Comments of the
Semiconductor Industry Association (SIA)
On the
Department of Commerce
"Notice of Request for Public Comments on
Risks in the Semiconductor Supply Chain"

86 Fed. Reg. 53031 (Sept. 24, 2021)
[Docket No. 210915–0189] RIN 0694–XC084

Submitted November 8, 2021

The Semiconductor Industry Association (SIA), represents global leaders in semiconductor manufacturing, design, and research, accounting for 98% of U.S. firms by revenue and nearly two-thirds of non-U.S. semiconductor firms. We appreciate the opportunity to provide input on the Department's efforts to formulate solutions to the supply chain challenges that face our nation.

Supply chain disruptions in the Covid-19 era have created a perfect storm of unprecedented challenges with rippling effects on the global economy. In 2020, the world experienced a once-in-a century pandemic that throttled supply and created unanticipated swings in demand. Some downstream sectors reduced production and chip purchases while others saw soaring demand for semiconductors to maintain critical functions during lockdowns around the world. Underlying this dynamic, massive dislocations in global logistics and transportation networks coupled with shortages of raw materials, key components, and intermediary products exposed extensive vulnerabilities in highly interdependent and globalized value chains already weakened by geopolitical friction and lean production strategies pre-dating Covid-19. Among the supply chain disruptions occurring worldwide, the global semiconductor shortage has played a particularly consequential role.

In response, the semiconductor industry has pushed production capacity to its limits to increase output to historically unprecedented levels in 2021. Throughout the pandemic, the industry has powered the nation's critical infrastructure, defense industrial base, manufacturing industries, healthcare sector, workforce, and digital solutions amid a growing number of new and old challenges. At the same time, supply chain challenges and dramatic market volatility have placed tremendous strain on the industry's capacity to meet expanding global needs during accelerating digitalization of the post-COVID19 era. The industry today operates in a difficult environment with competing and growing demand from multiple critical sectors of the economy. While chipmakers are working around the clock to ramp up production by every possible means in the short-term - and producing semiconductors well-above pre-pandemic levels - supply chain challenges do persist.

Understanding these challenges requires a holistic approach with consideration for each step of this highly complex and globalized supply chain. Depending on the type of end user, semiconductor devices travel through an intricate chain of distributors, component suppliers, assembly suppliers, distributors, and other steps. Circumscribing our attention and problem-solving efforts to just the fabrication step of the supply chain misses the deeper underlying challenge of an economy-wide shortage.

The global chip shortage simply cannot be resolved with top-down government-directed efforts to allocate limited supply in the immediate-term. Misallocation is not at the heart of the issue. Rather, it lies in precipitous and fundamental changes to market demand in the wake of an extraordinary event in the history of our industry, nation, and global economy. Demand for chips is increasing across the board and capacity will have to expand everywhere, including in the U.S. to meet the needs of the present and the future. The chip shortage requires a long-term, comprehensive solution aimed at strengthening the entire global semiconductor ecosystem and securing continued U.S. leadership in technological innovation and capacity in close partnership and coordination with our allies.

As an industry association, we are unable to provide answers to many of the specific questions in the Request for Information that pertain to company-specific information; however, as part of our ongoing partnership with and role as a resource to the Department, our submission provides industry-wide information on the semiconductor market and supply chain and draws attention to the need for this holistic approach to strengthen the U.S. semiconductor industry and make our nation's supply chains more resilient.

I. Preliminary Comments on the RFI

Before providing information responsive to Commerce's questions, we would like to briefly provide some comments on the purpose and scope of this RFI. The semiconductor industry seeks to work in close partnership with the U.S. Government to help the country and world navigate the global chip shortage. However, the extent of government intrusion into sensitive business matters or market decisions could result in adverse consequences for the industry and the entire economy.

First, Commerce is seeking confidential information such as customer identities that semiconductor companies are often contractually obligated to safeguard. Other questions seek business sensitive information (e.g., production levels) that are proprietary in nature. The disclosure of this information could be extremely damaging to the companies responding to the RFI.

In addition, it is difficult to discern the specific goals of the Department of Commerce in this exercise. While we appreciate Commerce's interest in addressing the supply chain disruptions facing the global economy, including the semiconductor industry, we do not see how the information collected under the RFI will materially advance Commerce's understanding of the enormously complex global semiconductor supply chain or advance solutions to addressing the current supply-demand imbalance. Companies throughout the supply chain are working diligently to address the disruptions facing their businesses, and these efforts by the private sector are best suited to address the near-term imbalance in supply and demand. Increased data sharing and transparency are valuable principles, but it remains unclear how Commerce intends to use the information collected under this RFI. We would be extremely concerned over potential governmental actions to allocate supply or otherwise intervene in the operation of the market.

In this submission, we wish to provide fuller context on the environment in which we have been operating and how the semiconductor industry has responded to the extraordinary demands on the industry over the past year.

II. SIA Responses to Questions "For semiconductor product design, front and back-end manufacturers and microelectronics assemblers, and their suppliers and distributors"

a. Identify your company's role in the semiconductor product supply chain.

The semiconductor supply chain is a complex, globally integrated mix of companies and regions needed to deliver increasingly innovative devices at lower costs. SIA prepared a report earlier this year detailing the semiconductor supply chain: "Strengthening the Global Supply Chain in an Uncertain Era."[1] This report highlights some of the key strengths of the U.S. in the global supply chain as well as some of the vulnerabilities.

