Advantages of Outsourced Test Services

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Introduction

The business model in today's competitive world of commerce has shifted over recent years to "services." Companies like Microsoft, Amazon and Google are prime success stories that have advanced the industry with business-enabling services. These economic productivity improvement services allow their customers to focus on product architecture, design and quick time to market. The service provider companies in turn have showcased sizable economic benefits and are largely profitable.

The analogy of such service providers in the integrated device manufacturer (IDM) world has benefited the industry for decades. Amkor Technology is an established company that has offered innovative assembly and test services to all IDMs, both established and start-ups, for more than fifty years.

Figure 1: Test is located at the back end of the manufacturing process.

To serve the diverse needs of world-class semiconductor manufacturers, Amkor offers more than 3000 different package formats and sizes. Packages range from traditional leadframe ICs for through-hole and surface mounting, to those required in high pin count and high-density applications such as stacked die, wafer level, MEMS, optical, flip chip, Through Silicon Via (TSV) and 3D packaging.[1] In addition, IC test services have been offered for all Amkor assembled products and other ICs for decades. As a result, billions of units are tested for customers each year.

Product Life

Typically, there are two product application categories. The first category is not in the critical path of ever-increasing bandwidths. These products have a longer life cycle and find themselves in multiple applications. Examples include converters (digital-to-analog and analog-to-digital), FETs, sensors and slower speed small serial memories. The second category includes technology drivers like microprocessors or CPUs, graphics processing units (GPUs), artificial intelligence (AI) processors, applications processors (APUs), memory controllers and modems. These products have a shorter application life and are subject to Moore's Law.[2] While product volumes are relatively high depending on the application (e.g., cell phone attach rate), these products typically see a re-architecture and re-design per a customer's business case and demand.

Test Steps

The typical and minimum manufacturing test flow is shown in Figure 2.

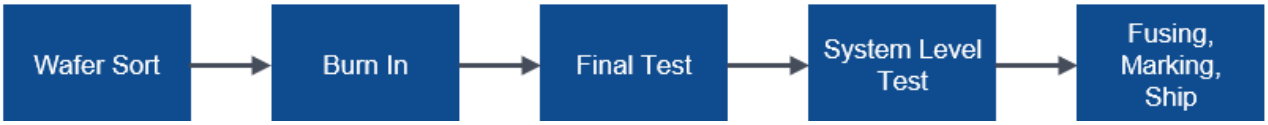

Figure 2: Overall (typical) manufacturing test flow.

Each of these test steps have a unique purpose and are an integral part of the manufacturing test process. In recent years, System Level Test (SLT) has gained increased popularity because of higher, block-level integration of functional blocks into a System in Package (SiP). As an innovative leader in advanced SiP, customized SLT technologies allow the product to be tested in its end-use application environment. While testing of fabricated ICs is primarily a business decision, lack of or inadequate testing can result in a loss of business due to degraded product being delivered to the end customer in the marketplace.

OSAT Advantages & Challenges

Amkor and the OSAT industry depend on automatic or automated test equipment (ATE) manufacturers for testers, probers, handlers and tooling. Manufacturers like Advantest, Teradyne, Cohu, National Instruments, Techwing, Chroma and many others provide the solutions. Unfortunately, test and measurement instrument developers lag the IDMs that develop the products. Design for Excellence (DFX) test methodologies for these products are also typically offered much later in the product maturity cycle. Amkor works closely with both customers and ATE suppliers to ensure production test capabilities are ready for new product introduction and volume manufacturing.

Many IDMs have realized the benefit of outsourcing manufacturing steps detailed in Figure 1. With time to market pressures, customers have demanded quick turnkey test flows without compromising test content coverage and quality. Amkor performs exceedingly well in this area offering complete turnkey assembly and test services at all manufacturing locations.

A reasonable fraction of Amkor's test activity addresses industry-leading IC business trends, including 5G, artificial intelligence and advanced automotive markets. Each market has its own unique product test requirements. For example, 5G typically refers to the wireless standard that promises to increase the data throughput beyond 4G limits. Higher bandwidths and lower latency for cellphone applications in the FR1 and FR2 carrier frequency bands of the spectrum have driven the need to develop new test instrumentation that scales above the traditional RF subsystem carrier frequencies. RF subsystem testers with carrier frequencies limited to 6 GHz and 160 MHz of bandwidth and increasing levels of power have served the test industry well for over two decades.

Artificial intelligence (AI) and machine learning (ML) applications are projected to dominate the introduction of newer instruction sets within processors requiring increasing processing power and inter-IC data communications at higher and higher digital data rates. These high-speed digital interfaces include but are not limited to display, memory, chipset I/O and Ethernet technologies. In the automotive market, product volumes and testing complexity have increased. In-cabin applications such as infotainment controllers and advanced driver-assistance systems (ADAS) are examples that have stringent mission-critical test requirements over wide operating temperature ranges.

5G Test

Amkor customers are developing 5G compliant products for two distinct applications, 5G base stations and 5G user equipment. The test requirements are different for each. With the implementation of 5G specifications for small cells, the relative 5G base station product volume is expected to increase by a couple of orders of magnitude. Both 5G base station and user equipment product test challenges include higher power ranges, higher download data rates, lower latency and an order of magnitude increase in the number of I/O channels for multiple-input, multiple-output (MIMO) and channel aggregation support. The U.S. Federal Communications Commission (FCC) approved the FR2 carrier frequency range between 24 GHz and 52 GHz that attenuates far more rapidly in air than the sub 6 GHz frequency range. These high-level test requirements are all relatively new to the RF test industry.

