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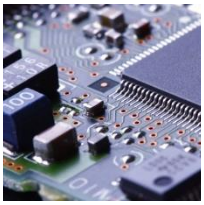
XRF

Non-destructive Failure Analysis on Electronic Components Using the XGT-9000



Application Note

Electronics XGT22

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Abstract: μ-XRF is a non-destructive analytical technique which can inspect defects, even non-visible ones, inside a sample because of the high penetration of X-rays. This application note introduces failure analysis to detect ion migration, voids, and foreign matter on electronics using the XGT-9000, with key features of the vertical irradiation of a 10 μm probe and the simultaneous imaging of fluorescent X-rays and transmission X-rays.

Keywords: Failure analysis, Printed circuit board, μ-XRF

Introduction

With the spread of telework, autonomous vehicles, and on-line sensors, electronics have become indispensable to our lives. Electronics include many small components, and even a small defect may cause malfunction. Therefore, analytical instruments capable of small spot analysis are essential to ensure the quality of electronics by detecting and understanding causes of failures and avoid costly recalls.

Figure 1 shows the XGT-9000 X-ray analytical microscope. The key features are the vertical irradiation with a 10 μm probe and the simultaneous imaging of fluorescent X-rays and transmission X-rays. This application note introduces three failure analyses on electronic components using the XGT-9000.

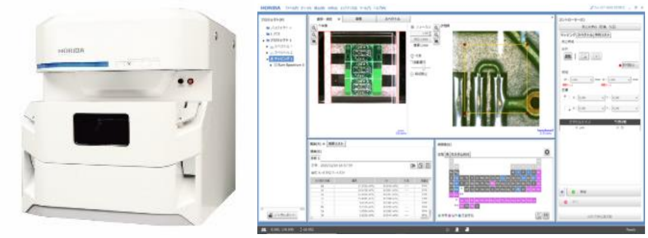

Figure 1. The XGT-9000 hardware and software interface.

1. Detection of ion migration using a 10 μm probe

Ion migration is caused by corrosion of a coating on terminals of an IC chip. It results in a short circuit between the terminals of the IC chip. Figure 2 shows the result of the map imaging on a defective IC chip using the XGT-9000. The measurement was carried out using a 10 μm probe. Figure 2 (b) shows elemental distributions around four terminals of the IC chip. These terminals here are made of Cu with an Ag coating. The presence and specific distribution of P suggests this is due to the existence of phosphoric acid, which is known to be one of the possible causes of ion migration. Figure 2 (c) shows the distribution of Ag on the area in a white dotted frame in Figure 2 (b). It revealed and showed that Ag ion migration occurred between the terminals.

Thus, thanks to the vertical irradiation with a 10 μm probe, the XGT-9000 can detect a small defect like a short circuit between terminals even when the defect size is tens of microns. Compared with electron microscopic analysis, μ-XRF is more powerful, as it allows detection of such ion migration inside the layer of a printed circuit board without having to do the cross-section due to the deeper X-ray penetration.

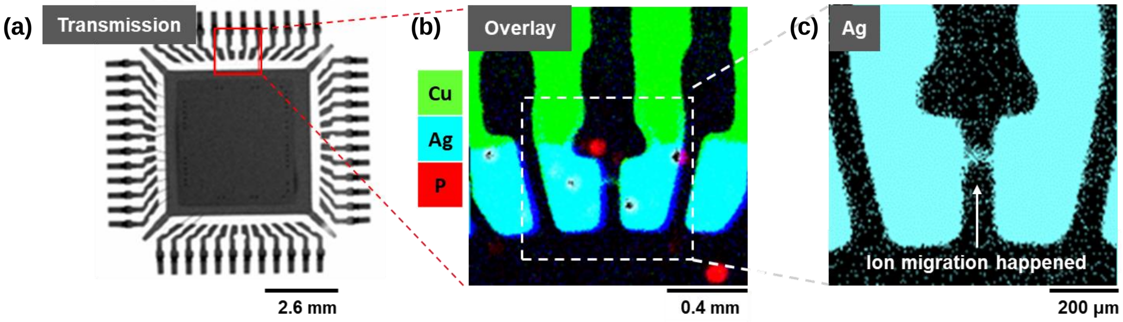

Figure 2. Map images of the IC chip where ion migration occurred between the terminals.

2. Void detection by transmission X-ray imaging

The XGT-9000 is equipped with simultaneous imaging of fluorescent X-rays and transmission X-rays. Transmission X-ray imaging can visualize the distribution of the difference of density. It can also find covered foreign matter or defects even when they are not exposed. Therefore, transmission X-ray imaging can help to detect and visualize a void that may not be visible in the elemental map images.

