Lloyd Doyle
automatic inspection solutions

CircuiTree

.....as printed in Circuitree

Is Optical Test Just an Illusion?

by Richard Frisk

Background

Automatic Optical Test first came to the printed circuits industry in the mid-1980s when its inventors were frustrated at buying their prototype PCBs without the confidence that they would work the first time in use. At that time, there was no such thing as electrical test against data as we know it today, and the entire CAM process in the PCB manufacturing industry was in its infancy. The situation was probably familiar to many board users at that time. Electrical test, as we know it today, using CAM generated data as the test reference, simply did not exist. What was the alternative?

At the time, the choice for the prototype PCB-user was very limited. Most had to take the risk that the boards would work when assembled without any sort of bare board test; sometimes this was a very big risk.

Enter AOI. Automated Optical Inspection for PCBs gained credibility towards the end of the 1980s, and was generally accepted to be good for inspection of the simple signal type images found on most multilayer inner-layers of the period. The first generation systems would scan circuits and generally find more faults than a human operator with more reliability-but that was about all that could be claimed in practice.

These early AOI systems were quite basic in terms of capability, normally using technology adapted from other industries. They either relied on shape recognition or a simple picture comparison to detect where faults had been introduced into the printed circuits. Once the areas for potential faults were identified, a fault report was generated which would be used to drive a verification station to show the potential faults to the operator. The operator subsequently had to index through the faults and pick out the ones that were real and discard those that were false calls. Such was the efficiency of these early systems.

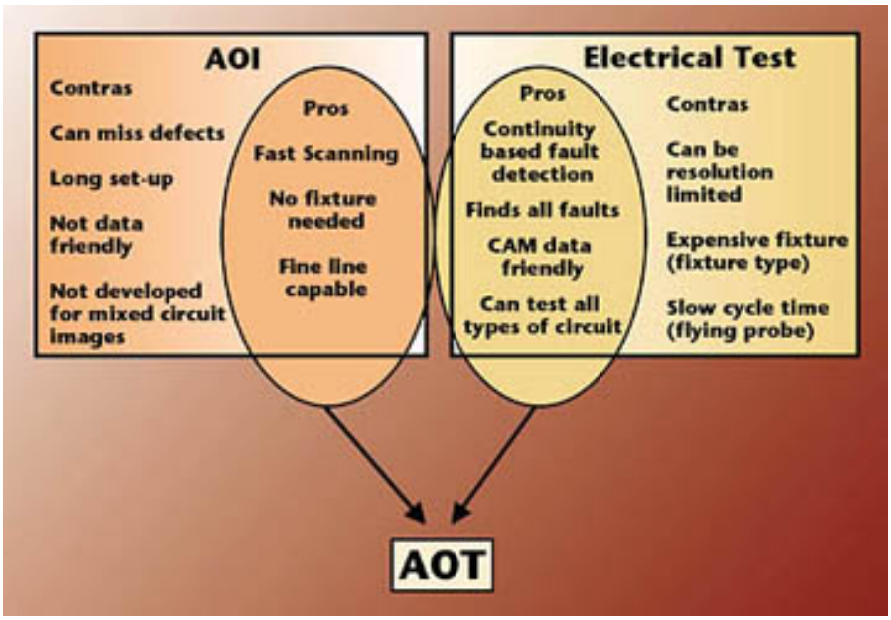
Molesey Road, Walton on Thames, Surrey KT12 3PJ England
Tel: +44 1932 245000 Fax: +44 1932 220555
www.lloyd-doyle.com
Lloyd Doyle Ltd. Reg No. 1607263
Lloyd Doyle International Ltd Reg No 2283674

The early AOI imaging methods used technology cameras and data processing hardware from the 1980s; generally they were rather limited in performance.
The choice was clear. Ask your PCB shop to manufacture your prototype boards using AOI for the inner-layers, and test the boards before assembly using a golden board comparison technique. This was the best solution offered, and although an expensive option (making a test fixture for only a few boards was very costly), it did not guarantee that the boards would be correct. It was not unheard of to receive a batch of prototype boards that had been through AOI and golden board test only to find that they were all defective. Perhaps they were all identical and had passed "test" but they could have all had the same short circuit on them! There had to be a better way of doing things.

AOT is Born

AOT was a process developed in the U.K. to address just this issue. A more scientific method was needed to ensure that bare boards in prototype quantities would be manufactured correctly. So how did it work and how was it designed?
AOT was designed to use the connectivity of the PCBs as its reference for detecting faults just as with the electrical test process. However, AOT was used on individual layers prior to bonding or on outer-layers one at a time, rather than the complete bonded board as in Electrical Test.

