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Application News

No. N137

Industrial X-ray Inspection System

Example of Analysis of Solder Filling Using inspeXio™ SMX™-225CT FPD HR Plus X-Ray CT System

Introduction

Electronic boards are installed in many products. A large number of electronic components are mounted on boards, and solder is often used to join the electronic components to the board. The quality of solder joints not only affects the stable operation of the device, but also has a large effect on product life. Even if a product passes inspections in the manufacturing process, poor soldering quality can cause mis-operation or failure. This article introduces an example of nondestructive observation and analysis of the soldering condition and amount of solder using a Shimadzu inspeXio SMX-225CT FPD HR Plus microfocus X-ray CT system (Fig. 1).

S. Iguchi

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

Solder Filling

Surface-mounted components and pin-type components are both widely used when mounting components on electronic boards. Surface-mounted components are installed directly on the board surface, while the terminals of pin-type components are inserted in through-holes in the board. In surface mounting, solder paste is applied to terminals called pads on the board surface, and the component is joined to the board by melting the solder in a reflow furnace. When mounting pin-type components, the joining terminals of the component are inserted in through-holes, and the component is joined by a flow method, in which molten solder flows into the space between the terminal and the through-hole wall. If the amount of solder in the through-hole during flowing is not adequate, the terminal may be disconnected during use, causing the device to malfunction, even if the product passed the continuity inspection. The process of filling a through-hole with solder is called solder filling, and its quality is judged by the hole fill rate. The evaluation standards established in Quality Judgment Standards for Micro-Soldering Technology Certification/Certification Testing[*1] specifies: "Lower limit of solder amount of a straight lead: Vertical fill rate of 75 % or more when the component surface is combined with the solder surface" (Fig. 2).

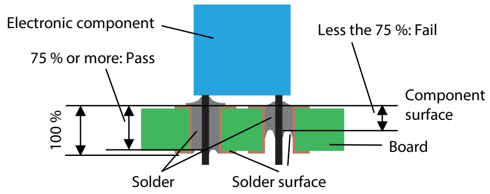

Fig. 2 Evaluation Standard for Solder Fill Rate (Straight Lead)

Observation of Solder

A 16 inch flat panel detector is used in the light-receiving section of the inspeXio SMX-225CT FPD HR Plus, and can capture a maximum field-of-view of 300 × 300 mm in fluoroscopic images and a maximum of φ400 × 300 mm in cross-sectional images. Since the mounted board observed here (Fig. 3) had dimensions of approximately 250 × 300 mm, it was possible to capture the entire board (Fig. 4). For detailed observation, higher-magnification views can be captured by bringing the work closer to the X-ray generator light source. Fig. 5 shows an enlarged fluoroscopic image of the area enclosed in the square in Fig. 4. Thus, observation from the entire product level to the component level is possible with a single instrument, even with comparatively large objects. Furthermore, because the inspeXio SMX-225CT Plus is a CT device, it is also possible to rotate the object for observation. For example, although the object appears normal in the fluoroscopic view from the front in Fig. 5, it can be understood that solder filling is insufficient when the object is observed from an angle (Fig. 6).

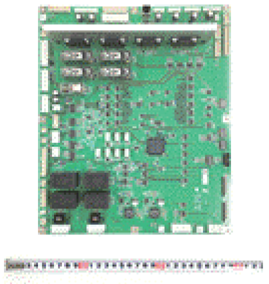

Fig. 3 External Appearance of Mounted Board

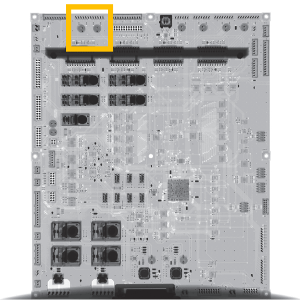

Fig. 4 Fluoroscopic Image of Entire Mounted Board

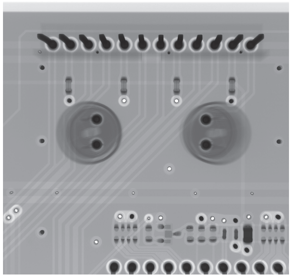

Fig. 5 Fluoroscopic Image of Area in Square in Fig. 4

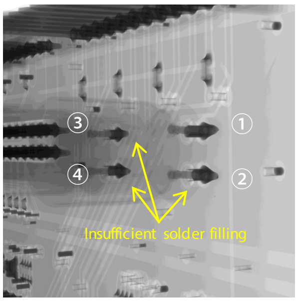

Fig. 6 Fluoroscopic Image in Fig. 5 from Angle

[*1] Issued by the Micro-soldering operator qualification sub-division of the Japan Welding Engineering Society (JWES).

Next, a CT scan of the position in Fig. 5 was conducted. In CT, cross-sectional images can be captured by rotating the work and calculating the data acquired from different angles. Fig. 7 shows a multi planar reconstruction (MPR) of the acquired data. MPR makes it possible to create arbitrary cross sections from obtained cross-sectional images. (In the MPR in Fig. 7, the numbers in circles indicate the terminals with the same numbers in Fig. 6.) Volume rendering (VR) display of the cross-sectional images is also possible by using the 3-dimensional analysis software VGSTUDIO MAX (Volume Graphics GmbH). Fig. 8 shows a VR display of the CT data in Fig. 7. In Fig. 9, this image has been processed on the VR program for easier viewing of the solder joints.

