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Physicochemical Properties of Sn-Zn and SAC + Bi Alloys

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Applying the discharge crucible (DC) method, the viscosity, density, and surface tension were determined for Sn-9Zn and Sn-2.92Ag-0.4Cu-3.07Bi (SAC + Bi) alloys. For comparison, the dilatometric, maximum bubble pressure, and capillary flow methods were used for measurements of these same physicochemical properties for the Sn-2.92Ag-0.4Cu-3.07Bi (SAC + Bi) alloy. The measurements were performed for Sn-9Zn and SAC + Bi alloys in the temperature range from 513 K to 723 K and 530 K to 1180 K, respectively. The experimental data obtained show that addition of Bi to SAC increases the density and decreases the surface tension and viscosity in comparison with SAC solder. Additionally it was found that the properties studied by different methods (maximum bubble pressure, dilatometric, capillary flow, and discharge crucible) were almost identical.

Key words: Sn-Zn, SAC, density, surface tension, viscosity, physicochemical properties

INTRODUCTION

Over the past 20 years, researchers have invested a lot of effort in identifying substitutes for lead solders, as they are harmful to the environment. This trend was reinforced in Europe by the EU RoHS and WEEE directives. Based on the analysis of many binary and ternary systems, two groups of alloys are considered as potential replacements for lead solders. The first group are alloys based on the Sn-Ag-Cu system (SAC) with addition of different metals.[1–6] Sn-Zn alloys with additions such as Cu, Ag, In, Sb, and Bi[7–13] form the second group. Studies of the mechanical and technological properties (wettability, wear, etc.) conducted for SAC alloy by Zhao et al.[14] and Kim and Jung[15] showed that most investigated properties are similar to those of eutectic Sn-37Pb solder.

In an earlier paper,[16] measurements of surface tension, density, and viscosity were presented together with their temperature dependences for SAC and SAC + In. Complete description of the experimentally obtained mechanical properties, physicochemical and technological advances for SAC alloy with higher Cu content provides greater opportunities to use this alloy in industry. It was shown that addition of up to 3 at.% Cu to the Ag-Sn eutectic steadily increased the density and viscosity of the alloy but did not significantly change the surface tension or contact angle. Very good agreement was observed between experimental data for the same physical properties as determined by different measurement methods. Thermodynamic data of the Ag-Cu-Sn system were used by Moon et al.[17] for calculation of the phase equilibria, and these data are used for the calculation of the melting temperature of various compositions as well as modeling of physicochemical properties.

Wide use of Sn-Zn-based solders is strongly limited by their oxidation. Addition of Ag, Bi, In, Cu or Sb is explored in order to minimize oxidation of Sn-Zn near-eutectic solders. Moreover, as shown by Jiang et al.,[18] these additives increase the mechanical properties and decrease the surface tension, wetting angle, and electrical resistance of the binary alloy. Addition of Bi to eutectic Sn-Zn alloy results in an improvement in the oxidation performance.[18]

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