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Application News

No. N136

Microfocus X-ray CT System

Example of Observation of Crystal Oscillators with inspeXio™ SMX™-225CT FPD HR Plus

Introduction

With the dramatic progress of electronic technology, miniaturization and higher functionality of the electronic components installed in products have also been demanded. Among those components, the crystal devices called crystal resonators and crystal oscillators are indispensable for accurate operation of products.

This article introduces an example of observation of the internal structure of crystal oscillators using an inspeXio™ SMX™-225CT FPD HR Plus microfocus X-ray CT system (Fig. 1)

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Fig. 1 inspeXio™ SMX™-225CT FPD HR Plus Microfocus X-ray CT System

Features of Crystal Oscillators

Crystal oscillators are one electronic component in which a crystal resonator and an oscillation circuit are integrated in a single crystal device. In a crystal oscillator, deformation of the crystal wafer occurs when a voltage is applied to electrodes attached to the wafer inside the components, resulting in regular oscillation, and an electrical signal with a constant frequency can be obtained by converting this oscillation to electricity. Crystal oscillators with this excellent frequency stability are widely used as clocks for stable operation of systems in various fields, including consumer products, automotive equipment, and medical equipment.

Observation of Simple Packaged X'tal Oscillator (SPXO)

Packaged crystal oscillators, called SPXO (Simple Packaged X'tal Oscillator), are general-purpose oscillators which utilize the stable frequency characteristics of crystals without compensation, and are used mainly in products such as televisions and digital cameras.

Fig. 2 shows the external appearance and X-ray fluoroscopic images of an SPXO. The fluoroscopic images from above and the side reveals that the product contains the IC used as the oscillator circuit and a crystal wafer.

Next, Fig. 3 shows a multi planar reconstruction (MPR) based on a CT scan of the area outlined in red in Fig. 2. In MPR images, the CT data acquired in the scan are stacked in virtual space, making it possible to display images of any desired cross section. In Fig. 3, the cross-sectional images (2) (upper right) and (3) (lower left) are mutually orthogonal to cross-sectional image (1) (upper left), and (4) (lower right) shows a cross-sectional image at an arbitrary angle to cross-sectional image (2). In the MPR images, the black and white areas of the fluoroscope image are inverted, so that higher densities are shown in white and lower densities in black. Thus, by observing these MPR images, the presence or absence of voids (air bubbles) in the conductive adhesive can be judged from cross-sectional image (3), and the condition of connection of the bonding wire in the oscillator circuit IC can be understood from cross-sectional image (4).

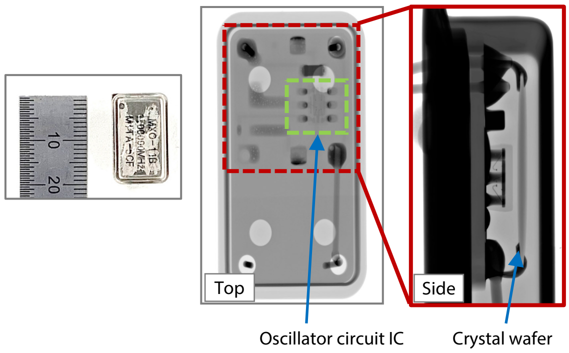

Fig. 2 External Appearance and Fluoroscopic Images of Simple Packaged X'tal Oscillator (SPXO)

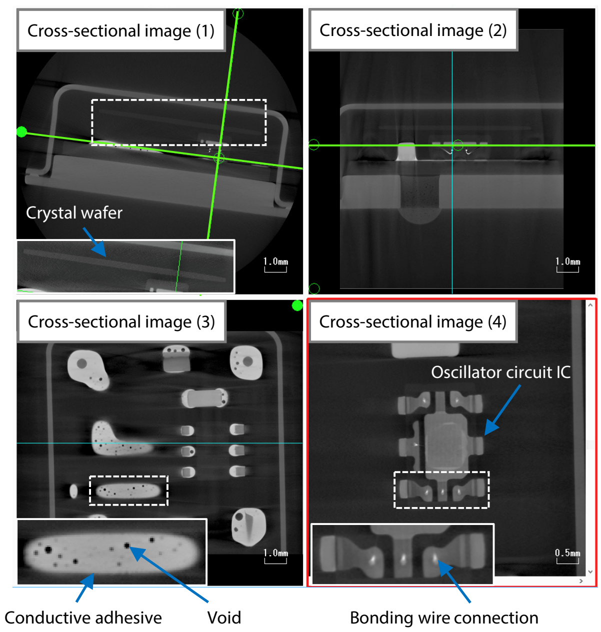

Fig. 3 MPR Images (Area Outlined in Red in Fig. 2)

Fig. 4 is a cross-sectional image showing the electrode parts of the crystal wafer (cross-sectional image (1) in Fig. 3). Multiple voids can be observed in the electrode parts on both side of the crystal wafer.

