Bureau of Industry and Security
U.S. Department of Commerce
Request for Public Comments
"Risks in the Semiconductor Supply Chain"
Docket #: 210915–0189
Deadline: November 8, 2021
Submitted by: IPC and USPAE

Introduction

On behalf of our more than 1,500 U.S. member companies in the electronics manufacturing industry, IPC and the U.S. Partnership for Assured Electronics (USPAE) support the ongoing efforts of the U.S. Government to evaluate and strengthen America's semiconductor supply chain pursuant to Executive Order (EO) 14017, *America's Supply Chains*.

We welcome the opportunity to submit comments to the Department of Commerce in response to its September 24, 2021, request for information on data gaps and bottlenecks that lead to inconsistent or flawed demand signals. As trade associations, we cannot provide you the company-specific data you request, but we do want to communicate the findings of a new IPC study on the semiconductor supply chain. This study underscores the importance of robust federal investments in advanced packaging, which is an essential part of that supply chain. The data-rich report includes the following findings:

- After more than two decades of outsourcing, North America now finds itself in a worrisome predicament: it can design the most cutting-edge electronics but cannot manufacture them.
- This problem spans the entire electronics ecosystem, but it has been driven in recent years by the U.S. semiconductor industry's embrace of the "fabless" business model. As chip manufacturing has moved increasingly to third-party foundries offshore, so too have the supply chains that support and leverage silicon fabrication.
- The offshoring of the supply chain extends to advanced packaging of semiconductor chips for which the North American share of global production is just 3 percent. Advanced packaging principally comprises two industry segments: Integrated Circuit (IC) substrates and outsourced semiconductor assembly and test (OSAT). There are no U.S. manufacturers of advanced IC substates and only modest capacity within U.S. OSAT facilities.
- To achieve greater innovation, resiliency, and security within the semiconductor supply chain, federal investments in silicon must be paired with robust federal investments in advanced packaging.
- Failing to strengthen U.S. advanced packaging capabilities while boosting production of chips will *lengthen* the semiconductor supply chain, as manufacturers will be forced to send their chips abroad for packaging and assembly.

- Investments in U.S. advanced packaging capabilities will strengthen the entire U.S. electronics manufacturing industry, including those companies engaged in printed circuit board fabrication and assembly. These industry segments, though neglected by policymakers, are critical to a healthy, resilient U.S. electronics manufacturing ecosystem.

The full report on advanced packaging, which is due for release later this week, contains additional data, graphics, and mapping to illuminate these points. IPC will share the report with the Department of Commerce.

IPC/USPAE Overview

IPC is a global industry association based in Bannockburn, Illinois. We help manufacturers of all sizes build electronics better through technical standards, workforce programs, research, and advocacy. USPAE is an industry association working to ensure that the U.S. Government has access to resilient and trusted electronics supply chains. Together, our members support more than 5 million U.S. jobs and drive more than $700 billion in U.S. GDP. They span all segments of electronics manufacturing, including designers, printed circuit board (PCB) manufacturers, contract and assembly companies, suppliers, and original equipment manufacturers (OEMs) in aerospace, defense, medical, automotive, and other industrial sectors reliant on electronics.

Advanced Packaging Overview

Semiconductor chips are fragile and must be protected from thermal and mechanical stresses during operation. To provide this protection, chips are "packaged" using several different materials, mainly plastics. Once packaged, chips become active logic devices that perform computing and/or memory functions. Chips are just one of many different types of essential components within an electronic system.

Protecting chips remains critically important, but advancements in packaging are now being driven by the need to leverage "on package integration" as an alternative technological path to the promise of Moore's Law. Moore's Law held that the number of transistors that could fit onto an integrated circuit could be doubled every two years. This assertion held true for more than half a century, but silicon advancements have slowed, along with economic efficiencies. Instead, semiconductor designers are leveraging electronic interconnects within the chip package to achieve the greater functionality and economic efficiencies they previously realized through silicon scaling.

On-package integration is commonly referred to as heterogeneous integration which is simply putting multiple chiplets (logic or memory) in a single package. A chiplet is a functional circuit block fabricated on a wafer, typically in a smaller size than what would be possible in a system on chip. The chiplet can be attached to a laminate substrate in a 2D configuration or stacked one on top of the other in a 3D configuration within a package to produce greater functionality and greater processing speed.

Advanced Packaging Ecosystem

The advanced packaging sector has two principal segments.

