ELECTRONIC COMPONENTS NONDESTRUCTIVE TESTING: COMPARSION BETWEEN ACOUSTIC MICROSCOPY AND X-RAY ANALYSIS.

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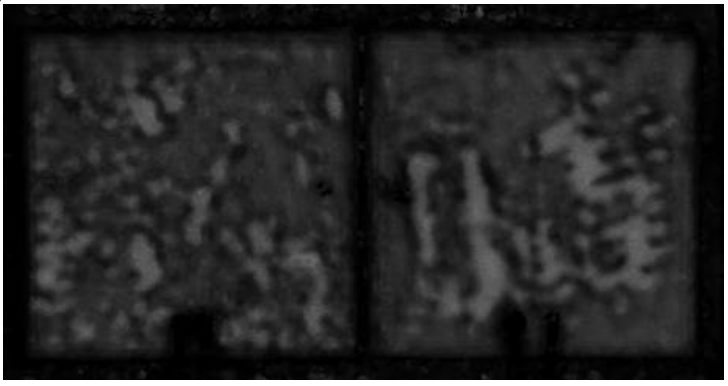
Nowadays, electronic devices characterization becomes more difficult due to the continued complexity increasing and miniaturization of integrated circuits (IC). Therefore, reliable techniques for quality control and failure analysis of electronic devices becomes more important than ever.

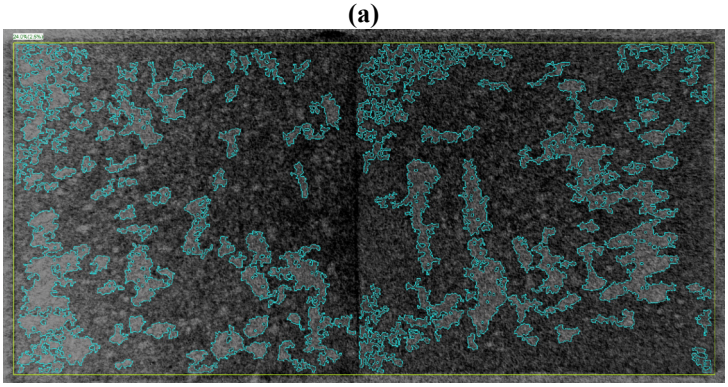
Scanning acoustic microscopy (SAM) and X-ray analysis are most widely used methods in electronic devices non-destructive testing [1]. In some articles (for example [2]) it is shown that in many cases acoustic microscopy is the only technology that allows quick and non-destructive defects detection; in others (for example [3]) advantages of X-ray analysis are demonstrated. In this work comparison between defect detection ability of mentioned methods is done.

Various electronic components were investigated, including different types of plastic and ceramic IC packages, diodes, transistors and BGA components. During investigations follow internal defects were detected: delamination between encapsulate and lead interconnect, die attach delamination, mold compound voids, voids in BGA connection, internal part destruction, internal part displacement, wire breakages. Defects such as delamination between encapsulate and lead interconnects, small mold compound voids and horizontal cracks were detected by scanning acoustic microscope only. In other hand, wire breakages, small internal parts displacement and small internal parts destruction were observed only in X-ray images.

Die attach delamination were detected well by both scanning acoustic microscope and X-ray analysis system (see fig.1).



