PCBAA
Printed Circuit Board Association of America

PCB 101

Status of American Printed Circuit Board Manufacturing

A key segment of the U.S. industrial base manufactures and assembles Printed Circuit Boards (PCBs). **Increasing global competition** affected domestic PCB manufacturers and assemblers' ability to do business as they competed with countries offering their manufacturers subsidies and benefiting from low wages. **American commercial businesses contracted dramatically** over the past several decades. This **weakened America's industrial base and threatens our national security**.

Where We are Headed Without Government Support

Absent significant government and private investment, continued erosion in the American PCB sector is likely and the ability to meet increasing DoD and commercial sector demands is jeopardized. Without increased investment and increased capacity, OEM military companies may adopt the use of foreign suppliers resulting in increased risk for counterfeit, nefarious, and poor-quality products for the defense industry. This is in addition to our **nation's current reliance on overseas providers for critical electronic components which leaves the U.S. vulnerable to supply chain challenges, disruption, and risk**: in the event of another global pandemic, or broken relations and/or war, the U.S. would be at catastrophic risk for responding to urgent demands for electronic systems.

American Companies are Struggling to Survive

To further quantify the degree of erosion in the bare PCB manufacturing sector, **as recently as the late 1990's there were more than 2,000 PCB fabricators in the U.S., and the U.S. PCB fabricator share of the global market for PCBs was approaching 30 percent**. According to current IPC market studies the number of PCB fabricators remaining **in the U.S. today is approximately one-hundred forty-five (145) and the U.S. global market share for PCBs has plummeted to 4 percent.**

Department of Defense Requirements are Daunting

Of the remaining domestic manufacturers, **only a handful have obtained the certifications necessary**, including:

- NIST 800-171 protocols and being prepared for the upcoming Cyber Model Maturity Certification (CMMC) 2.0 initiatives to protect Controlled Unclassified Information (CUI)
- Making the capital equipment expenditures necessary to support the demanding standards required for DoD PCBs.

Supporting DoD related business is a very capital-intensive business and continued reinvestment in technology is required for PCBs in leading edge platforms and systems. Scale is very important in advanced PCB manufacturing, particularly as it relates to achieving lower costs and increased technology capability to support microelectronics functionality and protect our nation.

Technology Advances Demand Significant Investment

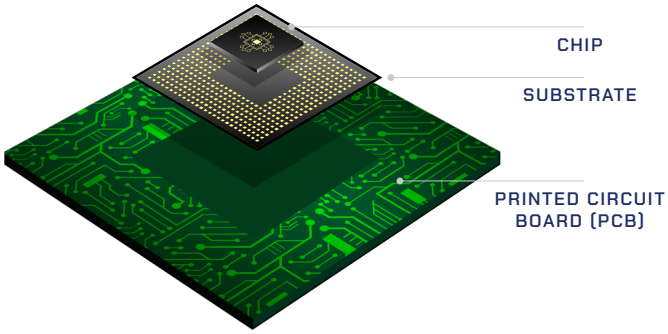
PCB manufacturers are experiencing significant capacity erosion directly attributable to the increasingly complex high-density interconnect (HDI) PCB design attributes required for the circuit board designer to extract maximal advanced microelectronic functionality. **The PCB is an integral part of the microelectronics technology stack (PCB + substrate + chip)**, and current PCB designs require multiple sub-lamination steps at the PCB manufacturing level to accomplish the complex via constructions required to fanout the advanced microelectronics device functionality. This complexity results in a PCB manufacturing requirement to essentially build 2, 3, 4, 5 or more individual PCBs through the PCB manufacturing process to be later bonded together into a single deliverable PCB with the final package interconnect drilled and plated through the build-up stack. This "PCB within a PCB" shift has resulted in organic capacity erosion for the same equipment sets in PCB manufacturing plants and is driven by PCB HDI density and functionality. The inverse relationship (increased CAPEX investment vs. decreasing final-product output) driven by HDI PCB design attributes is not sustainable or practical without government investment.

Without PCBs, Microelectronics (Chips) Simply Cannot Function

PCBs are the central nervous system of microelectronics. They are also the mechanical mounting platform for all electronic components and are the soldered interconnect mechanism for all electronic devices. Any **definition of microelectronics is incomplete without considering the entire technology stack** and including the PCB and the associated material substrate.

The PCB is the only component that is 100% build-to-print in every individual electronic system, whereas most microelectronics (chips) are multi-use and designed and built in mass production quantities and are purchased off-the-shelf by OEMs to assemble atop thousands of uniquely designed PCB types.

PCBs are Analogous to the Human Nervous System



"Technology Stack"

How PCBs are Made

PCBs are manufactured through a series of imaging and etching of circuit patterns onto dielectric substrates. To add more circuitry, more etched layers are pressed/laminated together, drilled or lasered to create holes ("vias"), then plated to electrically connect the layers through the holes. The final laminated board is laser imaged with the designed circuit pattern, then treated with various metallic surface finishes to provide the appropriate bonding platform for the microelectronic devices during assembly processes. Traditionally, this process was performed in a linear fashion, as depicted below.

