THE SOLDERING OF ELECTRONIC COMPONENTS WITH NEW ALLOYS FROM SN-CU-AG FAMILY

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Abstract In the most majority of the cases, at the electronic components soldered with tin-based alloys was noted the germination and the growth of the whiskers, which have caused damages in all areas. Given the preliminary researches, to mitigate the occurrence of defects in electronic components has been proposed a new soldering alloy from Sn-Cu-Ag family and a new obtaining technology based on melt spinning method. The solder joints were obtained from the new elaborated alloy and a commercial alloy from Sn-Cu-Ag family, using the reflow and soldering iron methods. The solder joints were structural characterized by optical microscope, scanning electron microscope (SEM) and X-ray diffraction. At the solder joints with new alloys it has been observed a reduction of the grain size as well as the proportion of intermetallic compounds.

Keywords: tin whiskers, reflow, soldering iron, melt spinning

1. INTRODUCTION

Tin whiskers are crystalline structures that growing spontaneously from the surfaces of tin in soldering electronic components. The whiskers are usually electrically conductive and thus, they cause shorting of electronic assemblies. Damages recorded due to this growths affected all areas (military industry, aerospace, medical, home electronics industry, energy industry, IT, automotive). Since first breakdowns have been reported, have tried various ways to prevent or decrease the occurrence of this growths. Currently, the whiskers are more common because of the Sn-based solder alloys [1].

The occurrence of tin whiskers is affected by the following factors: chemical electroplating, electroplating process, the characteristics of the solder alloy, substrate alloy of the conductive pattern on the PCB and not least the environment. Each factor is determined in turn by other factors. Solder alloy has a great influence by: shape, size and grain orientation, the presence of tin oxide and other intermetallic compounds, internal stresses in soldered joints and deposited layer thickness. In order to eliminate part or all of these factors influence it is considering in obtain a new Sn-based solder alloy in the form of ribbons using melt spinning method. This method based on a process of rapid cooling of the melt aims at obtaining single-phase structures, nanocrystalline or amorphous type that avoids the occurrence of intermetallic compounds, of oriented granulation and internal stresses in alloy. [2], [3]

2. EXPERIMENTAL PROCEDURE

Soldered joints have been made on copper, in two ways: with soldering iron and by reflow. Have been used two soldering alloys: a commercial one with chemical composition Sn99Ag0,3Cu0,7 and the other Sn97Ag2,5Cu0,5 prepared by melt spinning method in ribbons form with 15 μm thickness and width of 2 mm (Fig.1). In soldered joints with the soldering iron have been used the following parameters: voltage 230V and 25W power. Reflow soldering was done in an oven TRACK type using thermal profile of (Fig.2) [4],[5]. Soldered joints were characterized by structural analysis using optical microscopy, scanning electron microscopy and X-ray diffraction. Optical microscopy was done with the SMZ1500 Nikon microscope,
scanning electron microscopy was performed with Carl Zeiss EGF-1530VP FE-SGEM microscope and X-ray diffraction by Bruker D2 Phaser diffractometer.

3. RESULTS AND DISCUSSION

3.1 Characterization by optical microscopy of soldered joints

The analysis of soldered joints made with commercial alloy using soldering iron certifies the presence of bubble-type defects (Fig.3); these faults occur due unevaporated flux. At reflow soldering, with the same alloy the number of bubble-type defects is significantly lower (Fig. 4); it is distinguished a structure of acicular appearance with elongated crystals oriented in the direction of heat flux exhaust. In the case of the soldering alloy in the form of ribbons, both soldering methods ascertain a structure consisting of a solid solution based on Sn and eutectic mixture which is distributed at grain boundary (Fig. 5,6).
3.2 Characterization of soldered joints by scanning electron microscopy

SEM image of soldered joints with soldering iron using commercial solder alloy is shown in (Fig.7a). EDS mapping analysis performed on this image shows tin presence in the solder defect (Fig.7b). Also it can be seen that Sn formed intermetallic compounds with both Ag and Cu (Fig.7c, d). In the case of reflow soldering with commercial alloy it is found both the presence of tin in the solder defects as well as intermetallic compounds of Sn with Cu and Ag (Fig.8 b, c, d).

Fig.7 EDS Mapping for Sn$_{99}$Ag$_{0.3}$Cu$_{0.7}$ commercial alloy using soldering iron

Fig. 8 EDS Mapping for Sn$_{99}$Ag$_{0.3}$Cu$_{0.7}$ commercial alloy using reflow method
For soldering joints with the soldering iron using the soldering alloy in the form of ribbons, it can be seen in the mapping image (Fig. 9) the presence in a higher proportion of tin in the form of solid solution but also the existence of intermetallic compounds. The same situation was remarked for reflow soldering using the soldering alloy in the form of ribbons (Fig. 10).

**Fig. 9** EDS Mapping for Sn$_{97}$Ag$_{2.5}$Cu$_{0.5}$ alloy using soldering iron

**Fig. 10** EDS Mapping for Sn$_{97}$Ag$_{2.5}$Cu$_{0.5}$ alloy using reflow method
3.3 XRD characterization of bonded joints

Diffraction images of soldered joints with commercial alloy (Fig. 11 a,b) shows the presence of intermetallic compounds for both soldering methods. Although, in the case of reflow soldering is only one intermetallic compound (Cu₆Sn₅), it favours the tin whiskers growth. [1]

For the soldering alloy in the form of ribbons, the Cu₆Sn₅ compound is absent in both soldering cases. It can be seen, at reflow, that solid solutions on the basis of Sn, Cu, Ag are predominant detrimental intermetallic compounds.

![XRD graphs for soldered joints](image)

4. CONCLUSIONS

In order to reduce the growth of tin whiskers in soldered joints is being sought new Sn based solder alloys to ensure a structure which is homogeneous, monophasic and as fine as possible in soldered joints areas.

Alloys from Sn-Cu-Ag family can be obtained by melt spinning method in the form of continuous ribbons. Structural analysis of soldered joints made with this alloys revealed an increase in the proportion of solid solution and a decrease in the proportion of intermetallic compounds compared with soldered joints made with commercial alloy. Also, it was observed avoidance of formation the intermetallic compound Cu₆Sn₅ in
soldered joints with the alloy in the form of ribbons, which is the premise of diminishing the process of occurrence and growth of the tin whiskers.

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