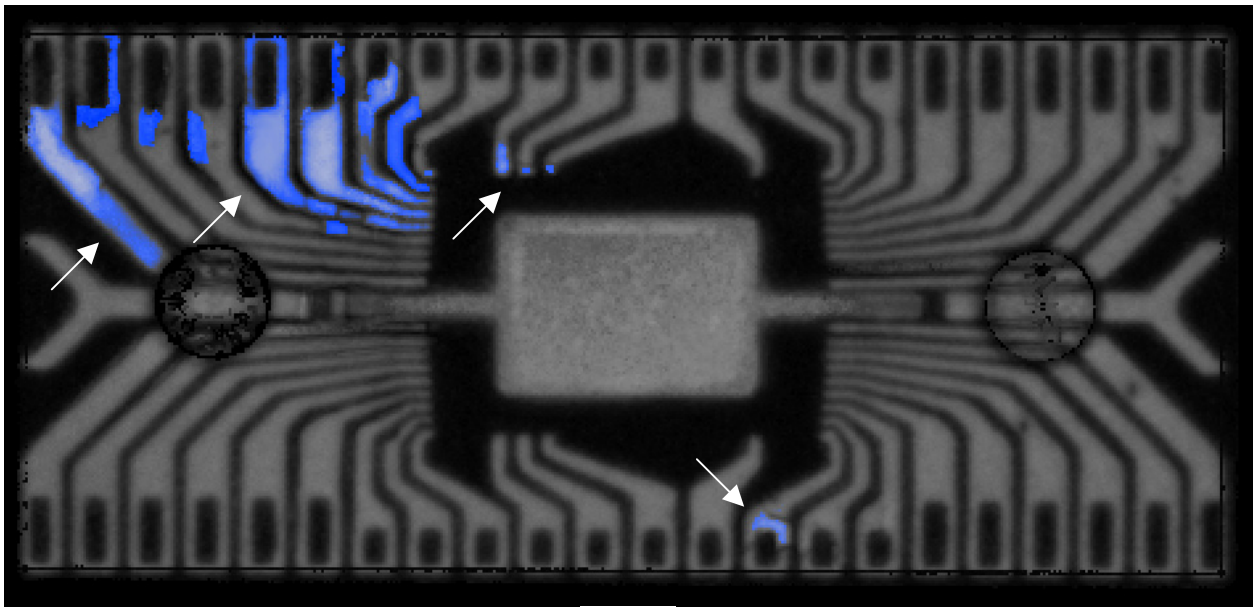
(a)

