstructure characterization .The hardness of alloy has been tested and was found of a value 10HRB as a ductile form .

الخلاصة :-

اقل درجة ذوبان لسبيكة اللحام ذات التركيب(قصدير 42 –بزموث 3. 57-زنك 0.7) نسبة مئوية وزنية تم دراستها بواسطة المسح المسعري التفاضلي .اغلب السبيكة المحضرة ذابت وبشكل حاد عند درجة حرارة˚C 136 درجة سليزية لسبيكة قصدير –بزموث , قصدير-زنك التصلبية . السبيكة المحضرة حلل تركيبها الدقيق بواسطة حيود الاشعة السينية والمجهر الضوئي فحص الصلادة وجد مقدارة (10) بمقياس برنل لتركيب مرن .

Introduction :-

Significant manufacturing cost reductions can be realized with lower- temperature melting and lead-free solder alloy .According to the European Union Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction at Hazardous Substances , Directive (ROHS),lead had to be eliminated from electronic systems by July 1,2006 [1].More over the lead –alloy of eutectic Sn-Pb solder yield problems during surface mount assembly .In order to alleviate these problems there is a push to lower peak reflow temperature during the soldering process [2].The most common alloy used in reflow soldering is eutectic Sn-37Pb of a melting point 183 ˚C[3]. Alternative solder alloys with lower melting points than these of eutectic Sn-37Pb has been developed and often considered for many applications[4].

The alternative alloy most frequently considered Sn-Bi-Ag ,Sn-Bi, Sn-Bi-Cu and Sn-In .The properties of lead-free solders are not thoroughly known and may there for be considered less reliable in select applications, e.g. Hi-rel aerospace, military aerospace –satellite and life –critical medical applications .

The aim of this work was to determine a ternary Sn-Bi-Zn alloy that not only melted at least (40˚C) below that eutectic Sn-37Pb , but also free of the ‐ 137˚C melting phases and had a narrow range of melting ‐ (10˚C) with homogenous microstructure good hardness and cheaper monufacting coast .

Experimental Procedure :

The samples used in this work were melted from pure elements(99.9 wt%)in a resistance furnace under inert atmosphere (obtained by a constant flow of Argon), and casted in alumina boat.

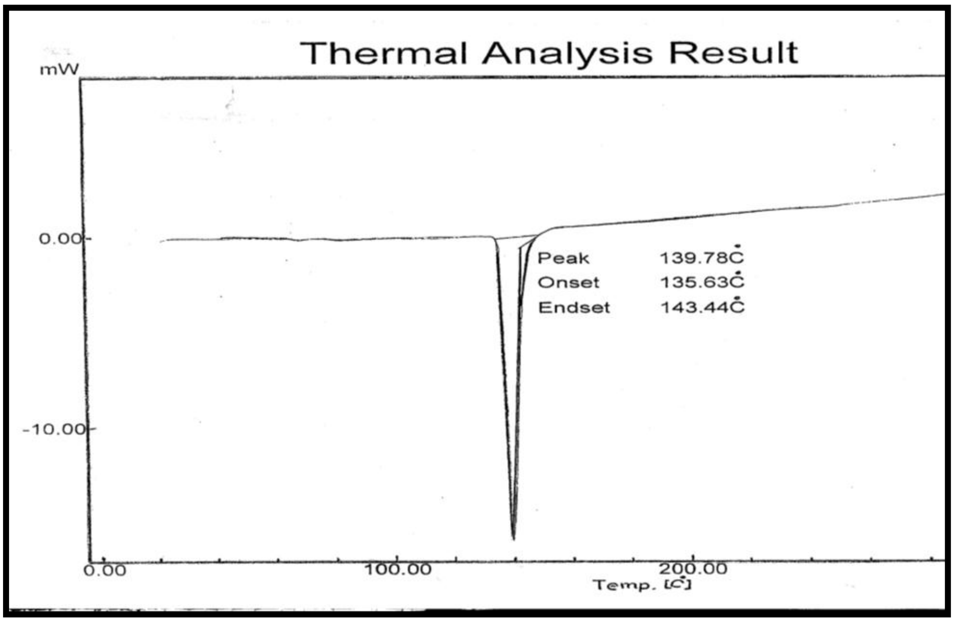
Two alloys were prepared for sake of comparison with its properties obtained in the studied systems. The differential scanning calorimetric (DSC) for the alloys was detected upon heating at scanning of 5˚C /min to determine the heat extraction that is conducting the onset melting point. The alloy was exanimate by XRD (Philips vertical powder diffractometer type PW1050 was used. Spectra were obtained by using Ni filtered Cukα radiation λ =0.15418 nm operated at 40kV and

20mA. The scan range 2θ was chosen between 10-40 degrees run at a scan rate of 0.2 deg/s), to determine the phases while optical microscopy was used to characterize the microstructure feature. In the cast alloys the hardness was determined. The load was 30Kgm and loading time was 20s. It was recognized that the indentation of brinel hardness (which used specially for metal, and alloy, with wide load range capable with ductile form) was large enough as compared to eutectic mixture (a solid solution of two or more substances having the lowest freezing point at all the possible mixtures of the components. This is taken advantage at in alloys of low melting point, which are generally eutectic mixtures, that were achieved in our present work).

Result and Discussion:

a. Thermal Character

The thermal character was found in the Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ ternary composition. Figure (1) is a typical DSC profile of the alloy. As have been by discontinues slope change on the per melting portion of the heat extraction well, the solders temperature of this ~ 135.63˚C (Onset).The primary liquids temperature was ~ 139.78˚C (Peak); there was a very small residual amount of solids that didn't completely melt until 143.44˚C (End set),compositional fluctuations well over a percent ware required to significantly after the melting character shown . For this composition, excess bismuth results in the ~ 140 ˚C melting phase; excess zinc results in lowering the ~ 136˚C melting points at the alloy[5].