Figure 1. Showing the roots of AOT.



It was this fundamental issue of using connectivity as the reference to detect faults that set AOT apart from the rest of the AOI systems. It gave AOT the ability to scan all types of circuit images and accurately report true alarms without reporting unnecessary long lists of false alarms. Only AOT can claim this.
Early AOT systems also relied on 1980s technology for imaging and data processing. Looking back, the systems were slow and very rudimentary in operation. However, the technology was fundamentally sound and gave a proven platform for future developments.

Molesey Road, Walton on Thames, Surrey KT12 3PJ England
Tel: +44 1932 245000 Fax: +44 1932 220555
www.lloyd-doyle.com
Lloyd Doyle Ltd. Reg No. 1607263
Lloyd Doyle International Ltd Reg No 2283674

AOT: The Adolescent Years

Having invented a sound core technology, the AOT process and range of systems that used its technology was developed from the initial application for prototype board manufacture. It had several clear advantages over AOI in the following areas:
* It was connectivity-based so could be used to find faults on any type of circuit including outer-layer images (early AOI struggled with complex shapes and outer-layer patterns)
* As CAM developed, the AOT reference data became easily available from all proprietary CAM stations
* Because it was connectivity-based, it found more faults than other rival technologies; it was a better "mouse trap"

AOT had clear advantages over Electrical Test systems:
* AOT didn't required a fixture to be made
* AOT was very quick (< 30 seconds to scan a standard panel)
* It didn't have any feature size limitations (small SMT device pitches)
* It could be used on inner-layers

But that isn't to say that its inventors were claiming that AOT would replace ET completely, just complement it when ET became limited.
Towards the end of the 1990s, the AOT systems had developed in many key areas, including:
* Niche markets (large format optical test, BGA optical test)
* High speed derivatives
* High resolution derivatives
* Automatically loaded/unloaded systems

In fact, compared to competing AOI solutions, the AOT systems could scan the largest size panels, at the fastest scan speed, at the highest resolution, and find all the critical faults without giving any false calls.
So AOT gained popularity in the early 1990s as its value in production gained recognition. Users of AOT rarely went back to AOI afterwards. However, in order to fully appreciate the value beyond the initial optical scan result, it was necessary to take data preparation, system integration, and overall yield into account. Once these factors were considered, AOT found many loyal followers.

Frequently Asked Questions Regarding AOT

So what are the key benefits of AOT compared to AOI and ET? To answer this question, let's consider the following questions that invariably are asked when a PCB manufacturer evaluates optical scanning equipment to improve his process.

1. Isn't AOT just a quirky form of AOI?

No. AOT offers everything that people expect from AOI, sometimes things that AOI systems can't deliver like high-defect capture with low false call rate.
It is true that both AOT and AOI scan the panels to form a working image for analysis, but from then onwards they differ completely. AOT uses a similar logic to ET for fault detection whilst AOI systems use other non-related logic systems.

2. Don't AOT and AOI give the same end-result?

Molesey Road, Walton on Thames, Surrey KT12 3PJ England
Tel: +44 1932 245000 Fax: +44 1932 220555
www.lloyd-doyle.com
Lloyd Doyle Ltd. Reg No. 1607263
Lloyd Doyle International Ltd Reg No 2283674

Again, no. Both systems can find faults on PCBs (although AOT vendors claim a higher fault detection rate) but importantly the AOT system will achieve this without a high number of false calls. The end result is that more boards will pass final ET that have been through the AOT process than have been through AOI.
The false call issue is a very important consideration for system throughput and efficiency as the more calls that are generated during scanning require more verification afterwards. Without a doubt, this lack of the need for verification puts AOT in a powerful position.

3. Do AOT systems have a dedicated data preparation station?

No, they don't, but this is a powerful advantage for the whole CAM department. One of the major benefits of the AOT approach is that the optical test system requires a data reference that is available on all CAM stations. The data format is published, and allows preparation off-line on a wide variety of CAM stations. The user is not tied into investing in any specific data preparation station, and is free to integrate AOT into normal CAM procedures.

4. Does AOT work for all image types?

Yes. Because AOT is connectivity-based, it can be used to find faults on all types of images: inner-layers whether signal or mixed technology, outer-layers, and even BGA carriers. If you wonder whether AOT can be used to scan a particular image, just think of it as an optical application of the test process and you will have the answer. AOT can scan all image types with the same high efficiency.

5. What will AOT do for me that AOI can't?

By using AOT during manufacturing, higher yields will be achieved in the complete bare board process. AOT uses the same basis for detecting faults that ET systems use so that when bare boards reach the end of manufacture and have been passed by AOT, all the layers will be correct.

