Automating Fine Pitch Device Handling

Today's fine pitch devices place special challenges on automated programming handlers.

Stuart Jensen, Data I/O Corp., Redmond, Wash.

The past decade has witnessed remarkable changes in the electronics industry, and not just in the number and variety of products available to businesses and consumers. Integrated circuits (ICs) have undergone profound transformations as product manufacturers demand ever increasing functionality in devices, while at the same time pushing for smaller device packages to meet demands for compact, portable and flexible products.

In a short span of time, devices have blossomed from simple packages such as 8-pin DIPs to the more typical 44, 52 or higher pin counts of many surface mount devices. Today, there is a vast array of device and package types. It is common now to hear semiconductor vendors introducing new surface mount technologies in 200- or 300-pin quad flat packs or ball grid arrays. A study by Dataquest indicates that by the turn of the century there will be new devices in packages containing 700, 800 or more pins.

The popularity of fine pitch devices has surged in recent years. These devices have very thin and very closely spaced leads; a typical fine pitch device may have leads that are only 20 mils apart. They offer high I/O and the potential for sophisticated algorithms in a very small amount of space. Virtually unheard of only a few years ago, fine pitch programmable devices, such as QFPs, TSOPs, and SOICs, are now hot commodities in a number of key markets. Some of these applications include: personal computers, particularly laptops, personal digital assistants and multimedia machines; cellular phones and other telecommunications gear; medical and test equipment; and automobiles, where fine pitch ICs control functions such as engine control, keyless entry, and braking systems. Fine-pitch devices fit the bill in these industries because they offer increased design sophistication and more I/O pins in a smaller real estate area.

New challenges

There are serious challenges, however, with these small, sophisticated devices. The proliferation of packages and pin counts is putting new and increased pressures on product manufacturers, both in the design labs and on the assembly floor. Companies are realizing the significant manufacturing implications when an engineering team chooses a specific device, and that engineering and manufacturing teams must therefore work more closely together.

Circuit board assemblers also are being forced to rethink how to handle small and complex ICs in production quantities while carefully weighing factors such as cost, competitiveness, and quality. This is especially true with fine pitch surface mount devices. These delicate leads can be easily damaged, and thus raise a number of complex issues. What kind of yields can a manufacturer get with current production methods? What are the risks/benefits of more advanced production automation vs. traditional and labor intensive

Figure 1. Automated device handling systems *help maintain the integrity of a device while improving manufacturing efficiency.*

Every company has to conduct its own analysis when using fine pitch devices

methods of handling devices? How can quality be monitored and assured at every stage, from design to the assembly floor, so costs are controlled and customers are satisfied?

There are no quick, easy answers to these questions. Every company has to conduct its own analysis when using fine pitch devices. On the issue of yield, manufacturers must look for the most effective, long-term solution. Manufacturers should evaluate their programming production environment for manufacturing defects caused by manual production methods, because the demand for fine pitch devices is surging and the price of failed devices can seriously affect the bottom line.

When fine pitch devices were first introduced, a typical approach was to use programming equipment designed for relatively small batches, and to use a significant amount of human handling to move the ICs through the process. This can be very expensive. For example, suppose a large manufacturing operation programs 8000 ICs a day, and each device costs $20. In one year, a conservative one percent failure rate quickly adds up. This is money that could be saved in the long run with an investment in a fast and efficient automated production handling system. Some questions that need to be examined by manufacturers: What is the current yield rate? If the yield rate is improved to 99.5 percent — a reasonable goal with today's systems — how much money would be saved? And what is the cost of the labor required with human handling? The answer lies in the quantity of devices used and frequency of change over to different package types.

Quality

The issue of quality is even more complex, because it touches so many critical areas of a company's performance and products, and ultimately, its relationship with its customers and the ability to compete in a worldwide economy. Most companies have recognized the importance of system-wide procedures and programs to ensure quality in every stage of design and manufacturing. This explains why an increasing number of manufacturers have completed or are working on ISO qualifications, and in the process have become very sensitive to the cost of poor quality and the need for advanced automation.

This awareness becomes particularly acute in facilities using fine pitch devices. Labor-intensive handling procedures can result in any number of problems. For example, devices can be incorrectly labeled or improperly oriented in tube holders, causing backward pin orientation and incorrect insertion on a printed circuit board, resulting in board failure.

More troubling problems are lead damage and ESD failures, which are difficult to detect with the naked eye. Lead quality and ESD are the two primary concerns of manufacturers when they consider automating their device handling and programming systems, since these are problems common with human handling that can result in serious and sometimes catastrophic consequences. The most significant aspect of lead quality with surface mount devices is coplanarity, or the degree to which leads are deflected after being touched.

In labor-intensive plants, fine pitch parts are handled in ways that are virtually guaranteed to damage leads, especially when they are picked up and placed in trays or programming sockets. Even a well-trained, conscientious employee is liable to cause damage when picking and placing all day with a pair of tweezers or hand-held wands. With fine pitch parts, leads may look good in a visible inspection, but actually may be bent or sitting unevenly on their pads due to mishandling. Poor coplanarity results in one or more pins with improper contact, possibly causing a poor mounting and a subsequent failure at the board level.

Similarly, ESD, which often occurs even with the most careful handling, can cause defects leading to device failure, PCB failure, or a defective end-product.