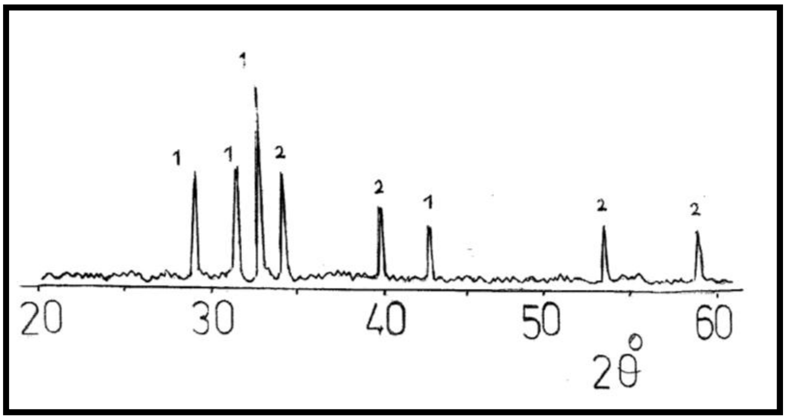


Fig(1):Typical Differential Scanning Calorimetric (DSC)profil for the Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ ternary alloy upon heating at scanning rate 5˚C/min.

b. Structure of Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ ternary alloy (X-ray diffraction)

The X-ray diffraction results of the specimen after casting are given in Fig(2) . The diffraction peaks of the Sn-Bi alloy are conspicuous near the interface between the antimony and zinc resulting the Sn-Zn phase . In the thermal diffusion temperature range (250 to 350) ˚C , Sn is melted and the solution of Bi and Zn in the molten Sn is considered to take place. From the Sn-Bi and Sn-Zn binary alloy phase diagrams [6]. It is evident that in this temperature range , Bi melts in the Sn liquid but Zn melts significantly in the Sn liquid . The Sn-Zn binary alloy phase diagram shows that

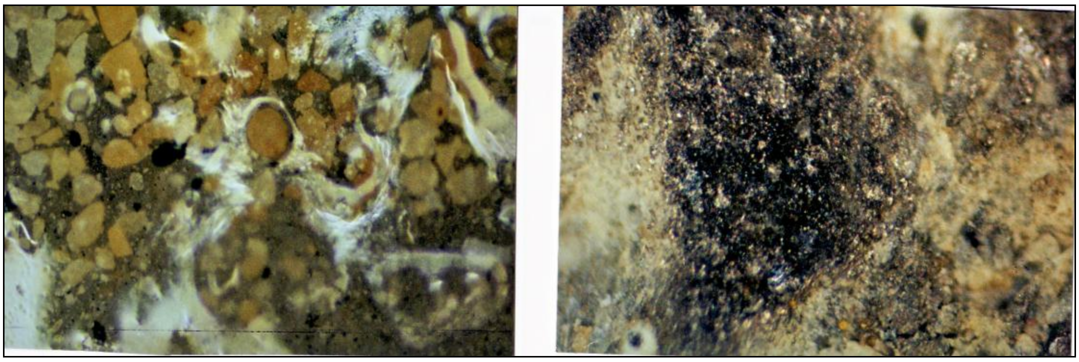
35 atomic percent Zn melts in the Sn liquid at 300˚C[6]. This values is equivalents to the proportion that all Zn melts in the Sn liquids in the case of the Sn –Bi –Zn ternary alloy.



Fig(2): X-ray diffraction pattern of the Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ ternary alloy , the numbers indicate the phases present (no.$_1$ Sn-Bi, no.$_2$ Sn-Zn).

c. Microstructure Analysis:

The microstructure of the Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ ternary alloy reveals the presence of the Sn- Bi eutectic alloy consisted of a primary phase and a mixture at fine Bi – rich solid solution (bright colored area)and Sn –rich solid solution (dark colored area)as shown in Fig (3a) .Remarkable microstructure changes were observed after completely melting and homogenate was achieved as shown in Fig(3b) . The microstructure of Sn- Zn eutectic alloy consisted of both an acicular structure , formed as a primary crystal (black spots)as shown in Fig(3a) . The solid solubility of Zn in Sn-rich solid solution and Sn in Zn – rich solid solution for Sn –Zn alloy were vary small at temperature from room temperature up to 199˚C[7], this is similar to the Sn-Bi melting produced it appears that was mainly associated with the coarsening of the eutectic microstructure and the solid solubility of the phase to achieve the homogenate as shown in Fig (3b).



(a) (b)

Fig(3): Optical micrographs of (a) the ternary Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ as-cast microstructure , (b) the ternary Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ as-cast homogenize microstructure .

d . Hardness:

The brinell hardness of value (10HRB) for the ternary alloy Sn $_{42}$-Bi $_{57.3}$-Zn $_{0.7}$ was obtained at room temperature it appears that 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. On the other hand, softening of microstructure coarsening of the microstructure for the Sn-Bi alloy. In the system Sn-Bi-Zn , it was assumed that hardening will over comes the softening point[8].

Conclusions:

The melting point of the Sn_{42}-$Bi_{57.3}$-$Zn_{0.7}$ ternary alloy solder was found to be ~ 136˚C . The microstructure change of Sn-Bi and Sn- Zn eutectic alloy solder were observed after completely melting and homogenization . It was found that the alloy of Pb –free solder having the softening hardness as solid – solution of Bi into Sn –rich solid solution of microstructure coarsening .

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