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Development and characterization of lead free solder alloy

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Abstract *-Tin- Lead (Sn-Pb) Solder was used widely in electronic industry in past few decades. But due to environment and health concerns over the use of toxic lead, attached with strict legislation of the banned of Pb use in electronic industry pulls the attention to development of new lead free solder. Present study aims to develop the lead free Sn-Ag solder and examine its micro structural properties using optical microscope. To determine the elemental composition of alloy XRF test has been done. The Vickers hardness test has also been done to determine the micro hardness of the alloy.*

Keywords- Lead free solder, Sn-Ag solder, Optical microscopy, XRF, Micro hardness

I. INTRODUCTION

Soldering techniques is a method of joining metals and Sn-Pb alloy is important soldering material. As the advanced electronic industry is developing, soldering technique is finding more application in small electronic devices such as cell phones, amplifier, and digital cameras. However it has been find out the lead used in electronic devices by soldering possibly mixed, and then pollutes the ground water, rivers and finally affects the central nervous system of human by beverages. To protect the global environment an initiative to ban the lead solder has been taken by the many developed countries.

Lead free solder may be the alternative for this. In the present study we have developed the new generation of lead free (Sn96.5-Ag3.5) composite solder to solve the discussed problems. The purpose of using silver is that it has higher conductivity which reduces the voltage drop in the electronic gadgets used in the electronic industry. These lead free solder was based on Sn containing binary and ternary alloy. Among the new invented lead free solder, Sn-Ag alloy used has importance because of its good wettability, higher strength, and excellent resistance as compared to Pb-Sn solder.

Wang et.al[1] had successfully fabricated of tin silver alloy and examined Several conclusions can be drawn from this research on the formation and evolution of microstructure of eutectic Sn-Ag solder on SMT joints. The microstructure of soldered joints consists of Ag3Sn intermetallics in a nearly pure Sn matrix with Cu-Sn intermetallics in both the bulk solder in the form of dendrites and at solder-copper interfaces in the form of layers. The microstructure of actual joints varies greatly for different soldering processes, as well as for parameter changes within a process.

Guo et.al, [2] had examine that Microstructural and examination showed significant creep deformation along particular Sn grain boundaries, and fracture nucleation probably developed from boundaries that were sliding excessively.

Lee et.al, [3] has investigated the effects of Ni addition on the microstructural evolution and adhesive strength of Sn–3.5Ag solder and examined that the addition of Ni powder to a molten Sn–Ag solder leads to the formation of in situ Ni_3Sn_4 dispersoids. The cooling rate has a significant influence on the microstructure of the solder. The composite solder joint results in the formation of $(Ni,Cu)_3Sn_4$ intermetallics particles and a $(Cu,Ni)_6Sn_5$ IMC layer at the solder/Cu substrate interface. The adhesive strength between the composite solder and the Ni-containing IMC is higher than that between the solder and the Cu6Sn5 layer formed in a conventional Sn–Ag solder.

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II. MATERIAL AND CHARACTERIZATION

2.1. Material

To develop an ecofriendly solder alloy the silver was used in present study in place of lead. The Material used was tin and silver. Tin and silver have been taken in granules form. The purity level of Tin-Silver taken for development of alloy was 97.5% and 98.5% respectively. The 96.5gm of tin was mixed with 3.5 gm of silver to develop the alloy.

2.2. Melting and Casting

For Melting of silver and tin resistance furnace was used. First of all 96.5 gm of tin was weighted and melted at temperature 600°C in a crucible. After melting of the tin slag was removed from the surface of the molten Tin. Then the Silver of 3.5gm added to molten Tin and stirred with the help of stirrer for two minutes. Then the mixture was again kept in the furnace at the temperature off 600°C for 10 minute. After ten minute it was removed from the furnace and stirred for half minute and poured in the mould.

2.3. Characterization and Testing

For metallographic study the specimen were ground and annealed at temp. 100°C for one hour after it was polished and etched with 97% alcohol 5% HCl solution for several seconds. The microstructure was examined using optical microscope at different magnifications. For elemental composition of the developed alloy XRF study of the developed alloy has been done. The micro hardness of the alloy was measured using Vickers hardness testing machine to provide better understanding of the joint microstructure and mechanical properties.