As mentioned before, the cost of replacing defective parts can be very expensive. But the cost of replacing faulty PCBs is significantly higher.

Detailed View of the Input PNP

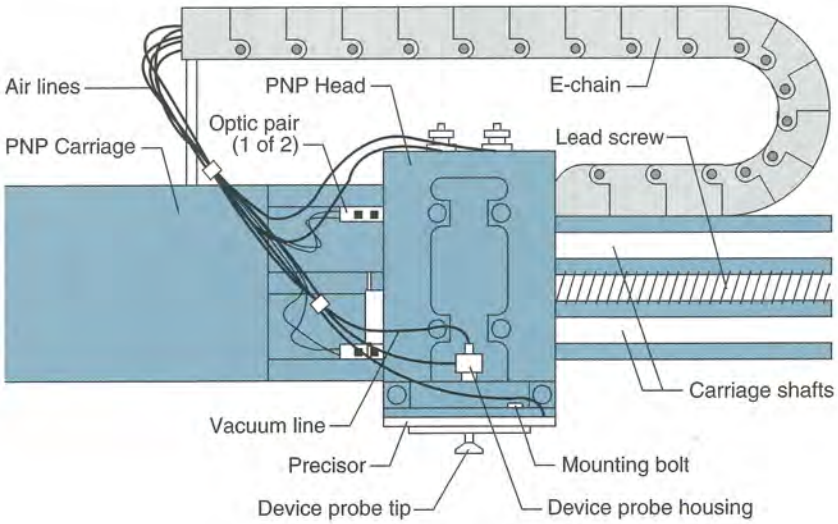

***Figure 2. Device transport throughout** a handling system can be optimized for maximum efficiency.*

The programming system should support the widest array of popular devices

When a defective device causes a product to fail, the cost can be enormous — whether in dollars lost due to recalls, replacements or liability suits, or in a damaged reputation.

Automated handling systems

As device complexity and pin count increases and the pitch between leads shrinks, the need for manufacturers to consider automated handling systems becomes paramount. In fact, the convergence of competitive market forces and shrinking device technology will demand automated handling of programmable ICs. The cost and quality problems associated with human handling of these devices is already serious, so companies must consider the sophisticated automated handling systems now appearing on the market that can program, test and mark fine pitch SMDs in large quantities.

Automated handling systems are a significant capital investment for any company, yet each company has specific needs. Therefore, manufacturers should look for a system that can be configured to fit specific requirements by inserting the appropriate subsystems. An automated handling system should be able to adapt to the different input and output media being used today, including trays, tubes, tape-and-reel, or any combination of these. This permits rapid changeovers when switching between device types and packages.

The programming system should support the widest array of popular devices, both with regularly updated algorithm support from the system vendor and with socketing technology that can be easily swapped on the assembly floor by a technician. A system's pick-and-place mechanism should ensure a constant flow of devices — even when a technician is loading and unloading devices. The system should also include a quality marking mechanism, and easy-to-use software for managing and monitoring the overall process.

To meet the high-volume, flexible needs of large run assemblers, contract manufacturers and distributors, or for moderate production runs with a high mix of device and package types, an automated handling and programming system should be fully integratable and modular. Being able to program, test, sort and laser mark large quantities of devices per hour while touching delicate leads only once during the entire input to output process will help meet these requirements.

The four crucial stages of operation for a handling system are input, programming, marking and output. Each stage should act independently so operations can be done in parallel for better efficiency and throughput. Vacuum tips can minimize handling damage during transport of the devices throughout the system (Fig. 2).

Using JEDEC- or EIAJ-approved transport trays or tubes for device input improves a system's flexibility and helps protect the devices. Also, more vendors are using tape as a shipping media and more production lines are requiring tape as an input media. As a result, full support for both tape input and output is critical. The programming sockets should be designed to minimize lead damage. If a device only has to be placed in a socket once, and it is held in place with locking clamps against a flat surface, the chance for lead damage is greatly reduced.

Ensuring device integrity

Because device integrity is so critical in fine pitch SMDs, manufacturers should expect system vendors to examine the effects of an automated handling system on specific devices using accepted industry methods. Because of the variety of available package types, and because new device packages continue to be introduced, the issue of coplanarity should be examined on a case-by-case basis. Measurement methods should be done in accordance with JEDEC specification JESD22-B108; customer acceptance criteria can be developed for each application based on the particular device.

Relying on manual techniques for handling and programming fine pitch surface mount parts is becoming an untenable scenario. Any time a device is picked up, moved, placed in a socket, or loaded in a tray by a human operator, there is risk of damaged leads. The care required in handling such devices by human operators, and the associated labor costs and risk of damage, often exceed the expense required to convert to automated systems. To stay competitive, manufacturers using fine pitch devices must reduce the risk of damage and subsequent fallout of components and completed products.

While automated systems can be physically large and sometimes expensive, maintaining the integrity of devices has become as important as efficiently using the silicon in the design and programming steps. Installing an automated system will address an assembler's concerns for quality, production yield and, in most cases, throughput. The resulting improvements in quality and yields are vital parts of the equation that will keep electronics manufacturers competitive today and in tomorrow's global markets. **EP&P**

Reprinted from **ELECTRONIC PACKAGING & PRODUCTION** September, 1997