What will AXI systems achieve in 2023?

In modern SMT production lines, AXI systems are mainly used for fully automatic inspection of hidden solder joints that are not visible to an AOI system. "If almost one hundred percent optical inspection coverage is required, there is no getting around the use of an AOI and an AXI device," says Andreas Türk, Product Manager X-ray Inspection at GÖPEL electronic in Jena.

But what will AXI systems achieve in 2023? "An AXI system is absolutely comparable to an AOI system - only the images are not as beautifully colourful." - Türk quips. At GÖPEL electronic, the AXI systems in 2023 have fast, scanning image acquisition, support inspection programme creation with a wizard, integrate themselves into the world of Industry 4.0 and monitor themselves thanks to the digital predictive maintenance concept. In addition, the inspection systems are networked with each other. If an anomaly is found, the information from the SPI, AOI and AXI systems is displayed together at the verification station. This helps to track down the source of the fault.

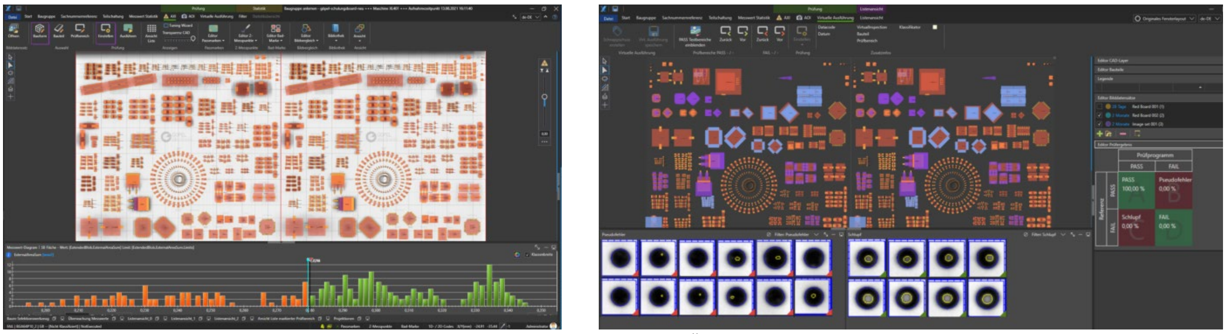

Figure 1: The test programme creation is similar to an AOI system. At GÖPEL electronic, AXI programme creation takes place completely offline. After the CAD data import, the image data sets required for tuning are recorded once. Now the further test programme creation can be carried out completely offline.

Image acquisition technologies Current AXI systems not only radiate through the assemblies vertically (so-called 2D) or from an oblique angle (so-called 2.5D) to inspect the solder joints. Rather, 3D X-ray inspection, i.e. the inspection of solder joints in several layers, is an established technology without which the highest degree of defect detection and inspection coverage cannot be achieved. In part, it is the combination of all three image acquisition technologies that provides the best inspection result in the mix. Since 3D technology calculates a synthetic 3D image from several obliquely captured images (so-called image reconstruction), it requires a longer image acquisition time than conventional 2D or 2.5D technology. 3D systems with flat-panel detectors struggle here with the axis movement times, because the time for stop-and-go movement of the axes is significantly longer than the actual image acquisition time. "As a rule of thumb, when using eight oblique images for a 3D image field, you can expect an image acquisition time of about 3-5 seconds" - explains Andreas Türk. Depending on the image field size and the number of required 3D image fields, this adds up and the image acquisition time for a high-runner product is then often too long. GÖPEL electronic has come up with something for this.

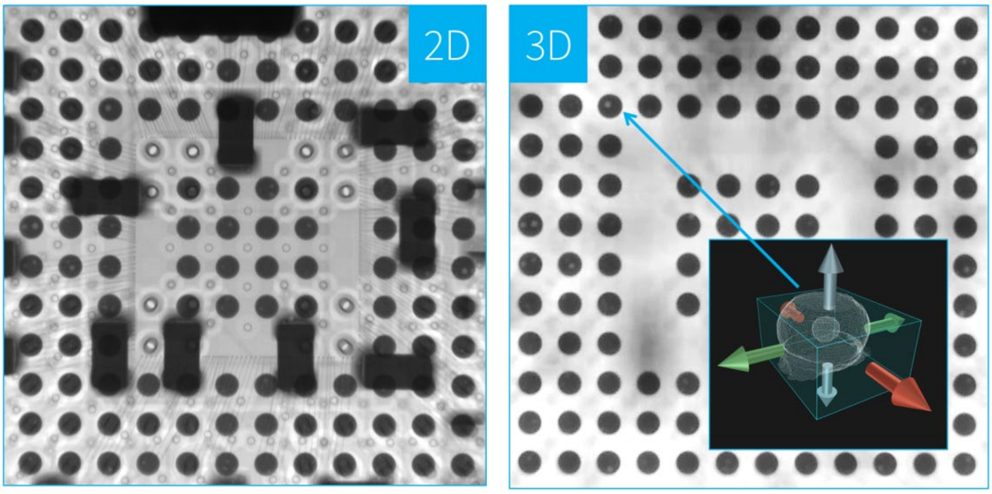

Figure 2: On the left, a 2D X-ray image of a BGA. Capacitors on the bottom side reduce the inspection coverage. In the 3D slice image (right), the capacitors are no longer visible. The BGA itself can be evaluated in several layers.