ATE suppliers have continued to meet Amkor's existing and projected technical expectations for developing competitive test solutions for its customers. An example is IC packaging that integrates antenna structures. Testing Antenna in Package or Antenna on Package (AiP/AoP) products[3] requires Amkor to work with handler manufactures to implement electromechanical solutions that will enable the required number of transmit and receive (Tx and Rx) channels to source or capture RF energy over-the-air (OTA) and convert it to conductive energy to allow the tester to effectively test the part to its required specification accuracies.

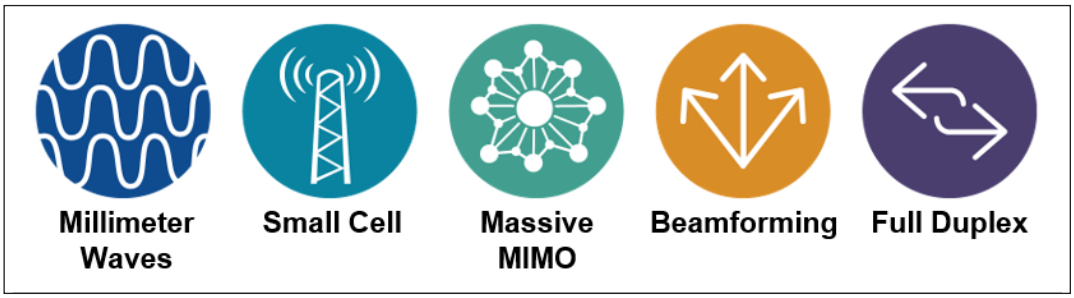

Figure 3: 5G test applications. (Source: IEEE).

AI Test

AI and ML processors are no different than other high-performance processors and their associated test requirements. However, the data rate and logic levels are increasingly challenging. The most popular test interfaces on these processors include PCIe, Ethernet (IEEE 802.3), display and memory. Other high-speed interfaces include MIPI DigRF variants, JESD204B/C, USB 3.x, Thunderbolt and proprietary implementations. Today, most of these interfaces are targeted to address effective data rates up to 32 Gbps. More recently, an ATE with pin electronics card (PEC) instrumentation has a data rate up to 2.5 Gbps, well within that capability. Typical DFx and test methodologies tackle production testing with a Tx to Rx loopback to test the physical layer (PHY) and scan to test the I/O logic for manufacturing defects.

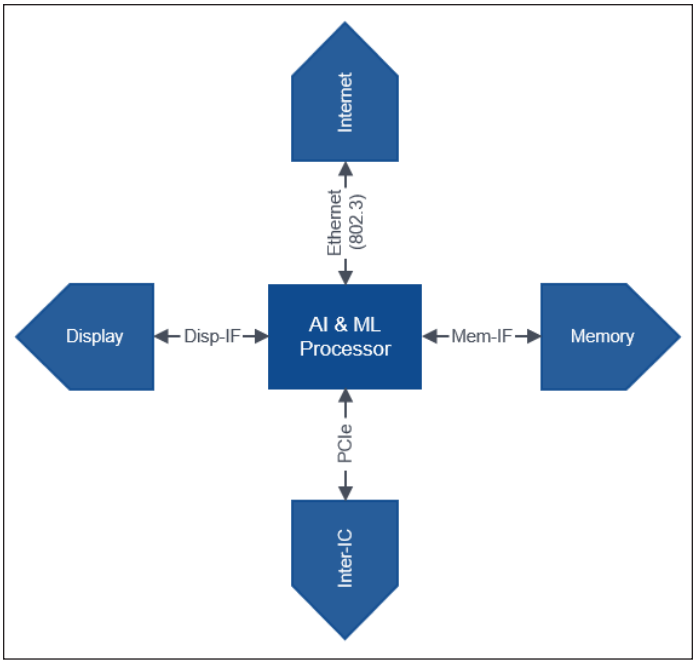

Figure 4: Typical (AI) processors and their digital high-speed test interfaces.

Automotive Test

Automotive electronic products have a significant amount of digital content for logic control and infotainment, analog and sensor products for system status reporting and 5G RF content for advanced driver-assistance systems (ADAS) including autonomous driving. Product test requirements are evolving and challenging due to a wide operating temperature range, high bandwidth and low latency RF carrier frequencies in the 77 GHz to 81 GHz frequency range.

Summary

As a leading OSAT supplier, Amkor's test capabilities and capacities offer advantages to customers for outsourcing test development and test production services for a wide variety of products. These services address test challenges, especially for 5G, AI and automotive ADAS products. As a result, test services continue to grow as a turnkey service strengthening supply chain management for customers.

References

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2. Moore's Law – https://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html

3. Antenna in Package/Antenna on Package – https://amkor.com/aip-aop

For more information on Amkor's Test Services, visit: https://amkor.com/services/test-services/

Key words: Semiconductor, Test, Probe, Burn-in, System Level Test, Test Development, OSAT, 5G, AI, Automotive, Amkor