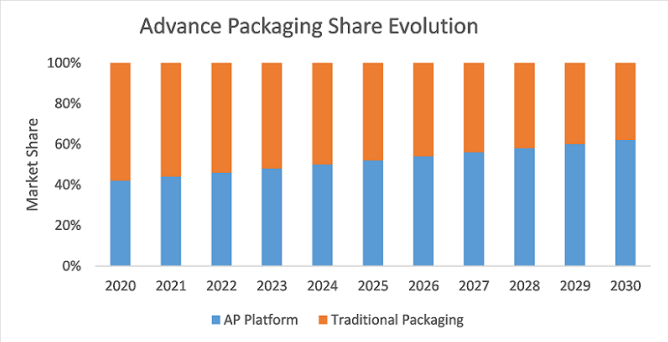
TERECIRCUITS

COMPANY PROFILE

Advanced Packaging and Assembly of Semiconductors is at a Crossroads: Sophisticated packaging approaches such as 3D stacking, Heterogeneous Integration, and Die-on-Wafer absorb more and more of the value chain in manufacturing, demanding new levels of precision. Next-generation semiconductor materials are so fragile they require new handling approaches to prevent damage. Meanwhile, the tools and materials of precision assembly have remained static for decades. The result is slowing production cycles and poor yields, at a time when demand is accelerating. Terecircuits meets these challenges with a groundbreaking core technology and process innovation that enable products requiring micron-scale circuit fabrication and assembly to be built at scale, faster and more reliably.

What is Advanced Packaging?

The goal of Advanced Packaging Technology is to assemble and protect the worlds' most complex semiconductors, which may be made up of many different interconnected components that are individually small, thin, and fragile. The resulting "package" must meet strict performance and reliability criteria, including physical, mechanical, electrical, and thermal requirements. According to research from Insight Partners, the worldwide advanced packaging industry was estimated to be worth $30 billion USD in 2020 and expected to grow to more than 60% of the semiconductor packaging market by 2030.



Traditionally accounting for less than 10% of the value chain, the complexity of assembling modern semiconductors is expected to drive up the value of back-end processes like advanced packaging to 20% or more of the final parts' value.

Why is Advanced Packaging Important?

Advanced packaging can raise the value of a product, adding functionality and increasing performance while lowering cost and improving time to market.

Advanced packaging enables the benefits derived from Moore's Law to continue.

When you can no longer pack more transistors into the same area, one approach to increase density is by going vertical. This chip stacking technology, known as 3D integration, is enabled by advanced packaging.

Advanced packaging enables innovation and new products.

Not every function in a product requires the latest and greatest performance. Increasingly, the technology needed for new products don't come from a single chip. Advanced packaging supports the use of different technologies for different functions by integrating a wide range of components in multi-chip packages for high-end supercomputing, mobile consumer electronics, artificial intelligence, and IoT devices.

Advanced packaging is a requirement for new semiconductors materials

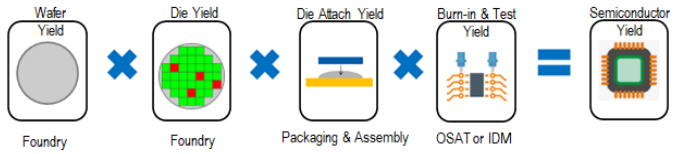
Silicon carbide (SiC) based power devices, for example, are driving a radical transformation of power electronics in electric vehicles, charging stations, and alternative energy. Because these materials need to operate in harsh environments, are extremely brittle, and far more sensitive to both mechanical and thermal shock, advanced packaging is required before they can be utilized in products.

What Are The Problems?

Although in many ways advanced packaging is not new, the adoption has been limited to niche applications due to high costs and low yields.

It's all about Yield

Production yield is regarded as the single-most important factor in controlling semiconductor processing costs. Semiconductor yields are the product of wafer yield, die yield, packaging & assembly yield, and final test yield.