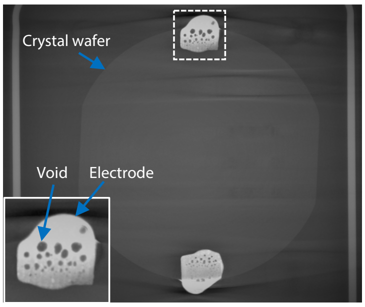

Fig. 4 Cross-Sectional Image (Electrode Parts)

Furthermore, by using VGSTUDIO MAX (Volume Graphics GmbH) software to analyze and visualize the data acquired with an industrial X-ray CT, it is also possible to display the CT data in 3 dimensions and observe objects in a form closer to that of the actual part. Fig. 5 shows a 3-dimensional image of the entire crystal oscillator, and Fig. 6 shows an enlarged 3-dimensional image of the oscillator circuit IC in Fig. 5 (area outlined in green). The condition of the soldered joints and the shape of the bonding wire can be confirmed by enlarged imaging. It is also possible to visualize voids in soldered joints, quantify their positions and volume by using the optional defect/inclusion analysis function of VGSTUDIO MAX (Fig. 7).

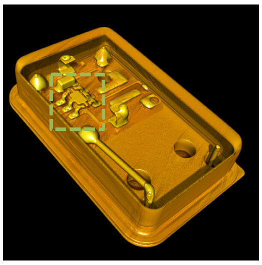

Fig. 5 3-Dimensional Image (Overview)

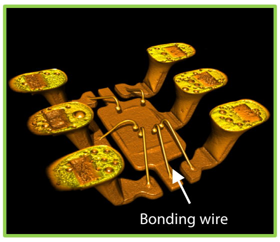

Fig. 6 3-Dimensional Image (Oscillator Circuit IC)

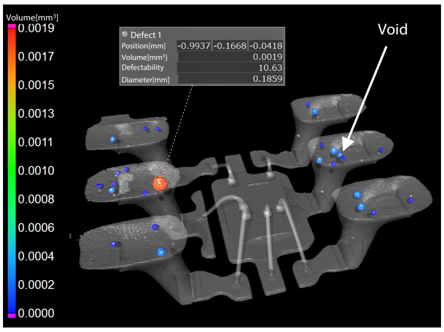

Fig. 7 Defect Analysis of Soldered Joints

Observation of Temperature Compensated X'tal Oscillator (TCXO)

Crystal oscillators with a temperature compensation circuit are called TCXO (Temperature Compensated X'tal Oscillator) and have a built-in temperature compensation circuit that further enhances the stable frequency characteristics of the crystal. This type of circuit can obtain electrical signals with far higher stability than basic crystal oscillators, and is used mainly in smartphones and GPS receivers.

Fig. 8 shows the external appearance and fluoroscopic images of a TCXO. In comparison with the SPXO shown in Fig. 2, this TCXO device contains a large number of parts and has a crystal cap which seals the crystal wafer.

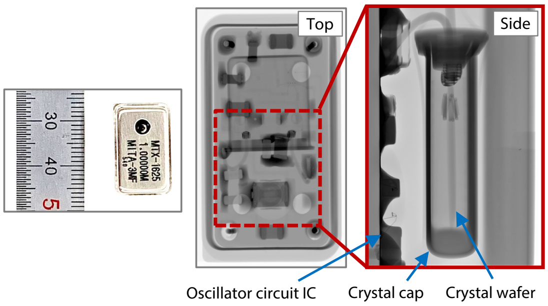

Fig. 8 External Appearance and Fluoroscopic Images of Temperature Compensated X'tal Oscillator (TCXO)

Fig. 9 shows a cross-sectional image of the crystal wafer electrode area (part outline in red in Fig. 8), Fig. 10 is a 3-dimensional image of the entire crystal oscillator, and Fig. 11 is an enlarged 3-dimensional image of the oscillator circuit IC (outlined in green) on the underside of the crystal cap in Fig. 10. By displaying the CT data in 3 dimensions in this manner, it is possible to observe the positions of mounted parts and the condition of joints in arbitrary cross sections which cannot be observed in fluoroscopic images.

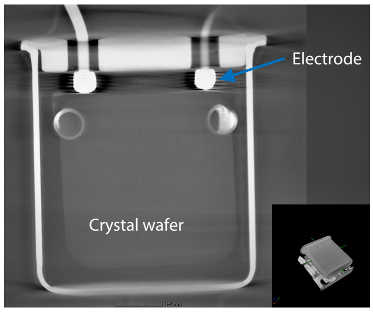

Fig. 9 Cross-Sectional Image (Part Outlined in Red in Fig. 8)

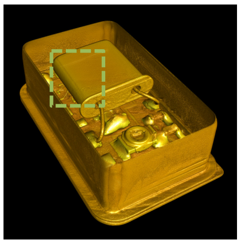

Fig. 10 3-Dimensional Image (Overview)

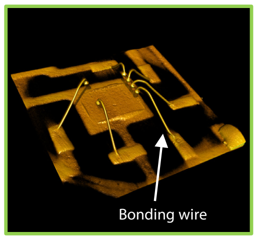

Fig. 11 3-Dimensional Image (Oscillator Circuit IC)

Conclusion

Non-destructive 2-dimensional and 3-dimensional observation of the internal structure of products is possible by utilizing the X-ray CT system, and the volume of voids and other information can be quantified by using analytical software corresponding to the purpose, enabling quantitative evaluations of products.

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