Reduction of cycle time The AXI system family X Line - 3D relies on line detectors to keep image acquisition time low. Several detectors take 2D, 2.5D and 3D X-ray images in parallel, directly in motion. This concept makes it possible to inspect larger areas of the PCB or complete multiple panels in 3D. In addition to the image acquisition time, the time for PCB handling, image processing and the optional MES export are also included in the total cycle time. For this reason, the X Line - 3D - systems have a three-chamber principle. Instead of only one PCB, there are three PCBs in the system in inline mode. Once the image acquisition of the PCB to be inspected is completed, it is immediately moved out of the beam path into another chamber. This is where the complete post-processing takes place. This reduces the total cycle time and the radiation exposure for the components.

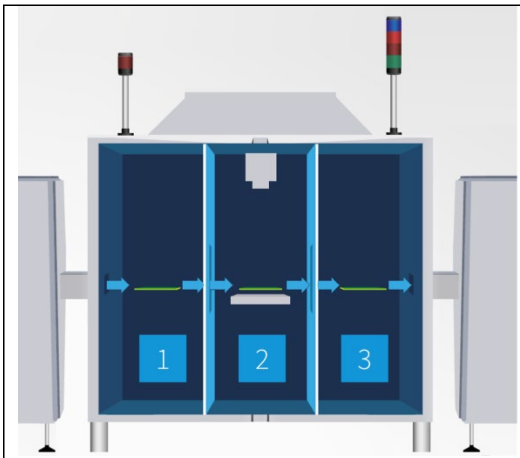

Figure 3: Three independent chambers in the system allow image acquisition and post-processing (reconstruction, saving measured values, MES, ...) to take place in parallel. This saves cycle time.

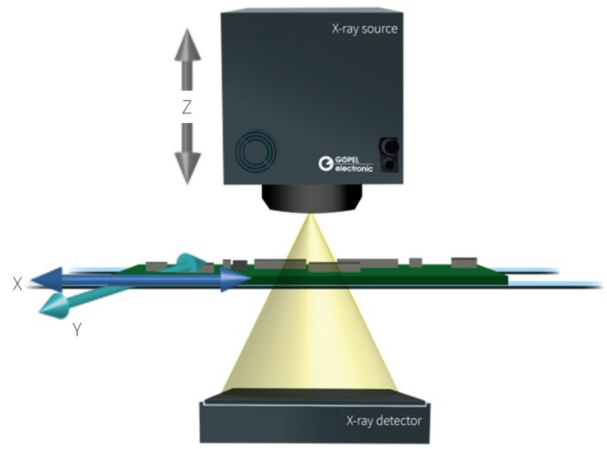

Figure 4: The X-ray image chain of the X Line - 3D consists of a maintenance-free micro-focus X-ray source and several line detectors. Only the usually light printed circuit board is moved in X and Y for image acquisition. The X-ray source is mounted on a Z-axis. The line detector package is not moved.

Intelligent PCB handling Over the years, the systems have also become smarter in terms of PCB handling. The PCBs to be inspected by the AXI vary in size, weight and friction coefficient, among other things. In the past, this was not taken into account and always transported at the same belt speed. This can cost valuable cycle time. For this reason, the belt transport of the X Line - 3D learns the optimal belt speed independently by means of intelliFLOW. After an automated teach-in process, the machine stores the optimal transport parameters specific to the inspection programme.

Digital maintenance concepts System downtimes for maintenance work are often problematic. A service & maintenance app therefore creates usage-based maintenance plans in advance and monitors the machine ("Preventive/Predictive Maintenance"). Self-diagnosis with predictive and preventive maintenance management ensures stable machine conditions and repeatable, constant performance. Every key component of the machine is monitored and a detailed maintenance summary is generated. A preventive maintenance plan reduces machine downtime and thus costs. Practically, work no longer has to be carried out according to scheduled maintenance cycles. Instead, usage-related values such as kilometres travelled on the axes, pneumatic strokes and X-ray source radiation hours are monitored. These values are provided with a warning and service threshold. If the warning threshold is exceeded, preventive maintenance can be planned. The app enables the simultaneous monitoring of several machines at a glance. This makes maintenance easier to plan and reduces downtime.

Enhanced human-machine interaction Humans will not be disregarded in 2023 either - this is shown by the enhanced human-machine concept. It consists of light bars integrated into the exterior design. They are located in the corners of the exterior cladding and show the operators various system statuses even at a distance. This helps to react quickly to avoid a line stoppage. For example, static colours are displayed for the basic operating modes: machine is checking, machine is waiting, machine has a fault or is in service mode. In the event of an error, a distinction is also made between the left and right sides of the machine. If there was a problem with the PCB infeed on the left side, it lights up red. A lack of material at the infeed or a PCB jam at the outfeed is also signalled by colour. In addition to the static colours, certain functions are also provided with animations. For example, the warm-up of the X-ray source is visualised by a progress bar. A result statistic of the last ten inspected assemblies, for example, can also be displayed as an option.

