Non Destructive Evaluation of Electronic Components by Oblique CT System

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Abstract
The high-density electronic components such as BGA (ball grid array) and CSP (chip scale package) are widely used in the electrical products. Solder joint between the components cannot be observed from outside. X ray fluoroscopy is used as inspection method. It cannot evaluate the joint defects correctly because information is compressed along the ray. The oblique CT is considered as a method for accurately examining the shape of the components. In this paper, we propose the oblique CT system that can nondestructively obtain the 3D shape of electronic components at a high-speed. This system obtains the projection images from various directions using the rotational transfer of flat panel detector and the fixed mounted open-type X-ray generator that has a wide radiation angle, and reconstructs 3D image using the image processing software.

1. Introduction
More and more concern is currently paid by designers and manufacturers to the quality of electronic devices. This is essentially due to the necessity of (i) detecting and locating those hidden defects which are vulnerable of causing the complete failure of the device when working in critical conditions, and (ii) evaluating the impact of defects upon the reliability of the adopted technology (defects tolerated by a technology can show themselves crucial for the subsequent one). Specifically, the quality of an electronic device is strongly dependent on the integrity of its die-attach assembly. The proper operation of the device within its nominal specifications requires that the die-attach assembly must integrally be without defects; this is particularly true for SMT (Surface Mount Technology) and Chip-On-Board (COB) technology (bare die, flip-chip and CSP).

Die-attach assemblies are multilayer structures consisting of a semiconductor die (typically Si or GaAs) mounted on a substrate (lead-frame, package case, single or multilayer, ceramic or organic composites) and hard or soft attachment materials. Typical failures are delaminations, cracks, voids, metal corrosion, and so on; they are generally localised at the interface between the different layers constituting the assembly. Expansion coefficient mismatches among elements of the microassembly, die backside or solder oxidation, and intermetallic phases can induce stresses following die bonding. For severe environments such as automotive and aeronautics, COB researches are led to improve die-attach quality in hybrid technology in particular with the development of new processes. Moreover, characterisation of die-attach integrity is directly related to the development of external test techniques and in particular of non-destructive techniques.

Defect detection and location in electronic devices can be accomplished by several techniques: optical inspection, infrared thermography, X-ray analysis, and ultrasonic microscopy. Specifically for die-attach assemblies, X-ray analysis and ultrasonic microscopy are the techniques to which most current choices of engineers and technicians are oriented. In this paper, we have used oblique CT system for non destructively evaluating the die attached assembly and electronic components. The field of computed tomography (CT) has attracted tremendous attention due to new detector technologies, high-performance computers and high-performance X-ray tubes.

2. Experimental Setup and Results
Figure 1 shows a schematic representation of the general computer tomography system which is a powerful nondestructive evaluation (NDE) technique for producing 2-D and 3-D cross-sectional images of an object from flat X-ray images. The test component is placed on a turntable stage that is between a radiation source and an imaging system. The turntable and the imaging system are connected to a computer so that x-ray images collected can be correlated to the position of the test component. The imaging system produces a 2-dimensional shadowgraph image of the specimen just like a film radiograph. Specialized computer software makes it possible to produce cross-sectional images of the test component as if it was being sliced.

Cone Beam Computed Tomography (CBCT) scanners mostly used for evaluating electronic components. This type of CT system uses a cone shaped x-ray beam rather than a conventional linear fan beam to provide images of the internal structure. CBCT system has limitations that the large magnification is not possible when inspecting flat and very thin object due to high source to object distance. In this
Fig. 1 : Schematic representation of the general computer tomography system.

Fig. 2 : (a) Cone Beam CT system (b) Oblique CT system

Fig. 3 : (a) Degradation in die attachment (b) Crack in BGA (c) Joint point in Flash memory (d) Solder defect in CSP (e) Degradation in PCB
work, we have used another CT technique, oblique CT (OCT). It obtains the projection image of an object from an oblique direction by rotating the X-ray generator and detector. And some systems employed rotation stage and X-ray generator and detector are tilted for the rotational stage. In the OCT, scanning objects move horizontally because X-ray radiation is inclined; thin and wide objects such as PCBs do not touch the X-ray generator and detector. Therefore, although the PCB may be close to the X-ray generator, we can obtain a 3D image with high magnification without destroying the components. Figure 2 shows the schematic diagram of CBCT and Oblique CT system.

Several defects in electronic components such as lamination layer degradation in die attachment, BGA ball crack, joint point in flash memory, and solder defect in CSP and degradation in PCB board were analyzed using oblique CT system. Figure 3 shows the oblique CT images of above mentioned defects.

3. Conclusions

We successfully used an oblique CT system for inspecting electronic components non destructively. This system collects the projection images from various directions using a rotational sample holder and a fixed mounted open type X-ray generator that has a wide radiation angle, and obtains the oblique CT image. In the experiments, we analyzed the die attachment, BGA and PCB board. The results demonstrated that the oblique CT system was able to obtain the effective information by non-destructive inspection of the electronic components.

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References