

Heraeus

X-ray Inspection for the Qualification of Solder Pastes



Case Study MXI

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Products from W. C. Heraeus reliably perform their work under engine hoods or the covers of electronic devices with little attention paid to crucial role they play in the long-term success of these products. Products such as: mobile telephones; microchips; heart pacemakers; air-bags; spark plugs and catalytic converters could not function without dependable materials from Heraeus. To help guarantee results which continue to give them their leading edge technology in the electronics sector, the business division W. C. Heraeus in Hanau operates a SMT technology center that develops, produces and markets materials for the assembly and connection technologies. Here, a variety of tests – including an X-ray inspection with the X8008 from Viscom – ensure comprehensive quality inspection. Complex electronic assemblies rely on a myriad of individual parts that must undergo a reliable material inspection. The components must be expertly processed and exhibit top quality in safety and longevity.

W. C. Heraeus: Worldwide expertise in precious metals and special materials

When apothecary and chemist Wilhelm Carl Heraeus first smelted platinum in industrial quantities in 1856, he laid the cornerstone for the modern Heraeus company. Today, this multinational precious metals and technology



Typical SMT circuit (Source: Universal Instruments GmbH)

giant, headquartered in Hanau, Germany, is the market and technology leader in the areas precious metals, sensors, dental and medical products, quartz glass and specialized light sources. The name Heraeus stands for materials excellence, a multi-faceted product portfolio, innovation and customer response. Their wide range of products in interconnection technology

includes bond wires,

solder pastes, silver conductive adhesive and thick film pastes for the manufacture or connection of components for electronic assemblies.

Heraeus boasts an enviable worldwide market presence, with 76 production sites and 25 of its own development centers. In all, this family business is represented by over

116 locations. In 2006 the company generated revenues of over € 10 billion, with over 11,000 employees distributed among more than 100 subsidiaries and holding companies.

Why is the qualification of solder pastes important?

Consistently lowering costs, improving quality and conserving resources cannot be accomplished without a fierce dedication to research and development. The SMT technology center in Hanau evaluates the entire SMT production process and targets key projects critical to the improvement of materials and the interconnection process. At this location, materials to connect electronic components for assembly and interconnection technology are developed, produced and manufactured. Among these materials are solder pastes, solvents, ceramic foils and conductive adhesives as well as thick film pastes. W. C. Heraeus



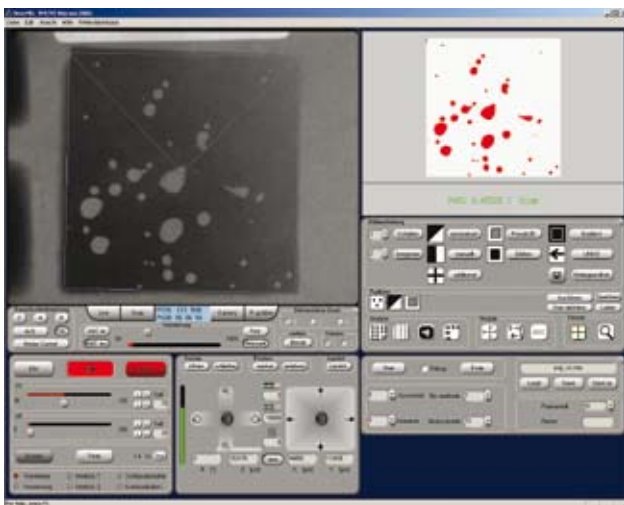
Fl.t.r.: Eberhard Hasler, Viscom AG and Jürgen Ehmes, W. C. Heraeus, with the Viscom X8008

can point to over 15 years experience in the production of materials for the surface assembly of specialized components for the automobile industry alone. The internal technology center provides development, manufacture and quality assurance for in-house needs and also for external customers. Long-standing experience in materials inspection and close contact with international research institutes mean that materials investigations can be implemented and evaluated with meticulous accuracy. Among other tests, the qualification and benchmarking of solder pastes are conducted with the Viscom X-ray system X8008.

Heraeus understands the critical role that R&D plays in assuring quality results for thousands of products. It is critical for “process” defects which emerge only in the manufacturing process to be identified, isolated, and corrected before the materials are used in production. Especially, the introduction of new products or material and process changeovers can cause yields to drop due to defective solder joints. „This is why Heraeus, together

with the customer, operates an optimized and proactive defect analysis in its own SMT technology center to eliminate the defect rate or at least to minimize it. So, Heraeus works systematically and in close collaboration with the customer to reduce defect rates and at the same time, raise the quality of their products“, explains Jürgen Ehmes, Application Technology Business Unit Surface Mount, W. C. Heraeus.

„The lion’s share of solder defects can be traced back to the paste print stage – up to 60 % of all defects has been confirmed by the industry. Therefore the choice of an appropriate paste and the inspection of print quality regarding volume, height, surface, displacement and bridging is of enormous significance. This is the only way to lower defect rates and ultimately, to optimize the



VMC user interface

print process. Also, defects are caught at such an early stage that rework costs can be reduced“, states Jürgen Ehmes. The current demands on the print process with lead-free solder pastes include ‘0201 components, micro BGAs, CSPs, FlipChips, zero-defect strategy, a reduction in defect costs and others. The associated range of defects can be positively detected by an X-ray inspection system.

