

The AOI under a new light

A few years ago, electronics manufacturers began to consider the introduction of Automatic Optical Inspection technology based on pattern matching. Up to that time, the goal of the process engineer was to automate and to speed up functional fault detection in manufactured boards. The limit of this kind of inspection was linked to the gathering and interpretation of data.

Today, the evolution of technology and the increased processing capability in computers provides extremely fast image acquisition and analysis, allowing AOI systems to work on inspection logic. This different inspection philosophy implies, on one hand a quantitative analysis of the product inspected and, on the other, fast processing of the acquired information.

The capability to measure and store values during inspection, allows the creation of historical statistics and improved traceability; in general AOI is a tool for the objective analysis of the manufacturing process.

Starting from this assumption, it seems reductionistic to consider AOI as a system capable of intercepting the *faults on the board*. The system must locate *the process faults*, highlighting the instances where process quality deviates from the initial conditions.

There are real-time monitoring systems capable of stopping the line or emitting a *warning* signal upon the occurrence of one or more events: these enable intervention before the process drift becomes drastic and causes a functional fault on the board. This is an immediate *feedback* for the operator.

Later, the analysis of the data will allow the technologist to underline the weak points of the production line and plan possible corrective actions.

With regard to optical inspection, there are two types of technological approaches (as shown in Figure 1): one light source with several cameras or one camera with several light sources. The “multi-camera” solution is based on the principle of illuminating the object to be inspected with one light and acquiring, from different angles, the reflection of light.

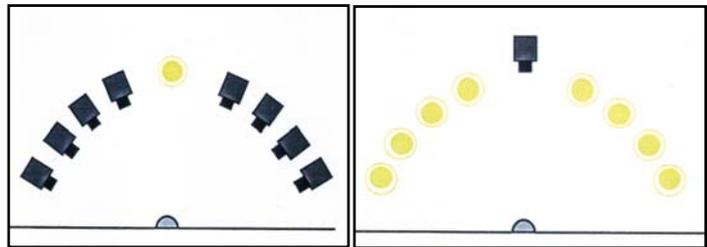


Figure 1

The “multi-illumination solution allows the acquisition of the different reflections coming from different sources at the same angle.

Supposing to evaluate a solder joint of an SMT component, even though both techniques allow the evaluation of the shape, the use of a single camera avoids the situation where the PC has to compose information derived from several different images, thus reducing CPU processing time.

The single-camera solution also simplifies the hardware and the management software. With a single camera it is also possible to illuminate the board concentrically with regard to the camera axis, reducing the problems caused by shaded areas.

In addition the single-camera solution allows the lights to be switched on in sequence, in order to highlight separately the different inclinations of the solder joint. However, in this case the number of images acquired increases (as many as are the lights in use). In order to keep the characteristics of a single-image acquisition it is necessary to turn on the different lights at the same time (in this case they must have different colors to distinguish them).

In this way it is possible to “color” the reflecting surfaces with different colors: each color corresponds to a different inclination angle of the surface.

A 16-million color image acquisition thus allows to discriminate 16 million inclination angles. The figure on the right reproduces a light system operating principle and the

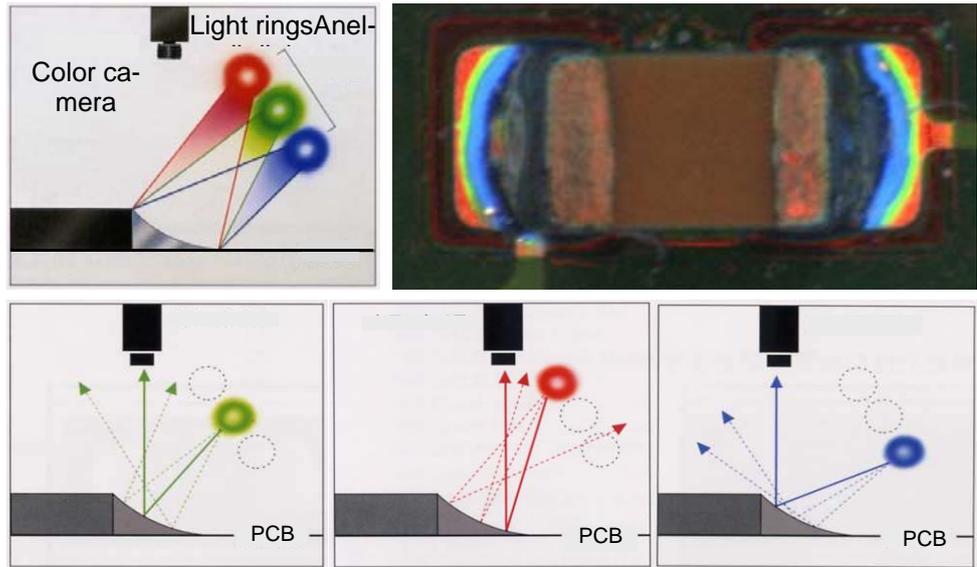


Figure 2

corresponding effect on the board. An essentially two-dimensional image acquires a third dimension thanks to the color information.

