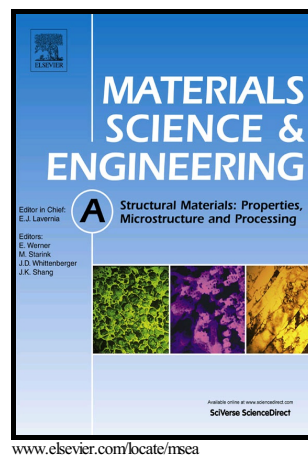


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Roman Kolečák, Igor Kostolný, Martin Kusý



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Characterization of soldering alloy type Zn-In-Mg and the study of direct soldering of silicon and copper

Roman Koleňák, Igor Kostolný, Martin Kusý

Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology
in Trnava, Jána Bottu No. 2781/25, 917 24 Trnava, Slovak Republic
roman.kolenak@stuba.sk, igor.kostolny@stuba.sk, martin.kusy@stuba.sk

Abstract

The aim of study was to characterize the Zn-In-Mg soldering alloy type and investigate the direct soldering of silicon and copper. The Zn-In-Mg solder type has a broad interval of melting, which depends on the indium content in the solder. Solder microstructure is formed of a matrix with pure Zn. The MgZn_2 phases and solid solution (In) β -In are precipitated along the grain boundaries. Tensile strength attains values from 46 to 124 MPa and is dependent on indium content. The bond with silicon is formed due to the reactions of active metals - In and Mg with the substrate surface. Diffraction analysis has also revealed the $\text{In}_{13}\text{Mg}_7$ phase. In spite of that, the bond formation with a copper substrate is not affected by In and Mg content. The bond is formed owing to interaction between the zinc from the solder and copper substrates. Two phases, namely CuZn_4 and Cu_5Zn_8 were observed. The shear strength of Cu/Zn-In-Mg/Cu joints attains values from 56 to 62 MPa and the shear strength of Si/Zn-In-Mg/Cu joint is within 34 to 42 MPa.

Keywords: solder, ultrasonic soldering, shear strength, intermetallic compounds

1. Introduction

The traditional Sn-Pb solders were once the most frequently employed solders in electronic equipment. However, the lead is toxic and detrimental to health and therefore manufacturers recently are forced to use other alternatives for soldering materials. Research in this field has advanced and various other soldering alloys were designed, which may replace these classical solders with Pb content. These are solders based on Sn, Bi or Zn [1, 2, and 3].

The Zn-based solders belong to a group of solders for higher application temperatures. These higher application temperatures vary within the range from 300° C to 440° C. Zinc solders with the addition of other elements attain soldering temperatures around 420° C, which makes them very attractive. These may be used in electronics for die-attaching as well as for optical components and circuit modules for gradual soldering in the automotive industry. With their high thermal conductivity and reliability, zinc alloys are typical in their dependence on other alloying elements. Research in the field of soldering ceramic materials is at present rather concentrated on the application of a direct fluxless soldering by use of active solders [4, 5, 6, 7]. The active solders applicable for fluxless soldering contain small amounts of elements such as Zn, Ti, In, Si, Al, Mg or lanthanides, all of which exert high chemical affinities to oxygen.

The authors in [8] realised research of the application of $\text{Sn}_{3.5}\text{Ag}_4\text{Ti}(\text{Ce}, \text{Ga})$ solder for direct soldering of ITO (indium and tin oxide) with Cu in air at a temperature of 205° C. For removing surface oxides, mechanical activation with ultrasound was employed for 30 seconds. The results revealed Ti presence in the interface between the solder and ceramics. This element was responsible for bond formation.

In work [9], the authors achieved direct soldering of SiC ceramics by the application of ultrasonic vibrations. The SiC substrates were soldered in air using $\text{Zn}_{8.5}\text{Al}_{11}\text{Mg}$ solder at a temperature of 420° C. The shear strength of these joints increased with the time period of

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