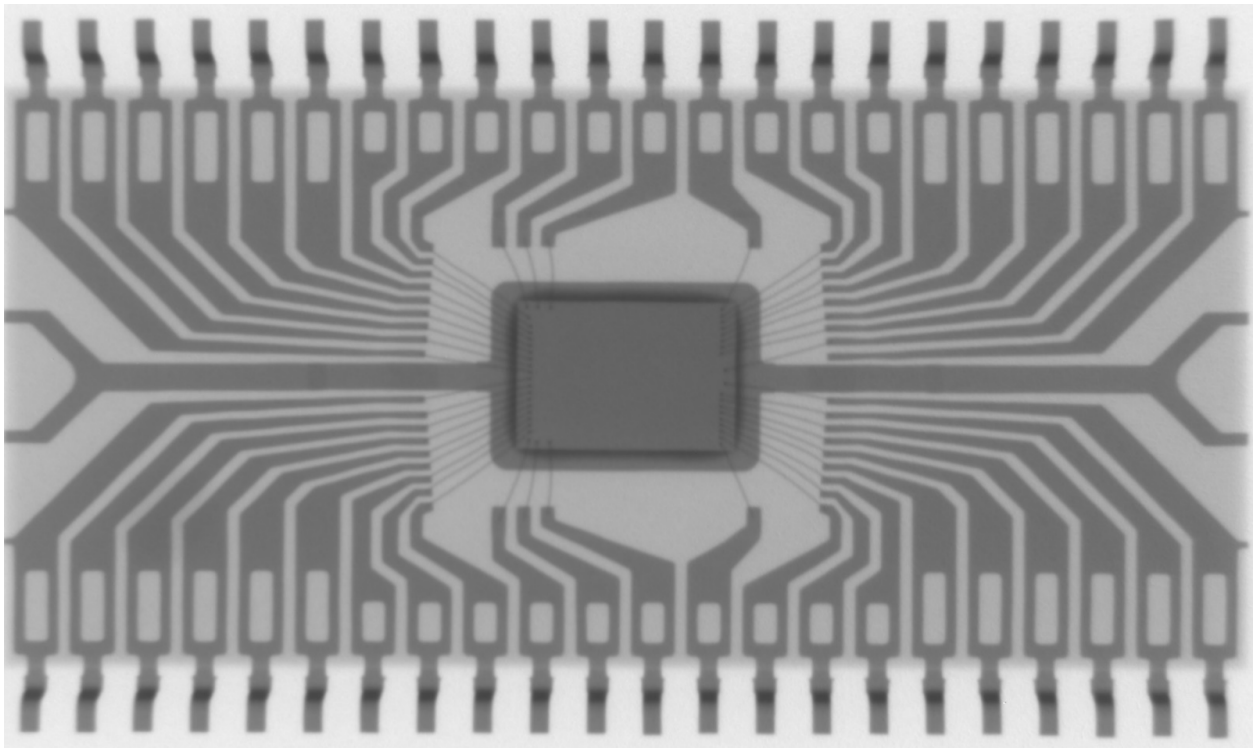


(b)

Figure 1. Die attach delamination: acoustic image (a) and x-ray one (b).

Most other defects were observed by either scanning acoustic microscope or X-ray analysis system. Good example to demonstrate difference between acoustic and X-ray images is shown in fig.2

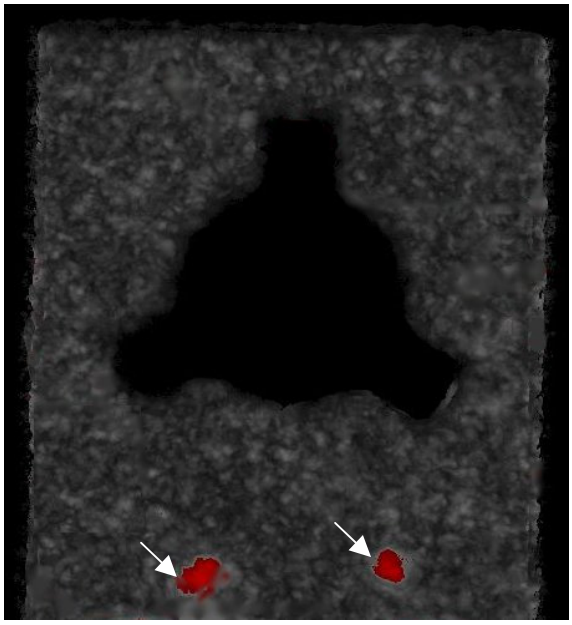




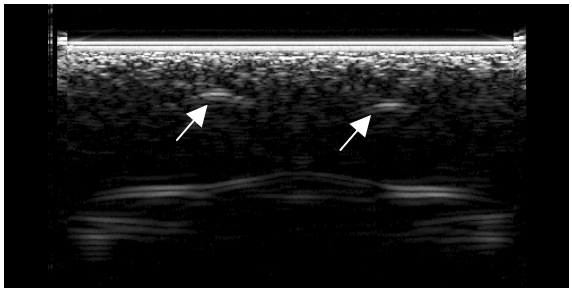
X-ray image shows interconnection wires clearly, but no delamination is observed on it at all. On the contrary, acoustic image shows delamination clearly, but lateral resolution of acoustic microscopes is not enough to observe interconnection wires and, in particular, wire breakages.

Another example, that shows mentioned difference is presented in fig 3 (a) and (c).

