



CIRCUITS ASSEMBLY

Test Strategies

New Test Strategy for Tomorrow's Manufacturing

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By putting the right test in the right location on the production line, faults can be found quickly, test coverage can be maximized and test costs can be reduced.

Traditionally, in electronics manufacturing, *automated test* has meant in-circuit and functional end-of-line test and has not included inspection techniques. For years, electronics manufacturing managers have viewed *test* as non-value-added, although test has been effective at screening bad product from good, consequently minimizing the risk of shipping defective products to customers. Several reasons exist why test retains this negative image despite its real contributions:

- Production spends significant effort tuning processes, aiming at perfection. If the production processes were perfect, test would not be needed.
- The need for test is a constant reminder that production is not doing its job correctly because the process is not perfect.
- Test uses valuable resources such as floor-space, capital, people and time, yet the product is usually unchanged by test, unlike assembly, so no value is added.
- Test is often a bottleneck to new product introductions.
- Test constrains design and uses valuable board space on the product itself.
- Testing the same thing multiple times in the process is a waste of time and resources, but there seems to be no easy way to avoid it.
- Manufacturers continue to test, collect test data, and not use the data once it is collected.
- Test has been promising to make the manufacturer's work easier, but it has not been able to stay ahead of new technologies.

In other words, test is used as little as possible, typically as just a go/no-go process to prevent shipment of bad product.

Besides these issues, rapid changes are causing pressures in the test and manufacturing departments. Technology changes have been happening since electronics manufacturing began (Figure 1). However, the pace of the changes and the impacts on the production, test and inspection processes have recently increased dramatically. Testing the same old way in these fast-changing times just will not work.

Enabled by the new technologies, product complexity is increasing dramatically as well. This complexity, combined with the new technologies, leads to test and inspection issues such as lack of visual and electrical access. Of course, the continuing pressure for manufacturing to reduce the cost of building product while improving quality still exists.

One time and resource crunch occurring in several industries these days is being caused by explosive growth. For example, the communications and networking industry is growing incredibly fast, with some companies planning to grow sales by 30 to 40 percent. However, at the same time, they are only planning to grow their personnel count by 8 to 10 percent. In other words, they are really trying to do more with less and they are looking to their vendors to help them do this.

A relatively recent development is a growing focus on process improvement. As the electronics manufacturing services (EMS) industry continues to prove its worth and enhance its services, companies with captive manufacturing are evaluating whether to continue to manufacture products themselves or whether they should outsource. As with everyone facing time constraints in their daily lives, time is more and more critical

to manufacturers: time-to-market, time-to-volume and time-to-profit. Product life cycles are shrinking rapidly, leading to more pressure to move new product designs into manufacturing production faster. Production runs are also shrinking, making process control harder to achieve and making “get-it-right-the-first-time” more critical.

Recently, manufacturing execution systems (MES) software programs have begun to appear in manufacturing plants. MES programs are marketed as tools to help the manufacturer win the battle

against time and to help handle the almost overwhelming information requirements in manufacturing. This software acts as a layer between an enterprise resource planning (ERP) system and the processes on the manufacturing floor.

MES programs have been defined as “placing on a single platform such diverse functions as quality control, document management and plant-floor dispatching. At its core, a MES [program] tracks work-in-process through detailed product routing and tracking, labor reporting, resource and rework manage-

ment, production measurement and data collection. By capturing ‘live’ information about setups, run times, throughput and yields, managers are able to measure constraints, identify bottlenecks, and get a better understanding of capacity.”¹

In general, test results data have not been easily accessible by MES. So, while MES promises significant process control benefits, they appear to the manufacturing manager to be yet another headache.

FIGURE 1: The changing technical and commercial environment.

