SAND2011-0566C

3D X-Ray CT Analysis of Solder Joints in Area Array Electronic Package Assemblies

Rajen Chanchani
Sandia National Labs*
Albuquerque, NM 87185
Tel: (505) 844-3482
Email: chanchr@sandia.gov

*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy under contract DE-AC04-94-AL8500.

Abstract – The inability to do visual solder joint inspection has been a major road block to using advanced ICs with high I/O count in area array packaging technologies like flip-chip, Quad Flat No Lead (QFN) and Ball grid Arrays (BGAs). In this paper, we report the results of a study to evaluate 3D X-Ray Computed Tomography (3DXRay-CT) as a solder inspection technique for area array package assemblies. We have conducted an experiment with board assemblies having intentionally designed solder defects like cold solder joints, solder-mask defects, unfilled vias in solder pads, and different shape and size solder pads. We have demonstrated that 3D X-Ray-CT technique was able to detect all these defects. This technique is a valid technique to inspect solder joints in area array packaging technologies.

1. INTRODUCTION

In high reliability applications such as in space, military, and medical systems, it may be required to visually inspect 100% of the solder joints. However, in area array package assemblies, solder joints cannot be visually inspected because they are located below the package in the small gap between the package and the mother board. In some cases, the inability to do visual solder joint inspection has been a major road block to using advanced ICs with high I/O count in area array packaging technologies like Flip chip, Quad Flat No Lead (QFN) and Ball Grid Arrays (BGAs). In turn, the inability to use area array packaging technology has a significant penalty with respect to system miniaturization, and in some cases performance.

In this paper, we report the results of a study to evaluate 3D X-Ray Computed Tomography (3DXRay-CT) as a solder inspection technique for area array package assemblies. For several decades, the medical community has been successfully using this technique for diagnosis. In the last few years, 3DXRay-CT has significantly improved in resolution and become more cost effective, and the equipment has become smaller in size.

3DXRay-CT involves taking a large number (~1440) of 2D x-ray images of an electronic assembly, while it is rotating 360^{o} around its center axis between a high energy (>50KV) x-ray source and a detector. These 2D images are computationally assembled to form a 3D image. The 3D X-ray image provides a detailed view of the sample's internal features, including, for example, solder joints in BGA assemblies.

2. EXPERIMENTAL

In this project, we have designed a special board assembly consisting of ACTEL FPGA ICs in 484 I/O BGA packages surface-mounted on a Polyimide-Glass mother board. As shown in Figure 1, the mother board was designed with intentionally introduced defects to simulate solder defects that are commonly found in board assemblies. The defects that we introduced were cold solder joints, solder-mask defects, unfilled vias in solder pads, and different shape and size solder pads. In addition to these defects, the assembly process created some additional defects such as air voids.

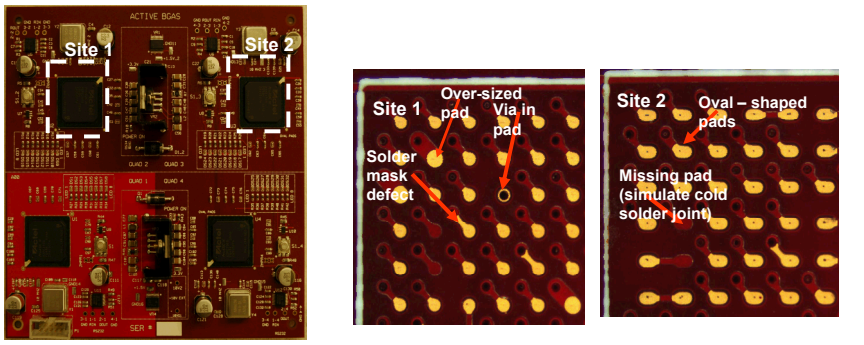

Figure 1: (a) Completed board assembly. (b) Magnified view of the board showing the intentional defects designed on the board that will create some commonly occurring solder defects.

3. RESULTS

As shown in the Figure 2 and Figure 3, 3d X-Ray - CT analyses of the samples showed that this technique can successfully detect all of the aforementioned solder defects. The quality of the picture could vary on the resolution, time of x-ray exposure, x-ray source, number of images compiled in the analysis and the equipment.

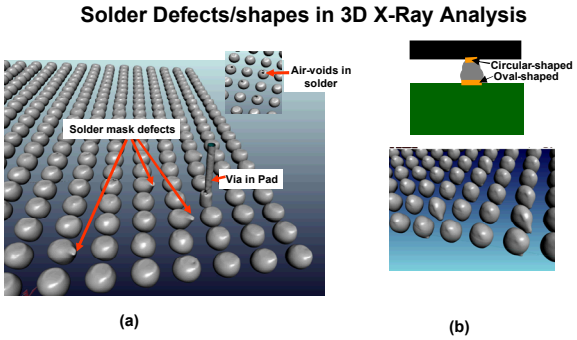

Figure 2: (a) 3D Xray-CT analysis of solder mask defects, via in pad defect and air voids in solder joints. (b) Solder joint shape when solder pads in the board are oval-shaped.

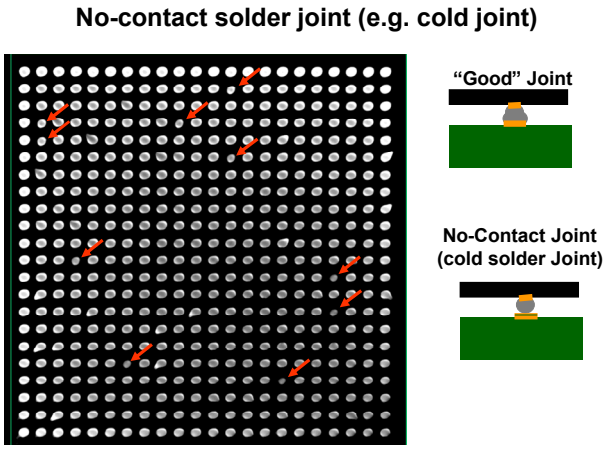

Figure 3: 3D Xray-CT analysis of no-contact solder defects (e.g. cold solder joints).

One concern with this technique is the long exposure to x-rays, and the possible detrimental effect on the performance of the IC. As a part of this study, we measured the radiation exposure from the analyzing x-rays. The measured x-ray exposure was less than 700 Rads. Furthermore, we determined that the exposure can be further reduced to below 100 Rads by optimizing the analysis parameters, namely the number of 2D images taken, and the exposure time per image.

4. CONCLUSIONS

The conclusion of the study is that 3DXRay-CT is a valid technique to inspect solder joints in area array packaging technologies.