Figure 3 shows a failure analysis on a printed circuit board using the XGT-9000. The measurement was conducted using an ultra-high intensity probe. Though there is no specific distribution in the elemental map images, the transmission X-ray image shows unexpected distribution within the IC chip. Solder paste is sometimes used between an IC chip and a circuit board to release heat, and the rate of void to the solder-filled area under an IC chip is one of the indicators of the quality of a printed circuit board. In this case, the transmission X-ray image revealed many voids under the IC chip.

Transmission X-ray imaging is not only effective for void detection, but also applicable to find defects inside harnesses and cables which are essential components for electronics.

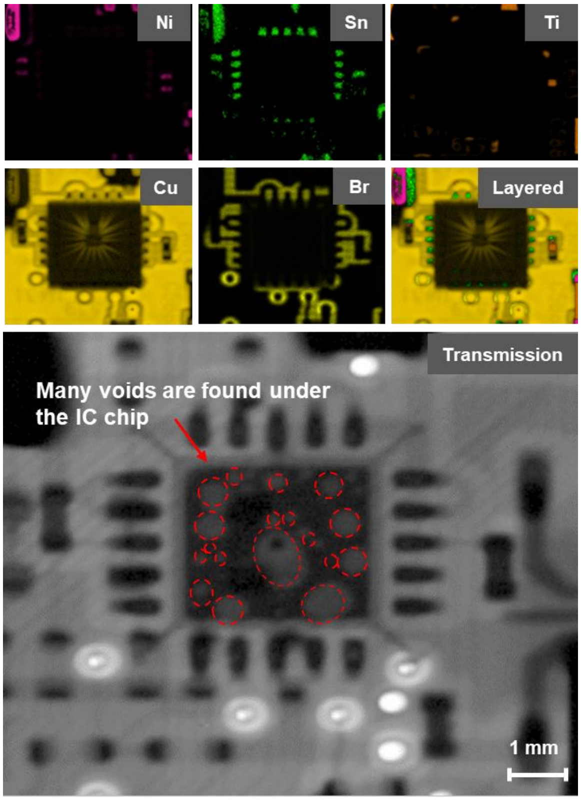

Figure 3. Map images of the printed circuit board with voids.

3. Foreign matter detection on a layered image

The XGT-9000 allows detection of defects inside a sample without sample destruction, thanks to the high penetration of X-rays. In addition to this advantage, the XGT-9000 software has powerful data processing functions, for instance, to create a layered image of elemental map images.

Figure 4 shows a failure analysis on a defective printed circuit board using the XGT-9000 with an ultra-high intensity probe. While the individual elemental images make it hard to find foreign matter on such a complex circuit board with multiple components, a layered image of elemental map images makes it easy to reveal and emphasize unexpected distributions. In this case, the layered image revealed the unexpected presence of Sn under the IC chip.

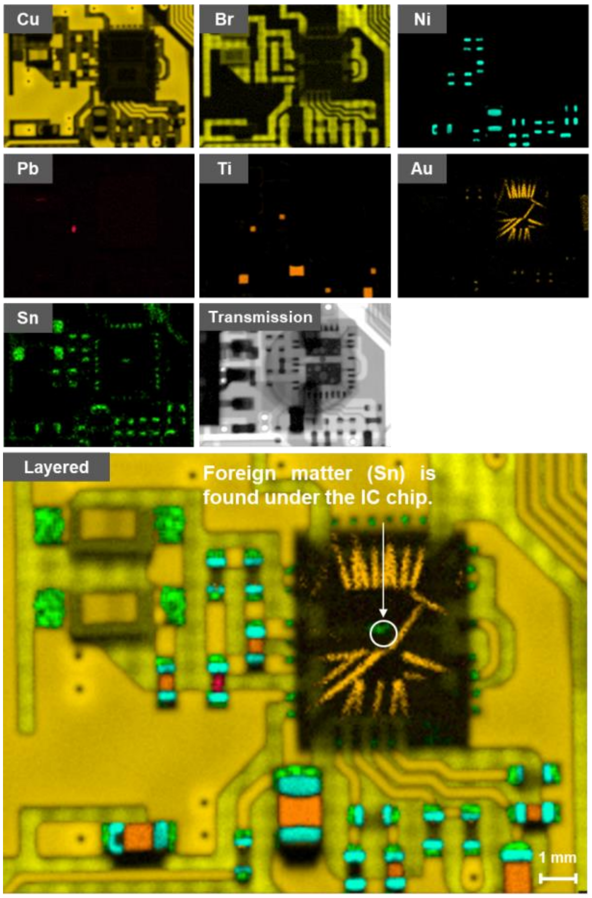

Figure 4. Map images of the defective printed circuit board.

Conclusion

The XGT-9000 is a powerful non-destructive analytical instrument for failure analysis on electronics. It helps us save time on sample pretreatment and enables us to preserve defective samples.

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