III. RESULT AND DISCUSSION

3.1. Microscopy

The microscopy has been done by optical microscope. Fig.1 (a-b) shows the microstructure of Sn-Ag alloy at magnification. From the Fig (a) and fig (b) tin matrix is clearly visible but the silver morphology is not visible because the silver and silver- tin reaction product are present at the grain boundaries which are not highlighted without etchant. Fig 2.Shows the micrographs of alloy with etching at different magnifications. During melting and mixing silver react with tin at eutectic temperature and form another reacting product Ag_3Sn. The reaction product Ag_3Sn is present at the grain boundaries in the needle type structure as shown in Fig 2(a).Silver increases the conductivity of the solder and minimize the voltage drop.

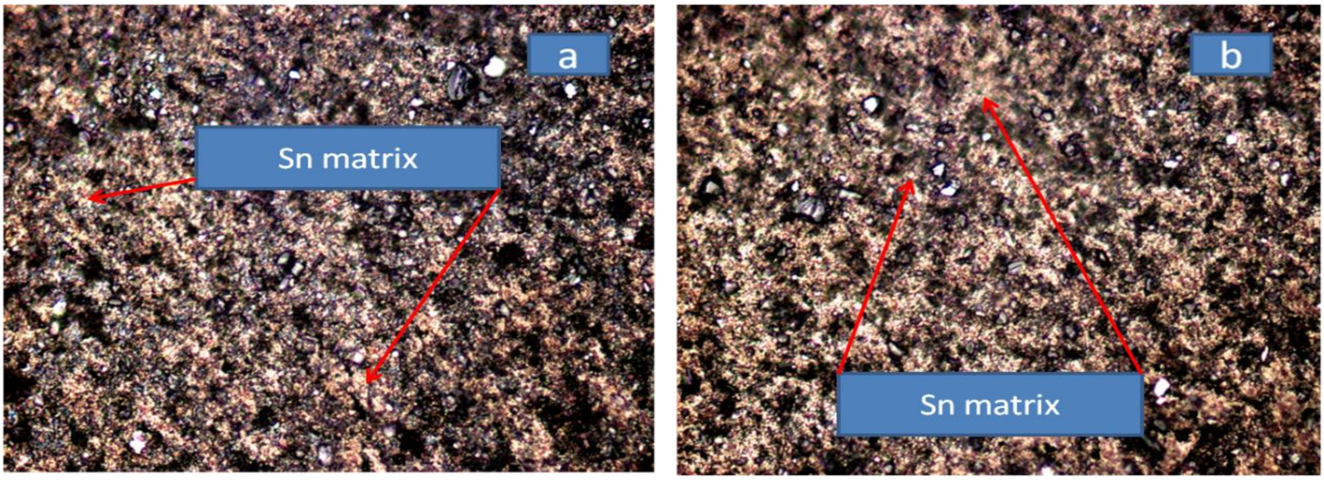

Fig.1. Optical micrograph of Sn-Ag alloy without etching at (a) 100 x (b)200 x

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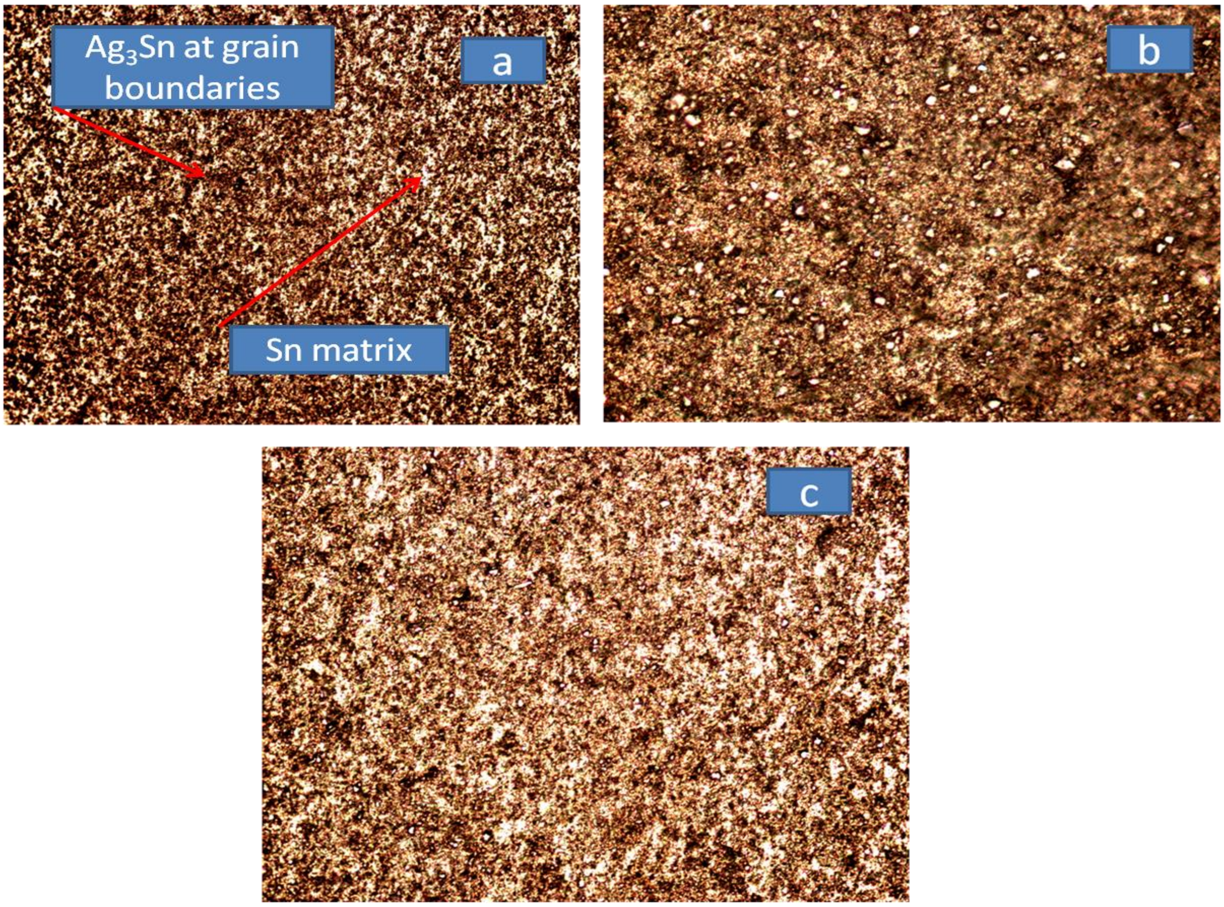

Fig.2. Optical micrograph of Sn-Ag alloy with etching at (a) 50 x (b) 100 x (c) 200 x

3.2. X-ray Fluorescence (XRF)

XRF has been done for the developed alloy .The elemental composition of the alloy is shown in Table 1.

Table.1. Elemental composition of Sn-Ag alloy

Sn	Ag	Cu	Cr	Cd	Mg	Ni	S	Sr	Intensity Scal
1931,7 KCps	24,8 KCps	8,3 KCps	0,6 KCps	0,6 KCps	0,2 KCps	1,0 KCps	0,2 KCps	1,1 KCps	
95,32%	3,06 %	0,45 %	0,32 %	0,31 %	0,27 %	0,27 %	99 PPM	64 PPM	0,9671

