Ag Content Effect on Mechanical Properties of Sn-xAg-0.5Cu Solders

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Abstract

In this work, the Ag content effect on material properties of Sn-xAg-0.5Cu solders was investigated based on tensile test for bulk solder. In this study, three different Ag contents including 1%, 2% and 3% Ag in Sn-xAg-0.5Cu solder were investigated. The material properties, such as elastic modulus, UTS (Ultimate Tensile Strength) and yield stress were evaluated for different Ag content bulk solder. In addition, the strain rate effect on material properties of Sn-xAg-0.5Cu solder was also investigated considering 5 different strain rates from 10^{-5} to 10^{-1}. Results show that the elastic modulus, yield stress and UTS of Sn-xAg-0.5Cu solder increase with Ag content. The relationships of strain rate, Ag content and material properties were developed and material constants in curve fitting equations were presented.

1. Introduction

With the increasing requirement for lead free solders, it is desired to know how different solder alloys effect on reliability of microelectronic assembly. The Sn-Ag-Cu solder is widely used as one of lead free solders in SMT assembly for microelectronics. More researches were conducted for such Sn-Ag-Cu based lead free solders [1-4]. Results showed that the Ag content would affect thermal fatigue life for soldered assembly with Sn-xAg-Cu lead free solder joint. The thermal fatigue life increases with Ag content in Sn-xAg-Cu lead free solder due to their different fatigue resistance and material properties [3]. However, recently the drop performance of electronic assembly becomes the hot research area and more data showed that the Sn-xAg-Cu lead free solders with low Ag content exhibited the longer drop lifetime than that with high Ag content [5]. Therefore, the different effect trend of Ag content on thermal fatigue life and drop performance was obtained. Some researches also observed that some metal dopants, such as Ni, could improve solder joint drop performance because such dopant can affect the microstructure and property of Sn-Ag-Cu lead free solder [4, 6].

In this work, the Ag content effect on material properties of Sn-xAg-0.5Cu solders was investigated using tensile test for bulk solder. Based on Pang's investigation [2], the material properties of lead free solder are similar for tests using both bulk solder and solder joint as specimen. So, the material properties from bulk solder also can be used in FE simulation for solder joint stress-strain behavior evaluation. In this study, three different Ag contents including 1%, 2% and 3% Ag in Sn-Ag-0.5Cu solder were investigated. The material properties, such as modulus, UTS, Yield stress, elongation, were evaluated for different Ag content Sn-xAg-0.5Cu solders. In addition, the strain rate effect on material properties of Sn-xAg-0.5Cu solder was also investigated considering 5 different strain rates including 10^{-5}, 10^{-4}, 10^{-3}, 10^{-2}, and 10^{-1}, which will cover the solder strain rate happened in thermal cycling, mechanical cyclic bending and vibration loading. Based on the tensile tests results, constitutive equations for characterizing the Ag content and strain-rate dependent properties for elastic modulus, yield stress and UTS were developed.

2. Tensile Test

The Sn-Ag-Cu bulk solder specimen with flat dog born shape was used in this work. Fig. 1 shows the solder specimen and its dimensions. Before test, the specimen is annealed at 100deg.C for 2 hrs to reduce the residual stress induced in sample preparation. Then the solder bar was fixed onto testing grip for tensile test using universal tester. The extensometer was used to measure the strain value based on the gage length of 10mm used in this test. Fig. 2 shows the test setup.

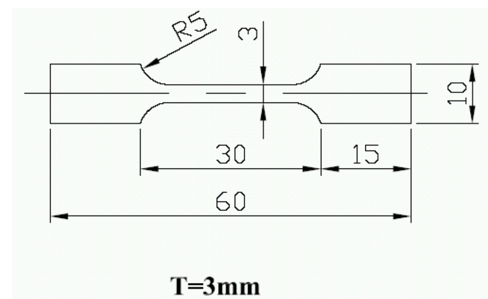

Fig. 1. Solder bar specimen

Fig. 2. Tensile testing setup

Solder material properties vary with temperature and strain rate significantly [7, 8]. This paper will focus on the strain rate and Ag content effect on solder material properties. All tensile