今天光电包装的一个主要重点是降低成本和批量制造，因为越来越多的光学元件正从长距离网络向城市网络和接入应用程序迁移。自动化和外购双管齐下。在本文中，通过电子制造服务供应商(EMS)和光电工业供货商的光电包装动议，说明这种团队合作。

Current Trends in Optoelectronics

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EMS providers and equipment suppliers are working together to make high-volume optoelectronic component manufacturing a reality.

Although they do not receive the notoriety that system in package (SIP), system on chip (SOC) and flip chip technologies are receiving today, optoelectronic packaging and component manufacturing are hardly inactive. A primary emphasis in optoelectronic packaging is cost reduction and volume manufacturing, as optical components are migrating from the long haul network to metro and access applications in increasing volume. At this point is where automation and outsourcing are working hand-in-hand, as is evidenced by the optoelectronic packaging initiatives underway at an electronics manufacturing services (EMS) provider and an automated equipment supplier.

FIGURE 1: Fabrinet's manufacturing facilities in Thailand.

As a contract manufacturer, Fabrinet (Bangkok, Thailand) specializes in precision manufacturing of complex optomechanical and electromechanical devices. The company currently performs contract assembly on a range of passive and active optical components, including optical switches, IPMMs, wave length lockers, fused fiber couplers, three-port filters and variable optical attenuators, laser modules, transmitter and receiver optical subassemblies (TOSA and ROSA) and transceivers. It also works with optical modules, including EDFAs, CATV transmitters, triplexers, DWDM multiplexers and tunable optical detectors.

As optical OEMs are increasingly outsourcing manufacture of their terminal-active optical components, EMS providers have become a major manufacturer of transceivers. This work includes sourcing and manufacture of TOSA and ROSA as the most costly component part of a transceiver. As the optoelectronic package is a hybrid processor of both electronic and photonic signals, a plethora of unique materials are used in device fabrication. This variety of materials is one of the factors that distinguishes optoelectronic device assembly from conventional microelectronic manufacturing. Devices may be manufactured from many materials, including silicon, quartz, doped silica, LiNBO3, GaAs and InP. Vertical integration in manufacturing shortens the supply chain, saving procurement, packing and shipping costs.

At an optical component contract manufacturer, the process of developing a new customer or application and transferring that product into volume manufacture has been refined through experience. A typical process in the field of contract optoelectronic component assembly proceeds according to the following steps:

1. During the *project evaluation phase*, a dedicated project or product manager is assigned, and the customer specification is received and understood by each project manager.

2. Concurrently, a team of packaging technologists works with the project managers to evaluate the technology and customer viability.

3. A specific team handles the customer request for quote (RFQ) by studying the production process of each product, yielding a proposal that details the process time, resources required, yield, scrap and volume.

4. Concurrently, a specific team works on the tooling design. The tooling design team works with the process engineer of each product to design the necessary tooling and fixtures that will be used in the production process. Some tooling and equipment is consigned from customers, and some is designed by the EMS provider where it provides the design to a local machine shop for fabrication.

5. In the *qualification sample build phase*, all the concerned parties get involved. Samples are produced and sent to the customer with a first article report containing the details of the build process and the results of sample build. This report provides the customer with a first article prove-out, cost, yield and volume data to the manufacturing strategy.

6. If the customer decides to proceed with the contract assembler, the EMS provider assigns a planner for each customer, initiating the *procurement phase*. The planner gets the order from the customer and develops the production plan. The responsibility of the planner starts with incoming raw material and extends all the way through finished goods delivery. The planner is responsible for handling a customer order for either initial or volume orders. Search for material utilizing the customer's approved vendor list (APL) is accomplished through the supply chain engineering team or buyer team. In the case of new supplier sources, a supplier evaluation and first article submission is required for supplier approval. When parts are received, the incoming inspection team inspects the incoming materials based on the incoming inspection request (IIR) issued by the supplier quality engineer. The raw materials are purchased according to a materials requirement plan. In production, the materials are controlled between material usage and inventory return by a work order system.