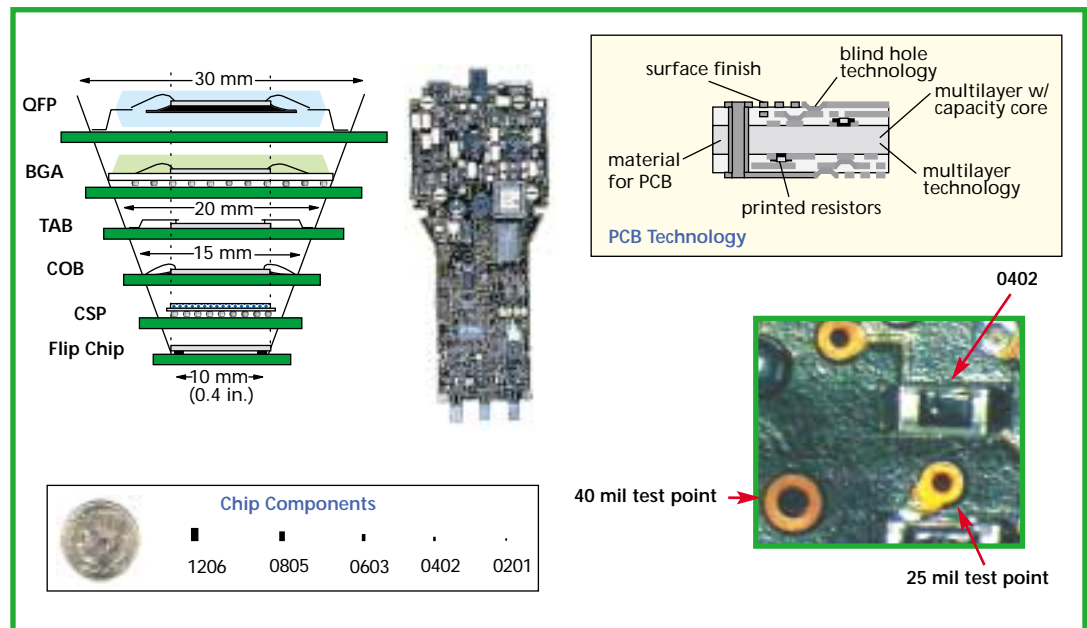
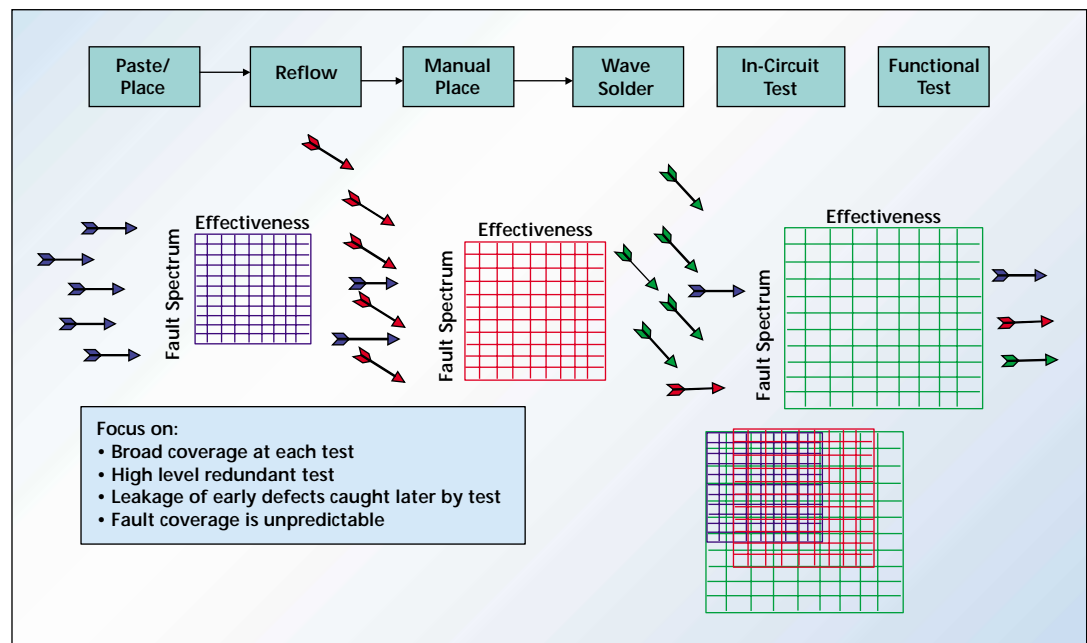


FIGURE 2: Conventional test strategy.



