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10th Anniversary Insights

“Packaging matured as volumes grew”

BY RALPH DUCEOUR

During the past 30 years, the semiconductor assembly process has undergone dramatic changes that continue to affect the industry's requirements for human resources, equipment and facilities. Increasing volume requirements and the advent of progressively more sophisticated technologies have been key drivers in this shift.

Labor Requirements Shape the Industry's Early Years

Semiconductor assembly began decades ago, although much of the innovation has occurred in the past 10 years. In the formative years of the semiconductor industry, the majority of semiconductor packages were made of glass or ceramic materials, and they were produced in-house by semiconductor vendors. Much of the assembly was done in North America, and only a handful of companies had assembly locations in Southeast Asia. In these early years, the packaging and assembly of semiconductors was an extremely labor-intensive process. The capital investment required at this point was minimal, and the equipment used to package these early devices was manual, or perhaps semi-automatic at best.

The solutions to the market's emerging requirements - whether a new package, new materials or new equipment - are originating from Asia.



In the mid-1970s, semiconductor packaging began to migrate to Southeast Asia to take advantage of lower labor costs in the region. In addition to having lower requirements for capital equipment, the need for sophisticated facilities was not as great as it is today. Temperature and humidity control were not as complex as the controls in today's more advanced clean rooms. As a result, companies were not required to invest as much in facilities as they are today.

Volume Requirements Shift the Business Model

As the semiconductor volumes grew over the years, the need for higher output created a corresponding need for greater productivity and, as a result, more advanced and automated equipment. This shift, which happened in the late 1980s, changed the industry's focus from labor to capital equipment. The cost of equipment and facilities has grown rapidly as semiconductors for computing and communications applications have become increasingly complex. To keep pace with the latest silicon designs, a new generation of automatic test equipment (ATE) is required each year. The average cost of a piece of high-end ATE is \$2,500 to \$3000 per pin. Additionally, this equipment requires a clean and cool environment. Setting up and maintaining the facilities that house the ATE is also extremely expensive, ranging from \$30,000 to \$70,000 per year for each piece of equipment, depending on the specific configuration.

Since the late 1980s, the industry has continued to migrate toward greater automation. This not only increases productivity in terms of output per given area and output per operator compared to the manual approach, but it also results in higher quality and reduced cycle time. To optimize their cost structure and profitability, companies today must now focus on efficiently using their capital assets.

The Evolution of Packaging Requirements

At the same time that the transition to automation occurred, a shift also happened in basic packaging requirements. In the 1970s, most integrated circuits (ICs) were manufactured with a plastic dual in-line package or a ceramic-

hermetically sealed package as opposed to today's leaded and array packages. Then the industry began to transition from through-hole technology to surface mount technology (SMT), ushering in a new set of requirements for back-end equipment. Since that time, SMT has enabled the creation of small outline integrated circuit (SOIC) packages and advanced SMT packages, such as quad flat packs (QFPs). Simultaneously, higher-quality materials, such as die attach epoxies and molding compounds, became available, leading to improved stress factors and thermal characteristics.

As the industry continued to progress, companies also focused on simplifying their processes and removing all non-value-added operations from the assembly flow. So, the industry evolved into a process flow that built quality into the products throughout the manufacturing process.

Asia Remains the Hub of Packaging Innovation

Over the past 25 years, the expertise for manufacturing semiconductor packages has continued to expand and grow in Asia. Initially businesses migrated to the area because of reduced labor costs, but as equipment and technology have improved, the expertise has remained there. All of the major equipment suppliers now have support sites in Asia, and most of them manufacture their equipment in Asia. Likewise, the majority of raw material suppliers are based in Asia and manufacture their goods there. In a nutshell, because of the industry's historical framework and ongoing requirements, the whole infrastructure required for IC packaging is located in Asia, rather than in North America or Europe.

The Future of IC Assembly

To meet market requirements, many Asian companies have moved into more advanced array packaging. Most of these subcontractors are also broadening the services they offer to include such things as design and development capabilities. These companies will increasingly expand their focus to include design, wafer probe assembly, final test, final pack and drop ship to become total manufacturing solution providers after wafer fabrication. They are also beginning to take over the role of developing new materials for packaging. The solutions to the market's emerging requirements - whether a new package, new materials or new equipment - are originating from Asia.

Similarly, the role of test is changing and is now frequently performed at the semiconductor assembly location, which in most cases is offshore and increasingly in Southeast Asia. Until recently, most of these subcontractors did not focus primarily on test capabilities. But today, subcontractors are required to support customers' assembly and test requirements.

Traditional subcontract IC packaging companies will continue to increase the depth and breadth of services they offer customers. In the future, these companies may also be involved with significant foundry operations, where they are providing full turnkey solutions from the wafer fab to the finished product. **AP**

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