7. In the *factory implementation phase*, the project manager calls a meeting with all concerned persons and assigns them the task of creating documented instructions to be used in the material flow, production line and maintenance system as required by the customer. In contract optoelectronic manufacturing, most functional tests are designed by the customer. In some cases, the EMS company provides software engineers to program testers for customers. Where required, a production team is trained at the customer site before volume production ensues. Employees are evaluated and certified before allowed to do specific operations. For example, engineers are trained how to perform device testing and evaluation at the contractor's site. Resource utilization is important in cost-effective manufacturing. For example, the operators can work on different processes to make full line effectiveness. Factory floor and clean room space are assigned depending on production volume, clean room requirements, customer confidentiality and similarity of technology.

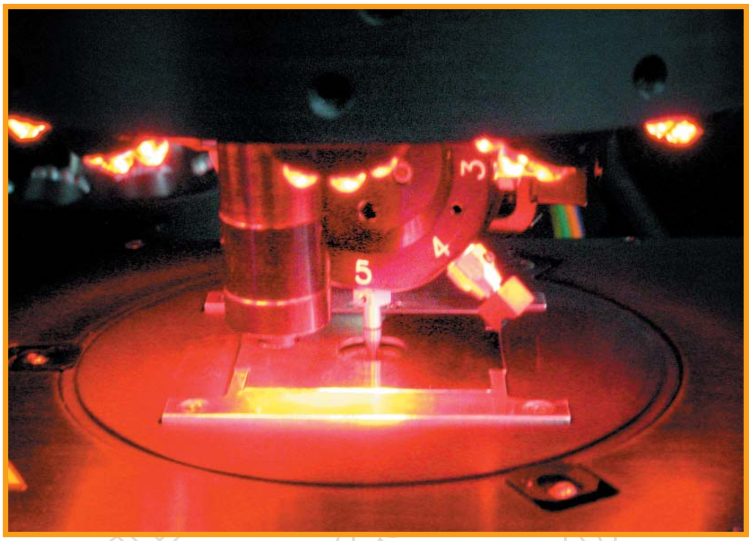

FIGURE 2: Precision die bonder tooling at Fabrinet.

The result of this process, in Fabrinet's case, is a contract optoelectronic component manufacturer with an ISO 9001:2000, 14001 and TS 16949 certified facility, turnkey materials management supply chain, Oracle-based information technology (IT) and a state-of-the-art, Web-based manufacturing intelligent tracking system. By augmenting its production capabilities with automated, high precision assembly systems, the company hopes to achieve revenue growth with high value-added optoelectronic components requiring scalable manufacturing capacity.

The importance of recipe-driven process control for optoelectronic assembly may be illustrated by considering the case of attachment of a laser diode within a laser transmitter. This extremely temperature-sensitive device requires careful process control during assembly. Precision eutectic component attach includes:

- pick and place of Si, GaAs or InP chips
- in-situ reflow of preform or pre-tinned devices, in concert with programmable x, y or z-axis agitation
- programmable pulse heating or steady-state temperature.

The reflow profile during an in-situ eutectic die attach process is engineered to provide consistent melting and a void-free attach interface. This profile results in consistent heat transfer from the laser diode and contributes significantly to temperature stabilization during laser operation.

Automating a process disciplines it. Variations in material and process that can be tolerated in a manually assisted process will lead to difficulties when that process is automated. Consider, for example, automatic die bonding vs. manual die bonding, where machine vision takes the place of the operator's "organic image processor," high-speed precision mechanisms and end-effectors are substituted for human tactile sensing and fine motor skills, and programmable machine logic replaces the reasoning powers of a skilled and experienced operator.

Driven by a skilled operator, an automatic die bonder is an extremely powerful, productivity-enhancing tool. However, equipment suppliers in the advanced packaging marketplace must understand their customer's processes to an even greater degree than their customers understand them. This idea is especially true in the case of complex process automation, such as the exercise of automating complex dispense and die attach processes, high I/O wire bonding and active optical alignment.

Conclusion

As an enabling technology, automated microelectronic and photonic manufacturing equipment is the engine that propels today's product concepts from the laboratory into large-scale commercial, military and industrial prominence. In the leading edge of the market, emerging packaging methods and novel materials provide the impetus for innovative advanced packaging and interconnection processes and equipment. Contract optoelectronic component manufacturers with materials management supply chain and precision manufacturing competencies are realizing high-volume, cost-effective manufacturing for these complex components. The equipment and process expertise that these suppliers are developing today will not only facilitate the efficient manufacture of optical components but will enable component designers to continue to push the envelope of communications technology into the foreseeable future. ■

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