

Solder paste inspection for 3D In-line systems come

Introduction

Lower cost, faster throughput and higher finished product quality. While the demands on the electronics manufacturing industry have not changed much during the current economic downturn the emphasis certainly has been changed to have a greater focus on cost. Now more than ever the industry has been forced to look closely at investment decisions to insure that the return on investment is appropriate. Solder paste printing is a key process in circuit assembly and control of this process is vital to ensure smooth running of any manufacturing line as well as end product quality.^[1]

The on-going miniaturization of PCBs to produce smaller consumer products such as pagers, cellular phones and laptop computers requires paste deposits as small as 200 by 200 microns. At the same time, very large-scale integration of electronic components demands small spacing (pitch) and large number of connections, which further complicates the paste printing operation.

This means that it is almost impossible to reliably assemble PCBs having fine-pitch components without some form of quality control over the paste printing operation and it's many variables. Consequently process engineers are faced with the task of obtaining a suitable inspection system to check the integrity of solder paste deposits. 3D in-line systems offer several significant advantages.

Automated inspection technology becomes widespread

The constantly increasing demands of the market for smaller and more reliable

equipment has resulted in a rapid change in manufacturing technology. This has required considerable development by manufacturers of test and measurement equipment to meet these new demands. The in-circuit tester, which a decade ago was indispensable, can now hardly handle the testing requirements made, particularly as a result of miniaturization, and has to be supplemented by other inspection techniques. The trend away from through hole to more SMT components means that the distribution of types of defects has also changed over the years. The number of shorts has fallen, but the proportion of solder faults has increased. These include insufficient solder volumes and lifted leads. Whereas with wave soldering technology, faults could be located almost exclusively on the final product after soldering, in SMT manufacturing it is possible to detect and eliminate faults after every stage of the process.

Post-paste application. A large proportion of faults occur at this stage of the process, and they can be removed very easily and at low cost. It is also the best time to use the inspection data for process control.

Post-chip placement. Here, both the chip components and the paste can be inspected, before ball grid arrays (BGA) or flip chips – which hide joints – are placed.

Post-component placement. Here, all components can be inspected for misalignment, skew and orientation.

Post-Reflow soldering. At the end of the production line, both component presence as well as solder joints can be tested.

Choosing the right inspection and test strategy

Choosing the correct strategy for SMT manufacturing is influenced by many factors and selecting between the options is not easy. Discussions between users and test vendors about testing strategies and the advantages and disadvantages of a particular test location can carry on endlessly. While theoretically it makes good sense to have automated inspection after every major process this is typically seen as very difficult to justify – especially in the current economic climate.

The reality is that the choice of inspection and test equipment will be product and customer dependent. The one constant is that whatever the appropriate decision is today, it is likely to be different tomorrow and therefore equipment flexibility is a key factor.

As the first key process in the line, control of the paste printing process is vital if the assembly process as a whole is to remain consistent and in-control. *Table 1* shows data from two manufacturers, which shows the distribution of process defects in two typical SMT Manufacturing lines. While there is obviously variation based on the specific circumstances, processes and products involved, the one thing that is consistent is that a large proportion of the defects have paste printing as the root cause.

Solder paste printing variables

The solder paste printing process has

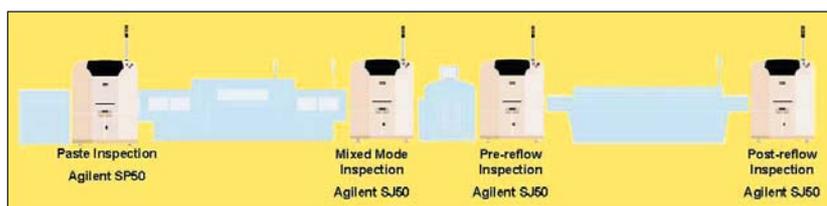


Figure 1. shows the four possible positions, at which AOI systems can be used in the SMT manufacturing process.

Table 1: Data from two SMT manufacturing lines showing the distribution of the root cause processes for process defects.