Critical Test Elements

Numerous manufacturers see these pressures acting themselves out. “I have no visibility to my line” is a common sentiment voiced by frustrated managers. Some say they are “flying blind,” trusting that they are putting product together correctly, with no opportunity to verify until test at the end of the production line. With these time pressures, line turn-around requirements and other considerations, relying exclusively on end-of-line test, while hoping to get process control information, is simply unrealistic.

One solution to these problems is a new test strategy, a paradigmatic shift from the way inspection and test data are utilized in typical manufacturing processes. This new test strategy consists of three critical elements:

- the right test in the right location
- test at the right cost
- real-time test information.

The Right Test in the Right Location

The traditional end-of-line test strategy has been used successfully in the past, but in today’s environment using it exclusively has some shortcomings. In general, in-circuit and functional end-of-line test provide good diagnostic information about electrical faults that they can detect (Figure 2). But many *structural* faults cannot be detected by these techniques. In addition, because of their location, these systems give information about failures and, therefore, indicate problems in the production process well after the problem is introduced. This time lag increases the probability that bad work-in-process (WIP) inventory will build up, leading to increased repair and rework costs.

Process control requires real-time process feedback and tight information feedback loops to trap and correct problems close to the source. By inserting an inspection system into the line at the appropriate place, structural faults can be detected upstream in the process, allowing timely corrections to be made to the drifting process.

In the past, this solution was impossible due to the lack of automated techniques that could efficiently and effectively test boards in the middle of the

process. Without the circuits being complete and without the solder paste having been reflowed, electrical test was not a viable approach. Now, with automated inspection techniques, manufacturers can put these inspection systems in where they used to rely on human visual inspection. These systems can thoroughly and repeatedly inspect the boards without getting tired or making errors. They can identify numerous problems throughout the process, allowing much less expensive repair and providing valuable feedback into the process.

More importantly, no single test technology can capture all faults. So as the fault spectrum has expanded, a need has grown to combine these technologies intelligently. By designing a test strategy based on a manufacturer’s own process and by putting appropriate structural, in-circuit or functional test in the right places, faults can be found quickly, test coverage can be maximized, and the cost of test can actually be reduced (Figure 3).

Each test or inspection technique has a portion of the fault spectrum that it is particularly good at examining. In addition, each technique has a portion of the fault spectrum that it cannot see. By using different techniques in different places in the production line, manufacturers are now able to utilize a technique right after the manufacturing step that intercepts the faults that are within that technique’s capabilities. For example, catching a placement or wrong-part problem right after the part is placed is far better than after the solder has been reflowed.

Having this range of solutions that focus at different areas of the fault spectrum allows manufacturers to save money in three ways: enabling higher fault coverage to prevent shipping faulty product; building less faulty WIP inventory because the fault is caught soon after it is caused; and providing earlier stage detection for a less expensive diagnosis and repair, while also allowing quicker process improvements.

Of course, information generated from test data is only as good as the data itself. Decisions based upon this information are equally good or flawed. The tester must be of the proper type to catch the

expected class of faults, and it must also be of high enough quality to yield accurate actionable information. A test strategy must employ world-class measurement systems to ensure that the finest measurement technology is being used to drive decisions on the factory floor.

Test at the Right Cost

The fault spectrum of each production line is different, so each line need not be populated with all types of test systems. The goal is to get as much value as possible from test and inspection while reducing overall test cost. Test consulting services are available that can help manufacturers define a test and inspection strategy to maximize the effectiveness of test at the lowest cost. These services typically examine the manufacturing process holistically and make recommendations to maximize output while minimizing capital costs over the entire product’s life cycle.

In addition, new test technologies and strategies can assist the manufacturer in reducing the cost of test. Recently, a new technology allows test systems to be linked to each other in the test development process as well as on the factory floor during production. Using this technology, expensive redundancy can be eliminated from test.

For example, an automated x-ray inspection system can be coupled with an in-circuit test system. The x-ray system tests for structural integrity of the solder joints. This test uncovers process faults such as shorts, insufficient solder, misaligned components and opens. Because these faults have been screened out already, the in-circuit tester does not have to repeat these tests. Therefore, the in-circuit test is much less complex and easier to develop. The results of this strategy are that the overall test development time is reduced, size and cost of the in-circuit fixture are reduced, fault coverage is dramatically increased, and the overall cost, including capital and operating expenses, of the test systems is reduced.