Once the colored image has been acquired, the software analyzes it: logic algorithms, combined with acceptability criteria (inspection libraries), allow the examination of what the camera has “seen”, determining whether the set limits have been reached or, possibly, exceeded.

All these inspection techniques are basically an emulation of the human decisional power: the basic features of a solder joint are translated into parameters and then measured. Automatic optical inspection has the advantages of objectivity and data collection capabilities impossible to reach in a manual inspection process.

Some faults are particularly important, if considered on the basis of the frequency of their occurrence. Probably 20% of faults influence 80% of the production process. Hence, an optic system is as effective in the same measure as it is able to detect these faults.

The figure on the right shows the distribution of the faults detected in an automotive production process, using an in-line AOI placed after the oven. At this point of the process, the problems of paste printing, lifted leads or blow holes have been detected as wettability problems. Operator analysis during the repair phase, then associated these problems to the real causes.

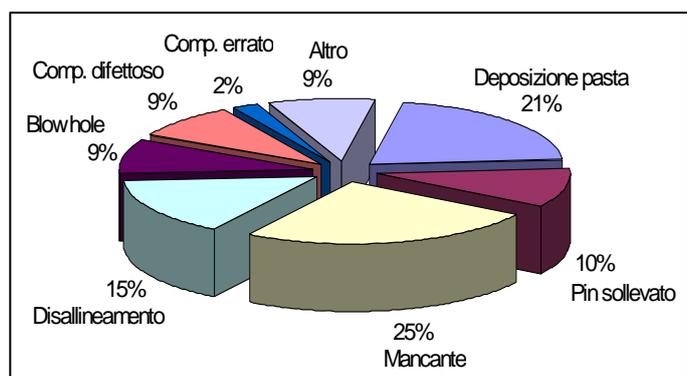


Figure 3

The faults may come out in different phases of a board lifecycle and may be a result of assembly process, test or life in the field. The assembly phase typically contributes about 75% of the total number of defects, and that is where an AOI system should be placed.

The use of color for component inspection is a fundamental feature: the presence of components (25% of faults) and their location (15%) can be determined in a more stable and effective way, since it is quite easy to distinguish the color of the PCB and the color of the component.

However, where the use of color expresses the highest added value compared to a gray scale inspection, is in solder inspection; the color resolution faithfully rebuilds the shape of the solder

joint, not only verifying its presence, but also its quality (wettability). The solder joint is an electrical connection but it is at the same time a mechanical anchor: the system must guarantee that the assembly has been executed in a satisfactory way, according to IPC standards or to the manufacturer's expectations; this should ensure a higher probability of survival of the product in the field.

Figure 4 shows how the color effect makes it extremely simple to detect a complanarity fault. The correctly soldered pad (on the left) shows a red color at the corners hence it is level; next to the electrode it is blue (warpage). The pad where the component is not soldered (on the right) shows the opposite condition: red next to the electrode and blue-green at the corners.

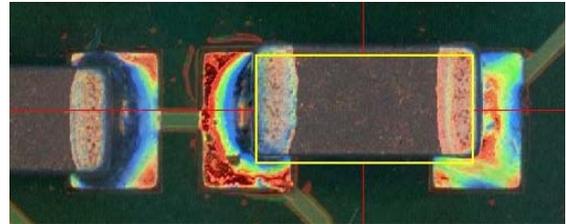


Figura 4

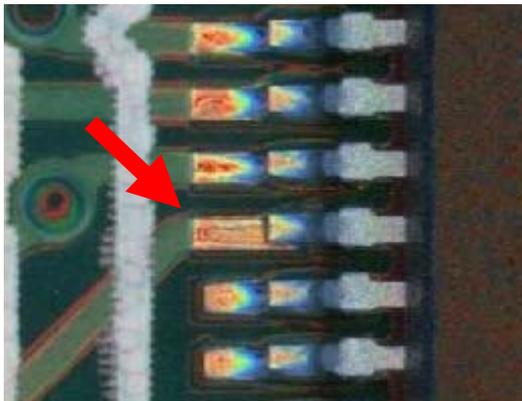


Figura 5

Fig. 5 shows the complete lack of paste: the pad presents an uniform red color.

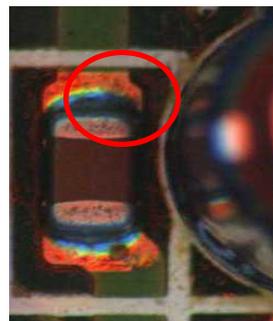
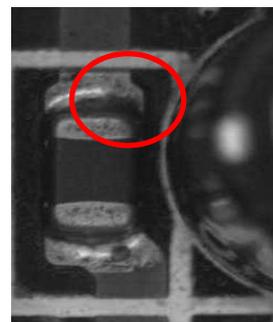


Figura 6

Figure 6 shows how the presence of a high component, such as an electrolytic connector, does not modify the color layout on the solder joints. One of the advantages of color-based AOI is, in fact the prerogative to extract color and not brightness; the solder joint will hence remain substantially blue even in shadow.

In conclusion, the use of color brings important benefits to automatic inspection, above all in solder joint analysis, which is, beyond all doubts, the best "lens" through which to monitor the production line.