Reliability analysis of the fine pitch connection using anisotropic conductive film (ACF)

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Received 9 August 2005; received in revised form 14 October 2005; accepted 17 October 2005
Available online 21 November 2005

Abstract

A novel method (the V-shaped curve) is presented to predict the failure probability of anisotropic conductive film (ACF) in IC/substrate assemblies. The Poisson function is used to calculate the probability of opening failure in the vertical gap between the pads, while the box and modified box models are used to estimate the probability of bridging failure between the pads in the pitch direction. The opening and bridging probabilities are combined using probability theory to establish four different failure prediction models. The results reveal that the model combining the Poisson function for fewer than six particles per pad with the modified box model provides the most accurate predictions of the failure probability of ACF in IC/substrate assemblies.

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Keywords: Anisotropic conductive film (ACF); Flip chip packaging; Probability; Opening; Bridging; Failure; Volume fraction; V-shaped curve

1. Introduction

Anisotropic conductive film (ACF) consists of adhesive resins and conducting particles. ACF is widely used in packaging technologies for liquid crystal displays (LCD) and flat panel displays (FPD). ACF provides unidirectional conductivity in the vertical direction and insulation in the pitch direction. Fig. 1 presents a schematic illustration of a typical cross-section of an IC/substrate assembly packed with ACF. Fig. 2 shows that normal, bridging and opening conditions in the ACF assembly.

It has been reported that in IC/substrate assemblies with an inter-pad spacing of 50 μm, the use of an ACF with five particles per pad ensures a stable contact resistance during testing at high temperatures (85 °C) and relative humidities 85% [1,2]. A density of more than five particles per pad is required if a reliable contact resistance between the IC and the substrate is to be ensured. A density of fewer than six particles per electrode is unacceptable. A defect (fewer than six particles per electrode) occurrence probability of less than 10−9 ensures a stable quality level in the electrical performance of the IC/substrate assembly. However, an excessive number of dispersed particles in the ACF may cause electrical short circuits (i.e. a bridging effect between the pads in the pitch direction). From the above, it is clear that designing ACF IC/substrate assemblies requires the ability to determine the optimum volume fraction for any particular IC/substrate geometry. Consequently, developing failure prediction methods for ACF IC/substrate assemblies is an important research task.

The present analysis develops two models to predict the occurrence of the opening effect, namely the Poisson function for zero particles on the pad and the Poisson function for less than six particles on the pad. Other two models are introduced to predict the occurrence of bridging failure, namely the box model [3] and the modified box model [4]. The individual opening and bridging models are then combined using probability theory to construct four separate failure analysis models.

2. Opening circuit analysis using Poisson function

The Poisson function given in Eq. (1) estimates the probability of there being n particles located on a pad [3]:
PogP_II(B_0): 147 \leq Z_2! 10

Hence, adopting these models will lead to a reduced processing yield. Therefore, the real model, i.e. $P_{II}(f)$, should be employed to predict the failure probability of ACF IC/substrate assemblies.

6. Conclusion

This paper has applied probability theories (i.e. the Poisson function, the box model, and the modified box model) to the analysis of ACF IC/substrate reliability. Four different models have been constructed for predicting the failure probability of the ACF in the IC/substrate assembly. The tips of the associated V-shaped curves indicate the ACF volume fractions, which ensure the lowest failure probability. The results have shown that the most suitable prediction method (i.e. the method whose results are closest to reality) is the method, which combines the Poisson function for fewer than six particles with the modified box model.

Acknowledgements

The authors gratefully acknowledge the support provided to this research by the National Science Council ROC under Grant Numbers NSC 92-2212-E-274-004, NSC 94-2218-E-274-002, and NSC 93-2212-E-274-007.

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