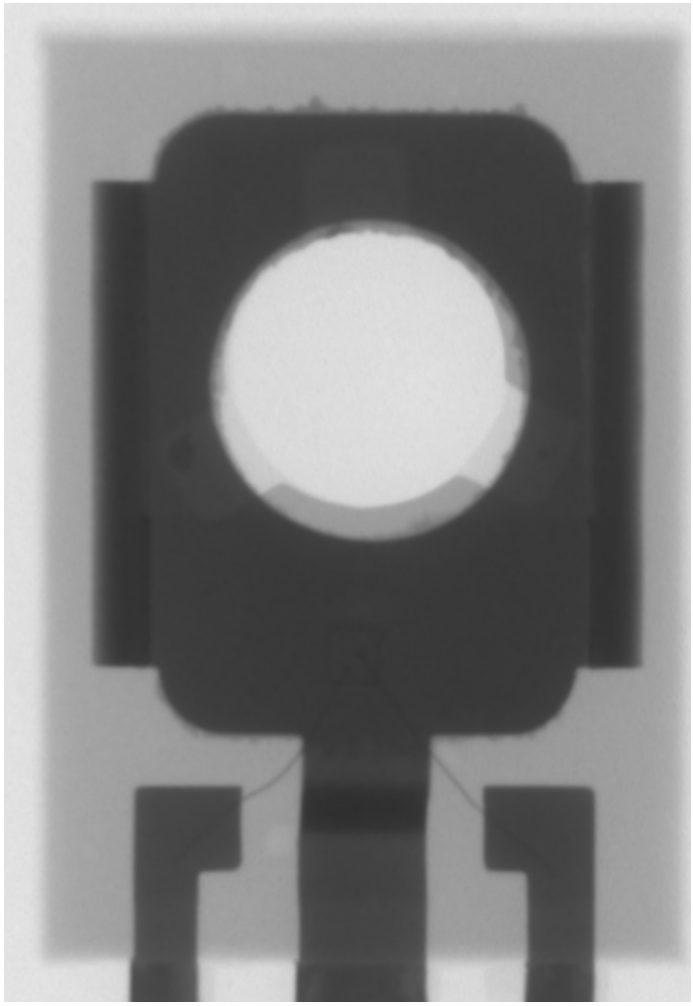
Despite the fact, that large mold compound voids could be seen in X-ray images, small ones are invisible for X-ray systems. For acoustic microscope even small voids detection is very simple, because they produce very strong reflection of acoustic waves. Moreover, acoustic microscopes can locate voids both on x-y plane and in z-direction without sample rotation (fig.2 b).



(a)



(b)



(c)

Figure. 3. Acoustic C-scan (a) and B-scan (b) images and X-ray image (c) of the same transistor in plastic package. Acoustic images show voids.

The same situation is with such defects as cracks. Some cracks can be detected by both scanning acoustic microscope and X-ray analysis system. But usually it is possible define cracks locations and measure their size only by scanning acoustic microscope. For example optic, X-ray and acoustic images of the same transformer are presented in fig. 4.