This was the rationale for the installation of the Viscom X-ray inspection system X8008 at the SMT technology center in 2002. At that time, the decision for Viscom came down to two reasons. „For one, if we have customers in common with Viscom, using the same system is advantageous because experience can be exchanged more easily. Also, Viscom is market leader in this area“, relates Jürgen Ehmes. Currently all electronic assemblies undergo a quality inspection with AOI and AXI after reflow soldering, with the following evaluation criteria: wetting, hot slump, spread, solder balls on solder resist, tombstones, voids, etc. Thus, solder defects are reliably recognized up front and solder pastes can be specified. If defective solder joints – too much or too little solder, insufficient wetting or voids – are found, the process practically comes to a halt as the product is reworked

and reenters the process again at the start. According to Jürgen Ehmes, „The X8008 finds itself in continuous use and new tests are being developed constantly, also from other departments. At the moment only completed printed circuit boards are being inspected, but an X-ray inspection at an earlier production stage is now being planned.“

The qualification of hidden solder joints

„One very important criteria for the qualification of solder paste is the detection of cold solder joints and voids, which cannot be detected with an optical inspection alone“, says Jürgen Ehmes.

The X8008 X-ray system offers a wide range of Viscom proprietary analysis algorithms for ball grid arrays (BGAs), surface soldering or adhesive bonds (voiding calculation) and for wire sweep analysis. During a BGA inspection, numerous solder point properties (number of balls/ numbering, ball diameter, roundness, displacement, percentage of voids, size, amount of solder, pad wetting etc.) are measured automatically. Solder defects including bridging, excessive solder, voids in the solder mass, displacement and missing balls must be recognized in the process.

The qualification of hidden solder joints with the X8008 from Viscom is done in four steps:

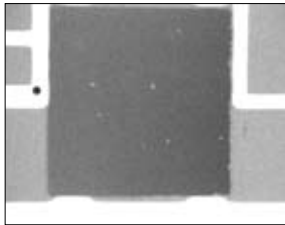
1. Generation of an overview image: this step recognizes missing balls, solder bridges and gross irregularities. A BGA can be investigated for rotation and displacement at this stage.
2. Partial view through magnification: this is where the verification of suspect balls by a comparison of structural details is done and voids are located.
3. Generation of angled views by tilting: in this step, the top and bottom sides of a PCB are displayed separately along with the ball formation in the third dimension (height).
4. Magnified views in detail: here, the wetting of the balls on the PCB pads is investigated.

„The X8008 commands a powerful tool for void analysis“, notes Jürgen Ehmes. First, the surface of the soldering is calculated with this tool to determine the void percentage in comparison to the entire ball. The integrity of the entire assembly can be compromised by an undetected large void.

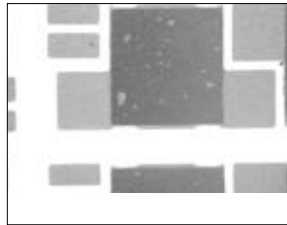
In an X-ray image, voids appear as lighter surfaces within the darker circle of the solder point or ball. A typical upper limit for void surfaces is 5 %; the percentage of voids within a predefined surface (usually the entire BGA is chosen) may not exceed that limit. The presence of voids in a BGA or in a single ball does not necessarily lead to malfunctions or failure. Yet, exceeding a specific percentage of voids in the entire BGA does increase the potential for component failure. The same holds true for individual solder points. The relation of voids to the ball regarding size or dimensions is crucial for later functional reliability.

continued ►

According to IPC-A-610 Revision D, $< \varnothing 25\%$ of voids in a solder sphere are acceptable. A void concentration of $> \varnothing 25\%$ is evaluated as defective. Quite often, it is also important to know whether voids exist and where they are located. Furthermore, the quality inspection provides an important process control tool for production. If material failures are detected, the cause of void formation can be investigated and appropriate action can be taken to correct the cause of the defect.



Evaluation criteria for different recipes of solder paste on DCBs: Void concentration with solder paste 1: 0.3 % voids

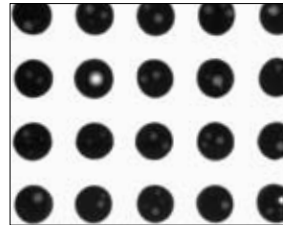


Evaluation criteria for different recipes of solder paste on DCBs: Void concentration with solder paste 2: 3.75 % voids

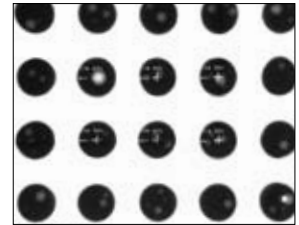
The result points out that the amount of voiding does depend on which lead free solder paste is used. Still, void formation is also influenced by the surface the paste is applied to. The use of lead free solder paste with lead free BGAs is preferred because it yields solder joints with very few voids. In contrast, if BGAs containing lead are used with lead free solder pastes, extensive bubbles result. Conversion to lead free solder pastes ensures higher quality, increased customer satisfaction, and a minimal impact on the environment.

Future trends and requirements

For W. C. Heraeus, future trends lie in the miniaturization of components, leading to smaller chip fields and more complex assemblies with frequent use of BGAs. The company also sees growing competition from Asia. „Right now Europe still has a very good name regarding reliability and quality. One strongly growing segment where Europe maintains a leading position is in power



X-ray inspection of lead free solder paste



Results of an automatic void analysis of the left image

electronics (DCB = Direct Copper Bonding). Nonetheless, Europe must invest more heavily in the development of new products and technologies to hold its position in this market”, forecasts Jürgen Ehmes. He firmly believes in the importance of inspecting electronic assemblies with AOI and AXI before they go to market. Future companies will no longer be able to turn a blind eye to the quality of their outgoing materials. With a comprehensive inspection, defect rates will continue to be reduced.

Are you interested in more details on this application or do you have any questions regarding X-ray inspection? The Viscom XP division will be glad to help you.

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