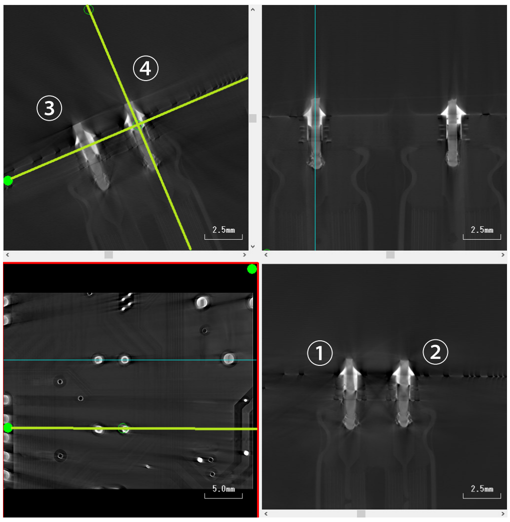

Fig. 7 MPR Images of Position in Fig. 4

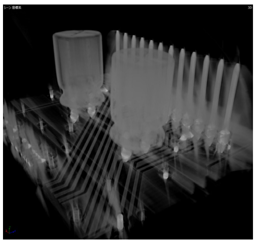

Fig. 8 VR Display

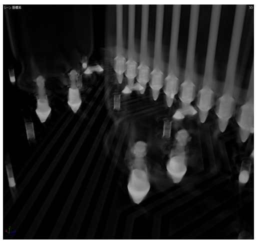

Fig. 9 VR Display Processed for Easier Viewing

Following the CT scan, solder filling was measured by using VGSTUDIO MAX. In Fig. 10, which shows solder position ① in the MPR image, the thickness of the board is 1.560 mm and the thickness of the solder is 1.422 mm. Therefore, the hole fill rate is 91.2 %, and solder filling satisfies the quality judgment standard of 75 % or more. Continuing this analysis, Fig. 11 shows the result of measurement of the solder at ②. Here, the thickness of the board is 1.519 mm, the thickness of the solder is 0.783 mm, and the fill ratio is 51.5 % and is judged as fail. The solder thickness at ③ and ④ was also measured in the same manner. Table 1 summarizes the results of the pass-fail judgments.

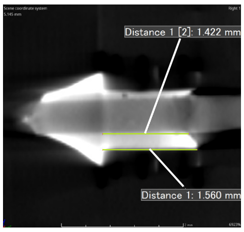

Fig. 10 Measurement of Solder Filling at ①

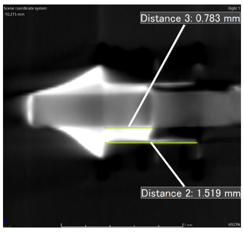

Fig. 11 Measurement of Solder Filling at ②

Table 1 Results of Judgment of Solder Thickness

Number	Board thickness	Solder thickness	Hole fill rate	Judgment
①	1.560 mm	1.422 mm	91.2 %	Pass
②	1.519 mm	0.783 mm	51.5 %	Fail
③	1.527 mm	0.891 mm	58.3 %	Fail
④	1.533 mm	0.882 mm	57.5 %	Fail

Next, the volumetric amount of the solder was measured. The spatial volume of the through-holes was 0.7 mm^3, which was defined as a numerical value of 100 %. Since VR enables 3-dimensional analysis, it is possible to measure not only the 2-dimensional information of distance, i.e., the solder thickness, but also the volume of the solder. Fig. 12 and Fig. 13 show the results of measurements of the solder volume at positions ① and ② in Fig. 7, respectively. Similar volume measurements were also carried out for positions ③ and ④. Table 2 summarizes the results of the pass-fail judgments. In the measurements of the solder thickness in Table 1, the measurement method using the quality judgment standard in the above-mentioned Quality Judgment Standards for Micro-Soldering Technology Certification/Certification Testing was used. However, since this is a cross-sectional measurement, measurements at various positions are necessary. On the other hand, measurement of the solder volume enables quantitative measurement because the entire through-hole is measured. The optimum production conditions, such as the temperature of the reflow furnace and the amount of solder when applying paste, can be studied based on this information. Moreover, since it is possible to ascertain the condition of defect occurrence, this technique is also useful for increasing production efficiency, including yield improvement.

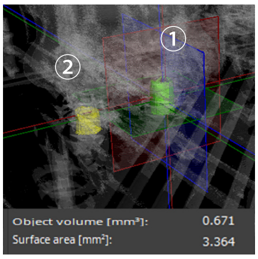

Fig. 12 Measurement of Solder Volume at Position ①

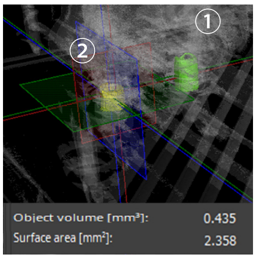

Fig. 13 Measurement of Solder Volume at Position ②

Table 2 Results of Judgment of Solder Amount

Number	Solder volume	Hole fill rate	Judgment
①	0.671 mm^3	95.6 %	Pass
②	0.435 mm^3	62.1 %	Fail
③	0.457 mm^3	65.3 %	Fail
④	0.300 mm^3	42.9 %	Fail

Conclusion

X-ray CT instruments not only enable nondestructive observation of the interior of samples, but can also make pass-fail judgments utilizing software in line with the content of the analysis, and improve manufacturing quality by feeding back the analysis results to the manufacturing process. In addition, cyclical tests such as vibration tests and thermal shock tests can be conducted with the same product, and the internal changes in the product in each test cycle can be observed. This provides valuable information for analysis of the fracturing process, and is also useful for shortening the time required for failure analysis.

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