It has been cleared from the above table that is 95.32% Sn and Ag is 3.06% and remaining element are undesirable impurities present in the small amount .Due to these impurities following affect is examined Cu present in alloy as impurities increase the corrosion resistance and counteracts brittleness from Sulphur, Cr increased abrasion and wear resistance and high temp strength, Ni and Mg increased toughness and impact strength of the alloy.

3.3. Micro hardness

The micro hardness of the alloy has been done on Vickers hardness machine at load 25gf at dwelling time 15 second .The hardness was measured at different points. Calculated Vickers hardness values at are shown in Table 2.

Alloy shows the uniform hardness of the alloy at different points and obtained the average optimum micro hardness of 12.9 HV.

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Table 2. Micro hardness of Sn-Ag alloy

Load (gf)	Dwell Time (s)	Micro hardness (HV)
25	15	13.1
25	15	14.2
25	15	11.4
Average micro hardness		12.9

IV. CONCLUSIONS

1 The Sn Ag alloy was successfully developed by casting process.

2 The optical micrographs show the uniform distribution of Ag and reactant product Ag_3Sn along the grain boundaries of Sn matrix.

3 Through XRF results we conclude that the alloy is lead free and ecofriendly.

4 The optimum micro hardness of 12.9 HV is obtained for the alloy

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