Chapter 8
Board Level Reliability

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8.1 Introduction

In recent years, manufacturing smaller and lighter devices has been the trend for both mobile phones and all other portable products. One of the most important factors leading to weight reduction has been the adoption of both BGAs (ball grid arrays) and CSPs (chip scale packages).

Most of the work done in the field of reliability of solder joints, which allow the assembly (and therefore both the electrical and mechanical connection) of BGAs/CSPs on the PCBs (printed circuit boards), has focused so far on the mechanical stress caused by thermal tests. During thermal cycles, the cracking of the joints is caused by the difference in thermal expansion coefficients between either joint and component or joint and PCB. Thermal cycles represent a useful qualification test for all those applications characterized by low energy dissipation, where a change in the environmental thermal conditions is extremely important during the whole lifetime of the device. In most cases the operating temperature range for portable devices is extremely narrow, and the useful product lifetime is relatively short (3 to 5 years). It is therefore safe to assume that solder joints do not crack in portable applications because of thermal stress. The main reasons for a break are instead related to both PCB bending stress and short-duration stress, like the impact after a free fall.

Mechanical shocks caused by the handling and normal use can cause a solder joint crack and resulting incorrect device behaviour. It is therefore extremely important to design and manufacture more robust packages and printed circuits, which can guarantee better performance in case of both bending and impact. For this purpose, two tests have been recently introduced, namely the Bend Test and the Drop

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1 Force over a unit of resistance area.
Test, in order to evaluate the reliability of the solder joints at board level: that is, samples composed of the PCB and properly placed soldered DUT (devices under test) are tested.

8.2 Bend Test

Three different causes for solder joints cracking after bending a PCB can be identified. A localized bend of the PCB, possibly due to a mounting screw tying it to the external box, can cause a creep crack of the joints of the device mounted near the screw itself. Creep is the spontaneous deformation of metal materials under the effect of a constant stress at a given temperature: it means that the creep crack can occur days or even years after the product has been assembled. The second cause of cracking can be the pressure of the buttons on a mobile phone: every time a key is pressed, the PCB beneath the button tends to bend. The amount of bending, and the resulting stress on the solder joints, depends on the mechanical characteristics (elasticity, deformability, etc.) of the product. The third cause for cracking is an impact. Solder joints can crack either because of slight stress events applied cyclically or because of a major stress caused by PCB vibration; in this case too, the nature of the stress depends on the mechanical characteristics of the product and on its orientation when it is dropped.

The bend test can be used to evaluate two different but equally important features of the solder joints: mechanical endurance, and stress endurance to cyclical bending of the PCB. In the former case, the test is normally referred to as a bending test: it is a simple static test where PCB bending is linearly increased over time until either the joints or the components fail. In the latter case, the test is referred to as a bending cycle test: the PCB is cyclically bent and the mechanical endurance of the joints is measured as cycles for fatigue. Figure 8.1 shows the different setup for the two tests, which basically differ in the way both load and bending are applied to the PCB.

In the following paragraph, the procedures used to estimate, by means of the bend test, both the mechanical and the stress endurance of the solder joints are described. It is important to highlight that there are no internationally-approved standards for these tests yet; for this reason it is very difficult to compare all the experimental results that can be found in the literature.

![Fig. 8.1 Bend test setup](image-url)