Losing yield at packaging, after 85% of the manufacturing costs have already been incurred, affects output per unit of input resources, waste, financial sustainability, time to market, and costs. Advanced packaging puts new stresses on tools and processes designed for low complexity.

Component handling, a critical element of advanced packaging, has remained static for 30 years. Die stacking requires nanometer-scale edge alignment. Some components, such as MicroLEDs, can be smaller than a red blood cell and impossible to handle with conventional tools.

The integration of several chips can result in a wide range of interactions requiring an unprecedented level of assembly precision. Current

packaging and assembly process flows introduce variation at every step, from dicing, to tape and reel transport, to the mechanical limitations of pick & place machines. Uncontrolled variation is the enemy of yield and quality. It's what experts W. Edwards Deming, Joseph M. Juran, and others spent their professional lives stressing to industrial leaders.

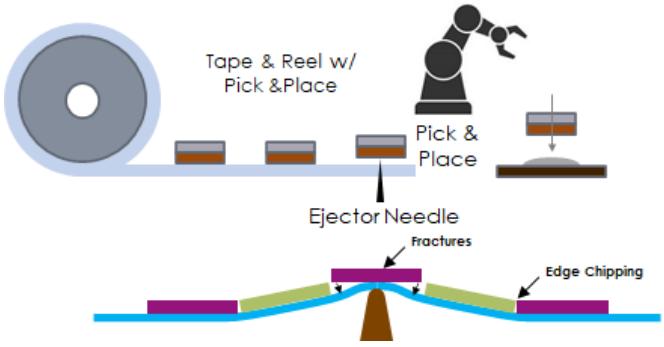
Packaging tools are too slow

Traditional Packaging & Assembly has been slow to innovate and automate. Once semiconductor wafers leave the highly sophisticated wafer fab, they are shipped to outsourced packaging, test, and assembly houses, which operate on high labor costs and low margins.

Until recently this model was good enough. Now, to meet the new demands of advanced packaging, assembly tools that trade off precision for speed are forced to slow down, creating worsening bottlenecks that limit production efficiency.

Packaging tools directly contribute to yield loss

Since the introduction of advanced packaging, assembly skills and methodologies have improved, but silicon damage during assembly remains an issue. After cutting a wafer into individual chips (dicing), the sides and tops of the chips remain exposed, subjecting them to chipping, cracking, and other handling damage during the assembly process.



Packaging tools themselves contribute to the problem, often using sharp needles to remove components from carrier tapes. This problem worsens when the materials are fragile, such as silicon carbide, or thinned (a requirement for flex circuits or 3D stacking.)

How Does Terecircuits Help?

Incremental improvements in advanced packaging will not deliver faster and more agile operations, higher production yields, and lower costs, The higher level of difficulty requires more specialized and precise tools and processes - the packaging and assembly equipment of the future needs a makeover.

Material Innovation

Terecircuits delivers advanced packaging productivity breakthroughs by replacing the mechanical processes used in circuit assembly and semiconductor packaging with a highly controllable Chemical Process that can easily handle millions of small, thin, and fragile devices.

Process Innovation

By employing hard carriers and wafer handlers like the front-end processes in the fab, we eliminate manual process steps, minimize sources of error, and reduce variability. We replace single-use non-recyclable carrier tape with a "smart" material that releases highly controllable propulsive energy in response to light, enabling die sort, transport, and component transfer; all from a single medium, gently, without the use of needles, grippers, or vacuum heads. Taken together, these innovations deliver higher yields at lower cost, without sacrificing throughput.

Paradigm-changing Throughput

Unlike mechanical transfer techniques that move individual components, the Terecircuits process is capable of 10-10,000x the throughput by supporting Mass Transfer, or the ability to move and accurately place tens of thousands of devices in a single operation. This eliminates bottlenecks and enables products that cannot be built conventionally, such as MicroLED displays. Mass Transfer also enables Parallel Assembly – a process that allows thousands of tiny IoT or Chiplet-based devices to be built at once.

319 North Bernardo Avenue
Mountain View, CA 94043-5225

www.terecircuits.com