- **Integrated Circuit Substrates:** IC substrate manufacturers produce the base layers used in the packaging of integrated circuit chips. The substrate connects the chips with each other and with the printed circuit board (PCB), in addition to protecting, reinforcing, and supporting the IC chip.
- **Outsourced semiconductor assembly and test (OSAT):** OSAT companies offer IC-packaging and test services for chip manufacturers. Their role comes into play at the end of the semiconductor

manufacturing process after the wafer fabrication. OSATs offer package/assembling solutions that convert bare semiconductors into finished semiconductors and that protecting the die. After packaging, they conduct final testing to ensure that the packaged semiconductors meet performance specifications.

Global Semiconductor Industrial Assessment

Companies headquartered in Asia are the global leaders across nearly the entire semiconductor supply chain, with the top companies dominating market share in semiconductor fabrication (TSMC, Samsung); advanced IC-substrate fabrication (Unimicron, Ibiden, SEMCO, Nan Ya, Shinko); and OSAT assembly and test, in which Taiwan is the leader with nine companies including ASE+SPIL and Powertech Technology). North America lags Asia in production capacity, but technical capability is a concern as well. Asian manufacturers also dominate the printed circuit board (PCB) and electronic manufacturing services (EMS/ODM) sectors, where outsourcing and off-shoring have been prevalent over the past 20 years. Asia's dominance in electronics arises from the region's breadth of manufacturing capabilities from chips through advanced packaging through PCB fabrication and final system assembly and test.

North American Semiconductor Industrial Assessment

Semiconductor

Chip plants run 24 hours a day, seven days a week. They do that for one reason: cost. Building an entry-level factory that produces 50,000 silicon wafers per month costs about $15 billion. Most of this is spent on specialized equipment, a market that exceeded $60 billion in sales in 2020. Three companies—Intel, Samsung and TSMC—account for most of this output. Their factories are more advanced and cost over $20 billion each. This year, TSMC is expected to spend as much as $28 billion on new plants and equipment.

Even more daunting, these facilities can become obsolete in only five years or less. Chipmakers must generate significant profit to reinvest in their facilities to stay current with ever advancing technology demands. Only the biggest companies can afford to build multiple plants, which is important for companies engaged in high-volume manufacturing. The more a company manufactures, the better they get at it. Yield—the percentage of chips that are accepted and not discarded—is the key measure, and anything less than 90% is considered a problem. But chipmakers can only exceed that level by learning expensive lessons over and over and building on that knowledge. These brutal economics mean very few companies can afford to keep up and/or break in.

Overall, the level of recent or expected investment in U.S. semiconductor fabrication is strong although a significant percentage of that expected investment is premised on federal support. We strongly support the bipartisan effort to appropriate more than $50 billion for CHIPS for America Act. Failure to do so will signal a lack of U.S. commitment to U.S. semiconductor manufacturing and innovation.

IC Substrates

The lack of IC substrate manufacturing in North America is the greatest concern identified in IPC's forthcoming study on advanced packaging. There is currently no capability in the United States to produce advanced IC substrates, called Flip Chip Ball Grid Array (FCBGA) or Flip Chip Chip Scale Package (FCCSP). The U.S. also has very limited capability and capacity to produce lower-end wire bonded substrates. Building, upgrading or expanding domestic semiconductor fabs/foundries without having domestic suppliers of IC-substrates and OSAT assembly will lengthen the supply chain, not shorten it.

The U.S. needs to invest in IC substrates most urgently. There are significant barriers to entry for FCBGA manufacturing, including an estimated $1 billion investment and a need to address a more than 20-year know-how gap, weak sub-tier supply, skilled workforce shortage (1,000 workers / facility), and lack of raw materials. We are aware of leading IC substrate manufacturers that are surveying opportunities in North America and domestic PCB suppliers that are attempting to enter the market to produce substrates, likely with newer technologies and at lower cost-points. We call on the U.S. Government to support the expansion of domestic capabilities and capacity in this sector, the total cost for which constitutes a fraction of the overall financial commitment necessary to bolster silicon fabrication.

OSAT

Amkor is the only U.S.-based OSAT provider in the top 20 globally; it is second overall. While Amkor is headquartered in the United States, it does not have assembly plants in North America. The U.S. also has more than 25 small and medium-sized OSAT companies, many with high capability. The main issue is limited capacity. North American facilities offer small to medium volume production, often for specific markets like the defense sector. Nearly all OSAT providers are currently running at full capacity, raising questions about their ability to meet increased demand for high performance computing and other leading-edge technologies.