Where are the problems in the line?		Company A	Company B
Paste inspection	<ul style="list-style-type: none"> No solder Insufficient solder Excessive solder Bridging 	50 - 70 %	17 - 26 %
Component Inspection (Optical, X-Ray, Solder Electrical)	<ul style="list-style-type: none"> Missing part Offset part Reversed part Wrong part 	30 - 35 %	45 - 50 %
Functional test	<ul style="list-style-type: none"> Out of spec Faulty part Handling damage 		

For the SMT line: of age

a significant amount of contributing variables. The printer parameters, solder paste parameters, human factors and the environment can all have significant effects. The reality is that only some of these factors can be reasonably controlled in a

real manufacturing environment. Paste printing is in general a well understood industry wide process. The reality however is that control of the process becomes significantly more difficult as the process window -specifically pad and stencil aperture sizes - become smaller.

Solder paste inspection options

Which approach makes best sense for Solder Paste Inspection? There are several decisions on which direction to take:

Off-line or In-line:

There are several offline systems available, including both standard microscopes and laser based measurement systems that are limited to sampling of the print process unless the board volume is extremely small. In-line systems can be both printer-based systems or stand alone in-line systems.

Sampling or 100% Inspection:

While offline systems are almost entirely used for process sampling there is typically a choice of in-line systems that have varying inspection speed capabilities which will determine whether inspection of 100% of the individual prints is possible or whether sampling of pads is the only viable option.

2D vs 3D

2D inspection systems are limited to looking at general pad coverage information and paste deposit location measurement. They give the user no feedback on paste volume. 3D systems typically have most of the capability of 2D systems as well as the capability for height/volume measurement. 2D technology is typically camera based while 3D technology is typically based on Laser Triangulation or Structured Light methodologies to obtain the 3rd dimension.

In-line automated solder paste inspection - changing dynamics

Which choice makes sense? Obviously the choice depends on large part on the type and volume of products being manufactured as well as the level of investment that is possible by the user. One of the dynamics that is not in question is that the availability and capability of in-line systems with 3D is increasing while their price points are decreasing - making this choice an extremely attractive option under almost any circumstances. These systems typically provide the highest level of coverage for both defect detection and for true measurement based process control where solder paste volume is the key variable.

There is some industry debate on the whether automated solder paste inspection is the best use of limited capital funds. Partly this is due to the lack of data that directly correlates solder paste volume to solder joint defects. Partly it's due to the fact that many of the problems that can be caused by lack of the control of the paste process do not always obviously have paste printing as the root cause. What is not in doubt is that there are solder paste defects that only manifest themselves long after the product has been shipped as solder joint reliability issues - something that has been recognized as a real concern for some high volume



Figure 2: High Speed 3D In-Line Solder Paste Inspection (Agilent Technologies)

consumer and computing products.^[3]

There are some strong reasons why investments in modern 3D automated solder paste inspection systems make extremely good sense:

High levels of defect detection - for coverage, location and volume. Some solder paste defects can be described as "special case" events - something that would not necessarily be identified as potential issues in advance using process control. This makes sampling only of the solder paste process much less effective.

Potential for real process control using measurement data - specifically for height and volume which becomes much more critical as pads shrink for modern devices such as 0201, CSP (chip scale packages), micro BGA (Ball grid array) and CCGA (ceramic column grid array).

While conceptually it makes good sense that solder paste volume is a key process indicator there are several studies that have determined that as pad sizes get smaller that solder paste volume is the best predictor of finished board quality^[4].

Flexibility reduces risk

One constant that has become even more apparent during the current economic climate is that change will happen. From a manufacturing perspective that means that it is even more critical to invest in capital equipment that has flexibility so that if the product volume or product complexity changes that there is also maximum flexibility to change equipment. Several AOI vendors now offer 2D solder paste as well as Pre-Reflow and Post-Reflow inspection capability using the same platform. In some case this also extends to 3D solder paste capability as part of a flexible platform.

Conclusions

Current trends in automated inspection are making high capability in-line 3D systems an attractive, effective and cost effective tool in improving process quality and reducing end product defects. This ever improving capability and value, matched with the capability for flexible adaptation of the AOI platform for potential use for component or solder joint inspection, makes in-line 3D solder paste inspection even more attractive for the SMT manufacturers.

References

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