DEVELOPMENT OF A CU-SAC305 BASED LEAD FREE SOLDER JOINT INTERFACE WITH IMPROVED RELIABILITY AND ENVIRONMENTAL STABILITY

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of
Doctor of Philosophy

MONALISA CHAR
(Registration No. NITD/PHD/PH/2017/00837)

Under the Supervision of

Prof. (Dr.) Amit K. Chakraborty
Department of Physics
National Institute of Technology, Durgapur
India

Dr. Abhijit Kar
Jagadis Bose National Science Talent Search, Kolkata
India

DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR
WEST BENGAL -713209
INDIA

September, 2022

Abstract

Soldering is a well-known metallurgical joining method, extensively used in any electronic/microelectronic gadgets. Post banning of lead in electronics, SAC305 has emerged as one of the few good materials as lead free solder alloy. However, relatively ***higher processing temperature, higher intermetallic compound (IMC) growth*** at the solder joint interface, ***poor mechanical stability*** of the joint interface and the ***high electrical resistance*** of the interconnects are some of the challenges that need to be addressed before SAC305 solder alloy can be routinely used inside the electronic gadgets. In this thesis an attempt has been made to address some of these issues by sandwiching a Cu-SAC305 solder paste between thin Sn multilayers as filler alloy to improve the properties of normal Cu-SAC305 based lead free solder joint interface. A transient liquid phase like soldering approach has been adapted which resulted in lowering of the joint processing temperature to 230°C, about 20-30°C less than that required for conventional SAC305. A comparative study on the microstructural, functional and micromechanical properties of layered (Cu-Sn-SAC305-Sn-Cu) and non-layered (Cu-SAC305-Cu) lead-free solder joint interfaces have been carried out. Through various investigations, presences of intermetallic compounds such as ε-Cu_3Sn and η-Cu_6Sn_5 phases have been identified. It has been demonstrated that the usage of Sn multilayers in conjunction with SAC305 solder paste can enhance the Cu-SAC305-Cu solder joint interface in a number of forms. Tin multilayers also helped to establish homogeneous microstructural distribution over the solder joint and lowered the rate of production of intermetallic compounds at the solder joint interface. The electrical conductivity of the Cu-Sn-SAC305-Sn-Cu solder joint interface was found to be substantially higher than that of the Cu-SAC305-Cu solder joint interface. The micromechanical characteristics of solder junctions were estimated using nanoindentation. Mechanical characteristics were also evaluated. The mechanical and micromechanical characteristics also showed improvement upon incorporation of tin multilayers. A qualitative investigation of the joint interface was carried out using non-destructive assessment techniques. Influence of humidity, aging and temperature on the stability of the Cu-SAC305 and tin multilayer sandwiched Cu-SAC305 alloy have been thoroughly investigated which revealed improved stability of the former indicating its potential suitability as a reliable and durable solder joint alloy. Long-term behaviour of solder joint interfacial properties has been examined using a theoretical modelling approach and correlated by validating it on previous data.