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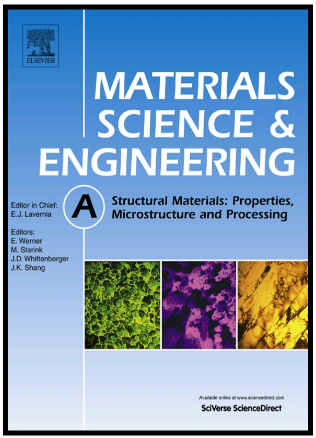

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Microstructure characterization and mechanical behavior for Ag_3Sn joint produced by foil-based TLP bonding in air atmosphere

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Abstract: Low-temperature transient liquid phase (TLP) bonding for Ag-plated substrates was systematically investigated by using foil-based interlayer of pure Sn foil or preformed Sn/Cu/Sn sandwich structure in air atmosphere. The influences of bonding process, such as bonding temperature, bonding time and foil thickness, on the microstructure characterization and mechanical behavior of TLP joint were discussed. Experimental results show that Ag-plated substrates can be successfully TLP bonded in air atmosphere by the protection of flux. The formation of pores in intermetallic compounds (IMCs) is a serious problem for Ag/Sn/Ag TLP bonding, which is attributed to the volume shrinkage of isolated Sn areas during isothermal solidification. Prolonging homogenization time, properly increasing bonding pressure, decreasing temperature, or reducing interlayer thickness can effectively reduce the shrinkage porosity, but is still incapable of eliminating pores thoroughly. Both shear bands and intergranular facets are simultaneously observed on the fracture surface of Ag_3Sn joint. Since the micro voids distributing along Ag_3Sn grain boundaries weaken the cohesion strength between two neighboring Ag_3Sn grains in some areas. Using preformed Sn/Cu/Sn interlayer is available to enhance the mechanical integrity, which is strongly depended on the Cu thickness and Sn thickness. The joint shear strength can be increased by even more than 100% by the introduction of Cu foil. Moreover, the remained Cu layer in the IMCs can act as a buffer layer during fracture process, leading to the improvement of the ductility of TLP joint.

Keywords: TLP bonding; intermetallic compounds; pore; shear strength; fracture; ductility

1. Introduction

In recent years, the demand for high-temperature electronics, which require highly reliable and stable functionality, has been rapidly increasing in particular for the automotive, aerospace, deep-well drilling and energy production industries [1-3]. For example, deep oil and gas drilling will be performed in harsh environments in the near future, and the control and sensing devices inside need to survive pressure reaching to 30000 psi and temperature up to 300 ºC for deeper exploration [3]. Thus, it will be an inevitable trend to substitute the conventional Si-based power devices for the wide band-gap (WBG) semiconductors such as SiC and GaN, since the former are limited to be operated less than 150ºC while the latter are capable of electronic functionality above 300ºC [2]. However, the unavailability of mature high-temperature packaging technology in the range of 300-600ºC operation partially hinders development and application of WBG semiconductors. In the past, most candidates including Cu-Cu thermo-compression bonding [4], nano-silver particles sintering [5] and