Automation streamlines assembly and test

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With careful process planning, companies that manufacture passive devices can use a variety of automation tools to reduce assembly time and even eliminate downstream steps through integration of assembly and test. By successfully harnessing the feedback from the equipment, they may be able to refine their processes and boost production to volume levels. A necessary first step in any automation process, however, is to re-examine the current process for bottlenecks.

RETHINKING THE PROCESS

Common to all types of passive components is the fact that assembly and test processes remain largely manual and time-consuming operations. While fused biconic taper (FBT) designs have an assembly advantage over planar designs for small port counts, planar devices offer distinct assembly and size advantages over FBTS as port counts increase. The problem is that the complex process of attaching fibers to planar devices remains a barrier to high-volume production.

For high-port-count devices such as 16-channel splitters and dense wavelength-division multiplexers, planar waveguide technology excels. Rather than concatenating numerous 1 × 2 FBT devices together in a large package, a 16-channel waveguide device can fit neatly on a small silica substrate. Clever circuit designs can be used to yield numerous 16-channel devices on a standard 6-in. silica wafer.

Despite this increased density, the wafer must still be visually inspected and sliced into individual devices. The wafer ends must then be polished and each device optically tested. Testing must be repeated after fibers are attached and again after final packaging. In both cases, automating several inspection steps can potentially reduce both processing time and costs.

WAVER INSPECTION

In waveguide manufacturing, it is critical to hone the process through visual inspection of the completed wafer. Depending upon the sophistication of the device manufacturer, in-house built video inspection systems possess a range of inspection efficiencies. Most incorporate off-the-shelf video cameras and x-y-z positioners to both move and inspect the wafer.

While these machine-vision systems may provide required resolution, pass/fail criteria are very difficult to formulate unless the firm has personnel that can develop pattern-recognition algorithms to look for irregularities in the manufacturing process. Test devices now on the market have built-in algorithms to identify occlusions in the wafer material, unacceptable v-groove depth or edge straightness, and masking errors in the waveguide “writing” process (see Fig. 1).

Most manufacturers of machine-vision inspection systems realize that their systems must deliver both qualitative and quantitative information about the parameters that influence process yields and control. If a device can be passed or failed before further slicing, polishing, or fiber attachment steps, then downstream yields can increase dramatically. In addition, cost reduction can be realized at a very early stage in the manufacturing process.

Once a wafer passes its visual inspection, it must be sliced and polished to produce individual devices or a block containing several devices. The next inspection step is to determine whether or not the device meets waveguide characteristics defined by the individual manufacturer. One way to check this criterion is to inject light of the correct wavelength into the waveguide device or block of devices and monitor the output.

To facilitate the inspection, engineers often mate a prefabricated fiber array of the correct fiber count to the input and output surfaces of the waveguide. To assure proper guidance of the source light into the input array, through the device under test, and back through the output array to the test equipment, they use index-matching fluid or gel to make a temporary connection.

As a manual operation, the process can take several minutes. Even if inspectors successfully achieve array-to-waveguide alignment, they still must confirm proper operation of the waveguide device through a host of optical tests such as insertion loss, polarization-dependent loss (PDL), crosstalk, and isolation.

Test systems are now available that marry automated fiber alignment with in situ optical testing capabilities, which can reduce inspection times fourfold. Because the type of device under test can vary dramatically, the test system must be flexible enough to accommodate any number of different wavelength sources, channel counts (depending upon the $M \times N$ count of the device), and detector modules to monitor power, wavelength, or other parameters (see Fig. 2). Equipment must also be able to accommodate new device designs down the road.

Manuators of passive devices such as fused biconic taper couplers, filters, or planar waveguides usually face time-consuming manual alternatives for assembly and test procedures. Automation equipment such as preassembly pass/fail video inspection, automated fiber alignment, and in situ optical testing enable manufacturing improvements and cost reduction.
If engineers can perform a simple insertion-loss measurement on a wafer before attaching the fiber, then making the pass/fail optical determination in situ with the assembly process can minimize or eliminate downstream expenses that would incur if the device were tested only after final packaging.

**FIBER ATTACHMENT AND PACKAGING**

With the optical testing complete, a batch of devices is now ready for permanent array/fiber attachment and packaging into an external rugged housing. Those companies that made “temporary” array connections to the waveguide via index-matching fluid during optical testing now must repeat the alignment and test process again before permanently epoxying the fiber or array onto the waveguide.

The movement of the device from inspection station to the alignment/testing station, the cut/polish station, and back to alignment/packaging is the most time-consuming part of the manufacturing process. It’s ironic that the suppliers of turnkey optical test equipment for these devices work to reduce port-count spectral test times to seconds while the device manufacturers themselves are taking several minutes, and sometimes hours, just to move the component from station to station.

The only way to solve this problem is for automation suppliers to cooperate with device manufacturers to develop alignment, packaging, and test equipment that will ultimately eliminate the need for such complex part movement.

**SIMPILIFY**

In essence, automated testing procedures such as preassembly pass/fail video inspection, automated fiber alignment, and in situ optical testing should be viewed as tools to enable future manufacturing improvements and cost reduction. Once companies identify processing bottlenecks, streamline the process, and then receive ongoing feedback from their test equipment, continuous improvement becomes a reality. Problems in a process can be identified and eventually eliminated to the point where inspection need occur only on a sampling basis rather than on 100% of the devices produced.

Likewise, the in situ optical tests and temporary alignment of arrays to waveguides could ultimately be replaced by in situ optical testing during the array epoxying process, thus eliminating a part-handling step. Ultimately, the job of automation equipment suppliers is to understand where bottlenecks exist during device manufacturing and to work with the device manufacturers to find new ways of eliminating them.

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