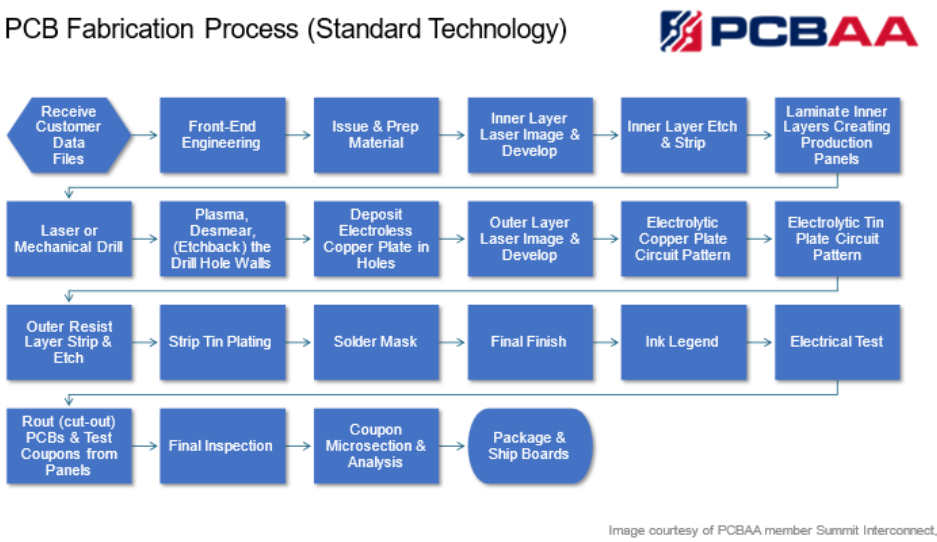
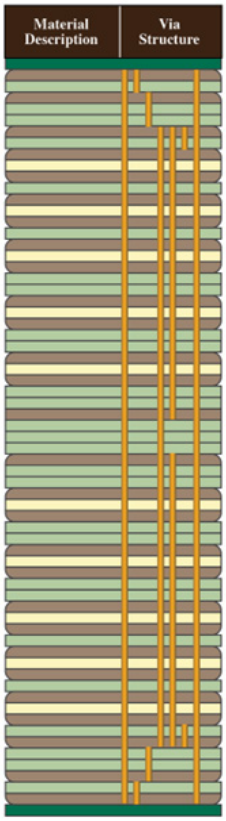


Image courtesy of PCBAA member Summit Interconnect, Inc.

With the increase in HDI circuit density driven by advanced microelectronics technology and the need to maintain robust design, many circuit designers have added multiple lamination-drilled/lasered via hole creation–plating cycles to their designs which effectively **requires making circuit boards within circuit boards**.

Multiple Lamination-Drilled/Lasered Hole (below)



To create one HDI PCB with 24 layers of circuitry (example), the PCB manufacturing reality is that two, three, four, five or more sequential laminations are required to manufacture it. The one completed PCB is built by manufacturing multiple sub-boards before final lamination. This requires more lamination press cycle capacity, smaller drill sizes performed by million-dollar laser machines, drill hit counts which are extraordinarily high, and laser-directed fine line resolution which is required to form the circuitry traces. Traditionally, in our industry's manufacturing processes, these steps were linear and were not required to be repeated multiple times. The domestic PCB supply chain was not set up to handle the capacity requirements of the organic erosion presented by the sequential lamination process requirement. There are very few U.S. manufacturers that can support the robustness, quality, and intricacies of next generation HDI and uHDI PCBs

<u>Pricing is Complex</u>

The offshore movement forced PCB pricing into a commoditized pricing structure. Formerly, PCB pricing was more realistically structured to support continued engineering, manufacturing growth, new technologies, and other innovations which led the U.S. to be a leader in microelectronics.

The change to a commoditized pricing structure forced the PCB industry offshore (outsourced to Asia) and removed process instead of being an integral function of the OEM. As a commodity, domestic PCB manufacturers were forced to cut costs and lower prices to the OEM. **As the prices were reduced, the profit margins available for investing in advancements and increasing capacity largely slowed for domestic U.S. fabricators.** This the primary contributing factor in the decimation of the U.S. PCB industry.

Intellectual Capital Was Also Offshored

Offshoring also resulted in a loss of control of the development of engineering processes and functions, and a l**oss of our intellectual capital (engineering and technician personnel)** for numerous generations of technology. This finally **resulted in engineering advancements being performed primarily in China** and drove that country's emergence as the global leader in PCB fabrication. The increase in complexity of PCBs and uniqueness of their requirements demands that these PCBs not be viewed as a commodity and instead considered as an engineered component.

Every PCB is Custom

PCB suppliers do not generate the designs they manufacture; all PCBs are custom, application specific, designed by the OEM end-user and are built-to- print by the PCB fabricator. Other components can be manufactured and placed on the shelf for use in multiple applications and appliances (such as chips). PCBs are unique to the end use application, have a shelf-life, and are fundamental to the technology stack. PCBs are the components that translate the microprocessor to a functioning end-product. PCB designs originate from the OEM in every instance with the unique technical and architecture requirements for every specific application; any change to those requirements or to the components of the system would require a change to design of the PCB.

There are no standard PCBs; they are customized for every product and product modification. PCB manufacturers must be able to respond to the ever-changing designs and performance criteria within a reasonable response period for both defense and commercial applications. More capacity is required for just current production demands. This requires more investment to re-balance our nation's capacity to align with current/future technology trends.

We Face a National Challenge

As a nation, we need to be able to respond to both legacy capabilities and future technologies, particularly for HDI and uHDI. This requires a depth in PCB manufacturing scale and capacity for the extremes in technology from legacy to advanced microelectronics that currently does not exist in the U.S. PCB industry. More investment and globally competitive government incentives are needed to rebuild the American PCB industry to protect our national interests and security.