Radiation exposure for components more important than ever. The reduction of radiation exposure for components is becoming increasingly important. The X Line - 3D tries to keep the radiation dose low through several measures. On the one hand, the low-energy radiation components that do not directly contribute to imaging are reduced via suitable filters in front of the X-ray source. Secondly, the assembly is transported out of the beam path onto another belt module directly after the image has been acquired, in order to avoid unnecessary radiation. In addition, the fast, scanning image acquisition process with very short exposure times minimises the dwell time of the test specimen in the beam path. This further reduces the radiation dose to the components. The offline programming software PILOT AXI has an integrated calculation tool for calculating the radiation dose.

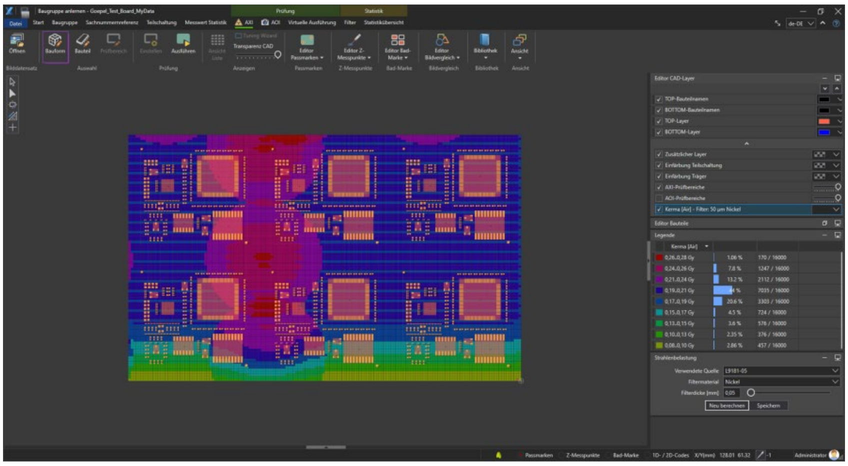

Figure 2: The radiation dose (kerma air) is calculated in grays in the offline programming software PILOT AXI as soon as the test programme is created.

Common defect display Test results and measured values of the AXI are stored in a central database and can be used to classify the defect by humans as well as to optimise the entire process. The heart of the central data storage is the PILOT Connect software from GÖPEL electronic. Here, result data from SPI, AOI and AXI flow together and can be jointly displayed at the verification station PILOT Verify. Not only GÖPEL's own inspection systems but also devices from other manufacturers can be connected. Due to the common error display, the evaluation of the automatically detected anomaly is considerably facilitated. MES connections the GÖPEL electronic AXI systems are implemented by our own software team within the delivery time.

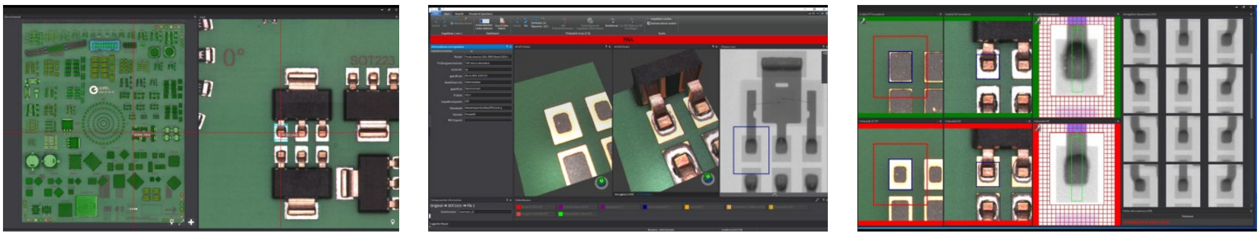

Figure 6: Combined SPI, AOI, AXI fault representation of a lean solder joint. Left: Overview image of the PCB with marking of the defect position by crosshairs. Middle: SPI, AOI, AXI image of the faulty component. Right: SPI, AOI, AXI detailed image of the individual solder joint incl. good comparison image, additionally AXI/AOI error image in different oblique views.

Conclusion

Since the first manual and automatic X-ray systems found their way into electronics manufacturing, there have been enormous technological leaps. Parallel to the ever-increasing performance of the systems, the electronics test specimens have become steadily miniaturised and more difficult to inspect with tried and tested means. In addition, high throughputs and ever more closely timed production processes have set a tight framework. X-ray systems such as the X Line - 3D from GÖPEL electronic are specifically adapted to these conditions and will continue to play a major, if not significantly important, role in the field of component inspection in the future.

Author:

Andreas Türk, Product Manager AXI at GÖPEL electronic GmbH