Kinetics of interfacial reactions in Sn-3.5Ag/Cu system during solid liquid inter-diffusion (SLID) soldering process

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Abstract

The growth kinetics of intermetallic compound layers formed between Sn-3.5Ag solders and Cu substrate by solid-liquid interdiffusion (SoLID) soldering was experimentally investigated by soldering samples between 260-360^{o}C for 20-240 min. The solder joints show that the intermetallic compound layer was composed of two phases: η-phase (Cu_6Sn_5) adjacent to the solder matrix and ε-phase (Cu_3Sn) adjacent to the copper substrate. The thickness of the η and ε intermetallic phases increases with increasing the soldering time and/or soldering temperature. The increase in the intermetallic layer thickness during the SoLID soldering process was found to obey a quadratic relationship with time. Therefore, the good linear correlation of the thickness versus square root of time indicates that the formation of the intermetallic compound layer is mainly controlled by the volume diffusion mechanism. The apparent activation energies calculated for the growth of η- (Cu_6Sn_5) and ε-(Cu_3Sn) intermetallic phases are 43.65 and 33.17 KJ/mol., respectively. These values slightly differ from literature where a simple power-law fit is used to extract those quantities. The power-law fit does not explicitly incorporate the interaction between the different IMCs growth behavior. In the current study, the activation energies for the IMC growth are calculated based on the Dybkov model in which the net growth rate of any IMC phase is a result of its growth due to a particular chemical reaction and its consumption in forming the other IMC phase. The values obtained in the current study are still within the scope of the literature values.