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Thermal Cycling Reliability of Sn-Ag-Cu Solder Interconnections. Part 1: Effects of Test Parameters

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The work presented in part 1 of this study focuses on identifying the effects of thermal cycling test parameters on the lifetime of ball grid array (BGA) component boards. Detailed understanding about the effects of the thermal cycling parameters is essential because it provides means to develop more efficient and meaningful methods of reliability assessment for electronic products. The study was carried out with a single package type (BGA with 144 solder balls), printed wiring board (eight-layer build-up FR4 structure), and solder interconnection composition (Sn-3.1Ag-0.5Cu) to ensure that individual test results would be comparable with each other. The effects of (i) temperature difference (ΔT), (ii) lower dwell temperature and lower dwell time, (iii) mean temperature, (iv) dwell time, and (v) ramp rate were evaluated. Based on the characteristic lifetimes, the thermal cycling profiles were categorized into three lifetime groups: (i) highly accelerated conditions, (ii) moderately accelerated conditions, and (iii) mildly/nonaccelerated conditions. Thus, one might be tempted to use the highly accelerated conditions to produce lifetime statistics as quickly as possible. However, to do this one needs to know that the failure mechanisms do not change from one lifetime group to another and that the failure mechanisms correlate with real-use failures. Therefore, in part 2 the observed differences in component board lifetimes will be explained by studying the failure mechanisms that take place in the three lifetime groups.

Key words: Reliability, temperature cycling, thermal shock, accelerated lifetime, test parameters

INTRODUCTION

The functionality and performance of advanced electronic devices such as smartphones, laptops, and tablet computers have increased significantly over the past few years. This has led to excess heat dissipation inside electrical assemblies, making thermal management of new devices an ever more important aspect of the design of reliable products. Furthermore, the electrical interconnection densities have increased and solder volumes decreased accordingly, adding substantially to the strains and stresses experienced by solder interconnections. Electrical devices are also designed to be used in more challenging operation environments; For example, telecommunications base stations are expected to operate for several decades in conditions where ambient temperatures can vary greatly. This means that solder interconnections are exposed to thermomechanical loadings and local heating in varying operation environments.

Accelerated thermal cycling tests are most commonly used to study the effect of thermal changes to assess the reliability of electronic products. These accelerated tests can be either thermal shock (TS) or temperature cycling (TC) tests, which are distinguished by the rate of temperature change. Thermal shock tests have faster ramp rates (typically $>30°C$/

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