6. Where can AOT go that AOI can't ?

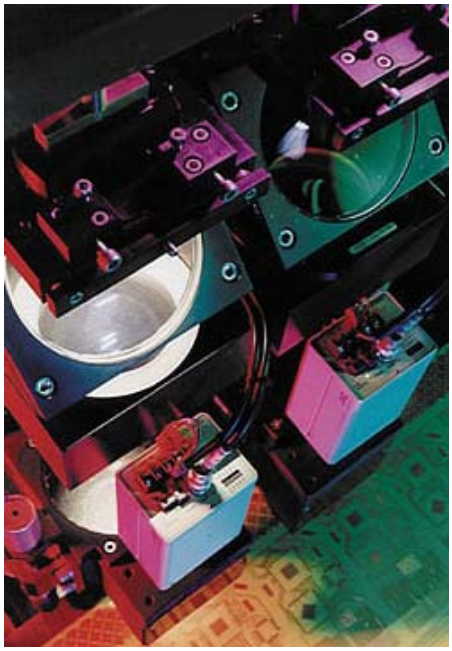


Photo 1. Showing a typical AOT optical system.

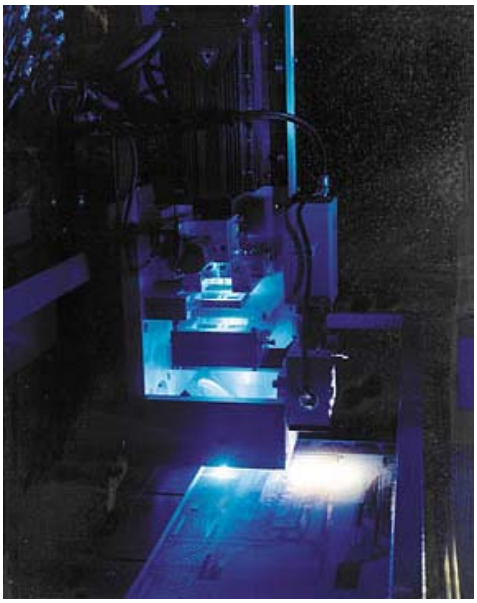
AOT is based on connectivity. As modern PCB images become increasingly complex, the circuit patterns become more difficult to define by a set of features, making analysis by AOI more difficult. AOT doesn't have this problem because no matter how complex a PCB image becomes, it can still be defined by connectivity and, therefore, AOT can still detect faults unhindered.

AOT: The Mature Years

Photo 2. Showing a typical laser illumination system for an AOT system.

What is the state of the art AOT system today? The fact that the basic AOT fault detection logic has not changed since its inception in 1982 tells us that the original fault detection methods are good at their job, but what has changed over those years are the mechanics, optics, and electronics which bring the technology to the shop floor.
High speed mechanics using linear drives mean that today's AOT systems can scan a standard 18" x 24" (450mm x 610mm) with 3 mil (75K) line/space circuit in less than 13 seconds. This is fast by any standard, but combine this with automatic loading and unloading translates into single systems that offer over 600 ft2 per hour (60 m2/hour) on the shop floor.
Panel illumination can be either white light based or laser based. Both systems use modern high frequency, charge couple device (CCD) electronics together with bespoke processing hardware, offering the best in image acquisition, allowing AOT to be more effective. It is the working image gained from scanning the panel that determines the quality of the AOT result.

The Future of AOI, ET, and AOT



AOT has a bright future. As PCB images become more complex, traditional AOI techniques based on pattern recognition will hit technology barriers. Together with increasing complexity comes diminishing feature size, giving orthodox test processes a real challenge in reliably hitting all test points as required with good contact.
AOT suffers from none of these limitations. With no barriers on image pattern and no "real estate" issues, AOT has clear benefits.
As a complementary technique for finding faults on printed circuits, AOT has a lot to offer particularly to the test arena; when test is not possible or cannot reliably give complete coverage, then AOT will show its real value.

Richard Frisk is President of Lloyd Doyle Limited. A mechanical engineer who started his career in Design Engineering in 1981, he has worked in the PCB industry for 16 years, chiefly in the capital equipment sector. Frisk has served in positions ranging from Technical Services, through Technical Sales to Sales Director. For the past 16 years he has put his efforts into the optical scanning equipment sector and currently heads up the Lloyd Doyle team.

Molesey Road, Walton on Thames, Surrey KT12 3PJ England
Tel: +44 1932 245000 Fax: +44 1932 220555
www.lloyd-doyle.com
Lloyd Doyle Ltd. Reg No. 1607263
Lloyd Doyle International Ltd Reg No 2283674