We believe at least one of the top 10 OSATs could be persuaded to locate operations in North America with a favorable mix of government and private support. Some EMS companies also are attempting to develop OSAT services in addition to their traditional offerings. Thus, while there are clear opportunities to be seized here, significant capital investment and government support will be needed to expand U.S. OSAT production capacity.

Key Recommendations

In the Full Report, IPC offers a complete list of 28 recommendations to rebuild the U.S. advanced packaging ecosystem. Included here are the most pressing:

1. **The Lack of Domestic IC Substrate Capabilities Is Challenge #1.** The expansion of advanced silicon production in North America by 2024 will require complementary expansion in regional substrate and assembly production, or else the effort to reduce supply chain risks will be for naught. The core challenge is the lack of infrastructure to support substrate manufacturing and the lack of skilled labor at competitive cost. The U.S. Government needs to help establish a domestic commercial IC-substrate capability and capacity. Failure to do so will lengthen, not shorten, the semiconductor and electronics supply chain. The cost of standing up a high-volume IC substrate manufacturing facility with cutting edge capabilities is likely to cost $1 billion or more. New technologies, however, potentially offer low-volume, high-mix manufacturers new capabilities at lower price points.

2. **Support Domestic OSAT Champions:** The U.S. Government should identify EMS/ODM companies and existing North American OSAT companies that could potentially fulfill assembly requirements and increase capacity for North American advanced packaging needs. However, significant investment in infrastructure will be needed including Class 10K (or better) cleanrooms and advanced manufacturing technologies for which there are often lead times of up to two years. We encourage the U.S. Government to support this sector through new and existing programs, like the DoD Manufacturing Technology (ManTech) Program.

3. **Critical Sectors:** The U.S. Government should focus a significant portion of its own investments and those it stimulates on the **Aerospace, Defense, and High-Performance Computing (HPC)**

markets. The volumes and demands represented by these markets (worth a combined $90+ billion) will help justify the investments needed to increase North American capability and capacity. These markets are also the most critical to U.S. national and economic security.

4. **National Manufacturing Institute:** The U.S. Government should invest in a manufacturing institute for electronic interconnection that serves to support innovation in advanced packaging, as well as printed circuit board fabrication and electronic assembly. The institute should emphasize the importance of "factory of the future" manufacturing.

5. **Allies and Friends:** The United States can complement the development of domestic supply chains with the development of strong, trusted global partners. It would be unrealistic and impractical to onshore the entire electronics manufacturing supply chain or locate it within a single region. Efforts like those underway in the US-EU Trade and Technology Council are critical to the emergence of secure, resilient, and dynamic supply chains for critical sectors.

Toward a Silicon to Systems Approach

Semiconductor chips—as marvelous as they may be—do not float in the air. They are useless on their own. So, too, are the advanced IC-substrates that the chips are bonded to. While they too are important and critical pieces of an electronic system, they are intermediate steps in a much larger process of designing and manufacturing final products and systems such as mobile phones, online games, HPC mainframe computers, and aircraft navigation. It is not until the final package is assembled -- when semiconductor chips are bonded to substrates, encapsulated, and tested – when an advanced package becomes functional, valuable, and available to be integrated into electronic systems and products.

Advancements in semiconductor packaging also have direct impacts on PCB technology and fabrication. The more sophisticated IC packages become, the more complex PCB designs must become. Final system-level assembly by EMS/ODM providers is where the final product comes to life; it's where electronics are assembled, powered-on, burned-in, firmware/software loaded, and final system tests are performed. Both PCB and EMS/ODM providers play a critical role in final system delivery and availability.

A healthy, capable assembly ecosystem is needed to bring a wide variety of technologies together to manufacture finished products. Any disruptions or bottlenecks within this end-to-end ecosystem can lead to delays in new products and innovations. Therefore, it takes all elements within the supply chain–from silicon to systems–to successfully produce electronic hardware products and to meet customer and market demands.

Next Steps

We appreciate the opportunity to provide feedback on risks to the semiconductor supply chain and look forward to partnering with the Department of Commerce as it continues its supply chain review and implements new policies.

To help further your work, IPC offers to host meetings and/or workshops that bring together industry, academia, and government to identify solutions that will improve America's critical supply chain challenges. Thank you for your consideration of these comments.