To Manufacture More, Automate

Automating the entire process of assembling, packaging and testing optoelectronic devices improves throughput as well as yield. Too much handling can spoil the product.

The rapid expansion of dense wavelength division multiplexing telecommunications networks has created a worldwide demand for optoelectronic devices that is becoming increasingly more difficult to meet. This stems primarily from the limitations related to production capacity and from package design issues that hinder high-volume production.

Proper package design and automation are very important in high-volume production of fiber optic components for telecommunications. Standardizing package configurations and designs would simplify automated manufacturing processes. Until this occurs, however, a palletized tooling approach improves throughput, cycle time and yield, offering an immediate solution to the pressing problem of production capacity and to yield issues that stem largely from excessive direct handling of components.

Packaging considerations

Package design considerations are important when the objective is a fully automated production line for component manufacturing. A product or a package that is fundamentally not designed with high-volume automation in mind will not render itself readily to an automated process. It will often require skilled operator handling at every stage of the process. This is quite labor-intensive, creates variable yields and increases the chances of component damage during manufacturing.

Also hindering rapid transformation of optoelectronic device manufacturing to a fully automated phase is the wide variation in package designs and configurations: No one package is standard for any particular device application. Each component manufacturer builds its own packages and develops its own packaging processes.

Nevertheless, some commonalities have begun to emerge. For example, in the case of active devices such as laser diode modules, many manufacturers are using laser welding to package their devices. Laser welding is a very repeatable process that works well in automation. Its inherent attributes of strength, cleanliness and long-term reliability also offer considerable advantages.

By using absolute positioning robotic-style motion control systems and process control software, these laser welding machines can automate and speed up assembly processes with minimal operator interaction and training. The result is a repeatable, epoxy-free process that can be used in the production of high-volume quantities of various types of laser diode modules, such as pump diode lasers for erbium-doped fiber amplifiers.

Beyond these advances in the development of sophisticated automated fiber optic component manufacturing machines, one of the primary limitations governing next-generation improvements in cycle time and yield is the manual loading and unloading of components. Although the machine operates on a turnkey, push button, automated basis, the operator must still load and unload components manually, one piece at a time. In addition, the full packaging process for a device may employ many different machines for different steps. Very often, these machines are from different manufacturers, each with its own tooling and fixtures. As a consequence, manufacturers waste a lot of time performing many loads and unloads, thus limiting the throughput and overall capacity of the production line.

Figure 1 shows a laser welding machine that represents the state of the art in automated laser diode packaging technology. However, a process flow chart (Figure 2) reveals that loading and unloading the device into the machine can take up to 40 percent of the process cycle time. It is during this manual loading and unloading that damage can occur — after most of the value is added to the component. Parts handling is typically cited as the largest yield problem in the production of fiber optic components: Fibers are cumbersome, fragile and tough to handle, and electrostatic discharge can also damage optoelectronic devices.

Advanced manufacturing

Newport’s AMS series of automated manufacturing systems incorporate all the automation benefits of standard laser welding workstations, including fully automated alignment, metrology and laser welding attachment. However, parts loading and handling with these systems are much more efficient.

A palletized loading system enables off-line preparation of component parts, displacing the loading cycle time from the assembly workstation and significantly increasing overall throughput. While one device is being packaged, a machine operator can prepare the next set of parts in a separate loading workstation, cutting machine cycle times by 20 to 50 percent.

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Each pallet tool (Figure 3) contains electrical connections to the laser diode module, a fiber spool clamp and a fiber loading fixture that guides the fiber ferrule assembly into the snout of the butterfly package. A retention arm secures the weld clip during pallet transport.

An operator can load this prepared pallet into the docking bay of the laser welding machine in a matter of seconds. This palletized loading approach can reduce typical fiber pigtailing assembly cycle time for a 980-nm laser diode pump module to about 5 minutes resulting in a throughput of 10 to 12 parts per hour. After placing the pallet in the docking bay and closing the safety door, the operator pushes a button to launch the laser welding process.

During this process, pneumatically actuated tweezers grip and position the metallic fiber ferrule in the butterfly package. Two pulsed Nd:YAG laser beams (one on each side of the fiber ferrule) weld the components into place. First they weld a saddle-shaped weld clip to the base, then the metallic fiber ferrule to the saddle-shaped clip.

The machine performs postweld shift compensation and correction with a combination of laser hammering and automated mechanical adjustment. This process can repeatedly achieve fiber-to-waveguide alignment tolerances of about 0.2 µm.

At the end of the process, the operator opens the machine enclosure and removes the pallet — without touching the now fiber-pigtailed laser diode module. The training time for an operator on the system is hours rather than the weeks of a more manual process.

The operator then takes the entire pallet to the next machine in the manufacturing line, where a similar docking station or cassette carrier serves as the pallet interface (Figure 4). This way, the parts can move quickly and safely from one machine to another.

We can foresee extending this concept by adding robotic systems or conveyor-type equipment to transfer the pallets from one machine to another. Furthermore, using relatively inexpensive pallets could lead to a point where the device is shipped to the customer while still encapsulated in the pallet — only to be removed when the end user is ready to install it in a final application.

Thus, automating and palletizing the manufacturing process can improve not only the production cycle time, but also the overall yield — simply by keeping operators from handling the components directly and by reducing the time needed to load and unload the parts.

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**Figure 2.** A laser welding system can attach an optical fiber to a 980-nm laser diode in 7 to 11 minutes, depending on package configuration and assembly requirements. But device loading and unloading can constitute up to 40 percent of the process time.

**Figure 3.** Specialized parts carriers (“pallets”) handle a device through several manufacturing stages. The pallet easily mates with a docking bay in various machines, greatly reducing the parts loading and unloading times.

**Figure 4.** Using cassette-style pallets, components can quickly move from one machine to another with minimal risk of damage.