Real-Time Test Information

Opening the window to the manufacturing process gives managers the visibility to the line they need and have wanted. But this visibility requires taking

accurate measurement data, turning it into useful process management information, and then presenting it in a way that is useful. For this information to be truly useful, all of these steps must be done in real-time.

Manufacturing information processes are diverse. Some manufacturers use data analysis systems that they have owned for years and do not want to lose; others are currently shopping for new systems. Some have or are creating home-grown solutions, while others are purchasing off-the-shelf or turn-key systems. Because each manufacturer has excellent reasons for its own software decisions, the need to integrate test systems into any of these environments, whether proprietary, off-the-shelf or customer-built, is important.

Offering open and standard ways for test data to be easily used by any solution a factory has, including MES, is clearly a way that test system manufacturers can add value in the marketplace. As noted, test results data are typically difficult to pull into these systems, and, therefore, much data that is collected is never used. Especially as the XML standard expands the ease of connectivity, the importance of embracing these standards and agreeing to work with competing systems from this perspective while competing on other system qualities is growing higher.

An easy and standard interface also allows manufacturers to choose how much quality control they want to implement in their process. Some will choose a full-up MES package, some will want an inexpensive tool, and some will simply want to use a spreadsheet application to track their data. Either way, opening the results interface in a standard way, allowing MES to get data out of distributed systems on the line in real time, and turning this data into decision

support information will add value to manufacturing.

Another trend in the marketplace exposes some needs for manufacturing managers. EMS providers typically contract to deliver a certain quality level of

different platforms to work together collaboratively, costs will be held in check.

With more and better information available about a production line, manufacturing managers can make the rapid decisions that are required in today's

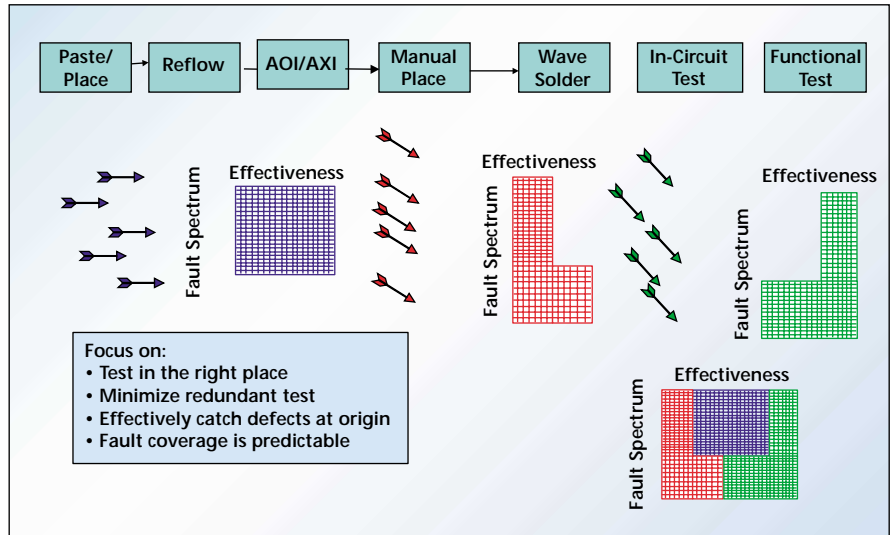


FIGURE 3: The new test strategy.

product. Original equipment manufacturers (OEMs) typically have to accept this quality level on delivery, without being able to get good insight into the EMS provider's process quality. Thus, the OEMs do not know how many times a board was reworked or the number of failures happening on a specific part or region of the board. The standards, along with tools to allow visibility into the line, can easily allow OEMs the visibility into the EMS provider's process that they desire.

Summary

By testing in the right production location, electronics manufacturers will be able to solve some difficult process problems. More faults will be found, and they will be found earlier. By allowing

fast-paced world. As outsourcing grows and the time, resource and quality pressures continue exerting their forces on manufacturing managers, the new test strategy can assist these managers in handling these forces. As the new test strategy is implemented, the former promises made by test will become reality. ■

Reference

1. Cahners manufacturing systems web site: www.manufacturingsystems.com.

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