Characterization of Failure Behaviors in Anisotropic Conductive Interconnection

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The effects of bonding forces and reflow process on the failure behaviors of anisotropic conductive film (ACF) interconnections were analyzed. Conventional reflow process was employed with peak temperatures of 220 °C for soldering of Sn-37Pb and 260 °C for soldering of Pb-free Sn-Ag or Sn-Ag-Cu. Two kinds of main failure mode were detected after double reflows at 220 °C: formation of a conduction gap between conductive particles and Ni/Au-plated Cu pad, and delamination of the adhesive matrix from the plated Cu pad on the flexible substrate. The determination of the failure mode was mainly affected by the variation of the bonding force. The main failure mode of the reflowed ACF joints was conduction gap for the joints with lower bonding forces and adhesive matrix delamination for the joints with higher bonding forces. However, only adhesive matrix delamination was observed after reflows at 260 °C. A theoretical calculation was also conducted to predict the connection resistance of the ACF joint before and after reflows. The calculation showed that the optimum bonding forces are between 65 and 70 N. [doi:10.2320/matertrans.48.1070]

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1. Introduction

The electronic industries have relied heavily on the use of eutectic Sn-Pb solder for through-hole and surface mount assemblies. This is mainly due to its advantages of good wetting properties, low prices, low melting temperature, adequate physical and mechanical properties and good fatigue properties.1,2 However, pressure for the eventual elimination of the use of Pb in the manufacturing of electronic products has grown significantly due to the environmental concerns about toxic release during product disposal through either incineration or landfill leachate. Two recent European Union directives, RoHS (Restriction of the use of certain Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment), require new electrical and electronic equipment produced after July 1, 2006 to be Pb-free.3,4 In response to these legislations, most major electronic manufacturers have stepped up their search for alternatives to the Sn-37Pb solder.

To date, these efforts have been focused on two alternatives: Pb-free solders and polymer-based, anisotropic conductive films (ACFs).5 Although various Pb-free solders have already been developed, most current commercial Pb-free solders, such as Sn-Ag and Sn-Ag-Cu, have higher melting temperatures than that of Sn-37Pb solder. Higher soldering temperature caused by the higher melting temperatures reduces the integrity, reliability and functionality of printed circuit boards, components and other attachments. On the other hand, ACFs generally have lower processing temperatures, which allow the thermal damage of packaging components to be minimized. In addition, ACF has many other distinct advantages that solder alloys cannot offer. It is flexible, capable of fine pitch interconnections, environmentally friendly and cheaper to manufacture.

Despite this focus on ACF interconnection technology as an alternative to solder joint technology, unresolved drawbacks of this technology include a lack of data for optimized bonding parameters and reliability problems. In previous studies concerning the bonding parameters of the ACF flip chip joining, it was reported that the electrical properties of the ACF flip chip package are highly affected by the bonding temperature and force.6,7 Especially, the contact resistance of the ACF joints is highly related with the deformation of the conductive particles induced by the pressure applied during the bonding process. This is because if the particles are too spread out between adjacent bumps or pads, as a result of excessive applied pressure, they may end up contacting each other and thereby creating a short-circuiting effect, whereas if the bonding pressure is too low, the particles may not be able to make contact between the connecting bumps and pads.7 However, in most of the previous studies concerning the bonding parameters, only contact resistance with varying bonding pressure was investigated, while various failure modes and mechanism which could be obtained with the reliability tests were not seriously discussed.

Another reliability problem of ACF flip chip assemblies is complicated by the fact that ACFs and solder are often used on the same device. In the general manufacturing process of the ACF assemblies, the first process is usually the ACF flip chip bonding to achieve high accuracy for fine pitch placement of components, and the second process is the conventional reflow process to join various surface mount components. Therefore, the ability of the ACFs to survive in

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