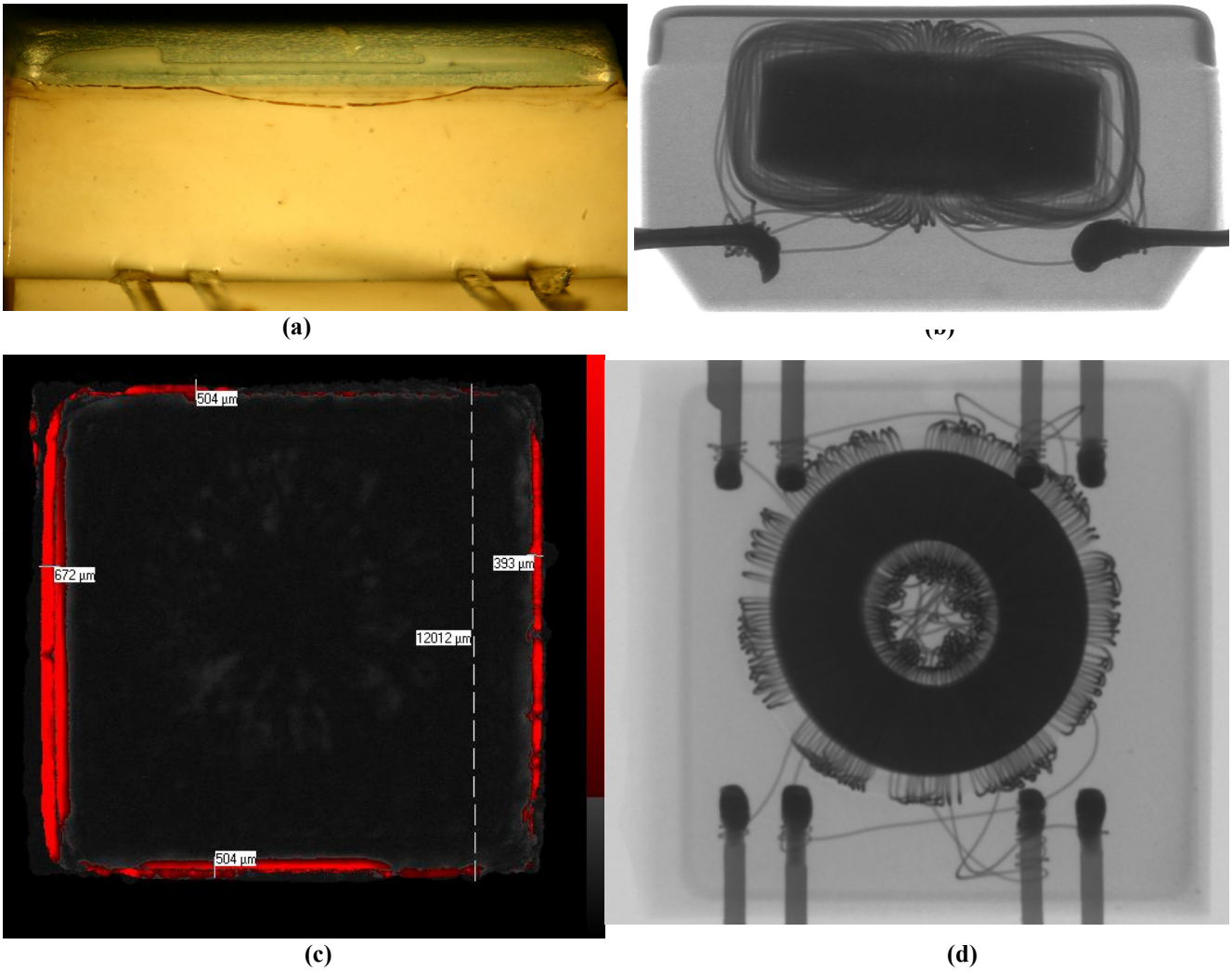


Figure. 4. Transformer in plastic package with horizontal cracks: optical image – side view (a), X-ray image – side view (b), acoustic image – top view (c), X-ray image – top view (d).

The fact that most defects are observed by either SAM or X-ray analysis system can be explained by absolutely different working principles:

- acoustic microscopes use RF acoustic waves with wavelength about a score of µm, which are collected after reflection.
- X-Ray systems use electron beam with wavelength less them nm, which is transmitted through the sample

It was shown, that some significant defects can be detected under ultrasonic inspection only, but some others are visible only in the x-ray images. Therefore conjunctive use of both methods is required for adequate nondestructive analysis of electronic components.

References

[1] R. Mahajan, M. Pecht. Reliability assessment of a plastic encapsulated RF switching device.
[2] Jicheng Yang. Non-destructive identification of defects in integrated circuit packages by scanning acoustic microscopy. Microelectronics and Reliability. Volume 36, Issue 9, September 1996, Pages 1291-1295
[3] Prof. Cheng-Chi Tai, Dr. Ming-Kun Chen, Nondestructive analysis of signal interconnection on thermally enhanced ball grid array. 12th Asia-Pacific Conference on NDT, 5th – 10th Nov 2006, Auckland, New Zealand