The U.S. leads in the most R&D-intensive activities – electronic design automation (EDA), core intellectual property (IP), chip design, and advanced manufacturing equipment – owing to its world-class universities, vast pool of engineering talent and market-driven innovation ecosystem. Allied economies in East Asia are at the forefront in wafer fabrication, the result of massive capital investments over decades, ongoing government incentives, and access to robust infrastructure and skilled workforce. China is a leader in assembly, packaging and testing, which is a relatively less skill- and capital-intensive activity, and it is investing aggressively to expand throughout the value chain. All countries are interdependent in the integrated global semiconductor supply chain, relying on free trade to move materials, equipment, IP, and products around the world to the optimal location for each activity. This global supply chain structure based on geographic specialization has delivered enormous value for the industry and increased innovation and reduced costs for customers, but it also creates vulnerabilities that each region needs to assess.

Among these risks, manufacturing emerges as one major focal point in global semiconductor supply chain resilience. About 75% of semiconductor manufacturing capacity, [2] as well as many suppliers of key materials – such as silicon wafers, photoresist, and other specialty chemicals – are concentrated in East Asia, a region exposed to high seismic activity and geopolitical tension. Currently, the entirety of the world's most advanced semiconductor manufacturing capacity is currently located in South Korea (8%) and Taiwan (92%),[3] although leading firms from both countries are in the process of bringing such capacity to the United States.[4] To address the risk of major global supply disruptions, the industry requires market-driven, government-funded incentive programs to achieve a more diversified geographical footprint, including the expansion of manufacturing capacity in the US, production sites, and sources of supply for critical materials. This would enable the U.S. to maintain a minimum viable manufacturing capacity in the leading nodes to meet domestic demand for the

[1] SIAxBCG Report on "Strengthening the Global Semiconductor Value Chain" (2021), available at https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/

[2] SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

[3] Ibid

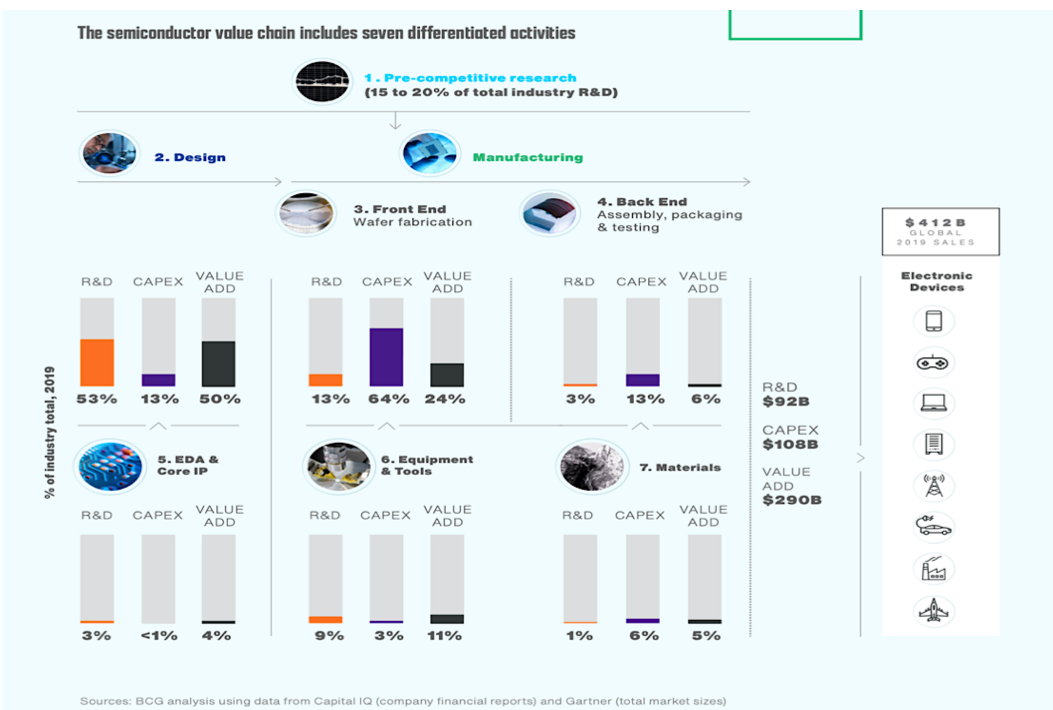
[4] https://www.reuters.com/technology/tsmc-says-construction-has-started-arizona-chip-factory-2021-06-01/.

advanced logic chips used in national security systems, aerospace, and critical infrastructure.

At a high level, the industry supply chain consists of several steps supported by a specialized ecosystem of materials, equipment and software design tools and core IP suppliers:

- **Pre-competitive research** to identify fundamental materials and chemical processes to innovate design architectures and manufacturing technology
- **Design** of nanometer-scale integrated circuits which perform the critical tasks that make electronic devices work
- **Water fabrication** involving highly specialized semiconductor manufacturing facilities, or "fabs," that print nanometer-scale integrated circuits from chip design into silicon wafers
- **Assembly, Packaging, and Testing** to convert silicon wafers produced by fabs into finished chips to be assembled into electronic devices
- **Materials** for semiconductor manufacturing from specialized suppliers
  Electronic Design Automation (EDA) software and services to support semiconductor design, including outsourced design of specialized application specific integrated circuits (ASICs) at the design stage
- **Metrology and inspection equipment** critical for the management of the semiconductor manufacturing process

The chart below details the seven differentiated activities in the semiconductor value chain and the percentage of industry R&D, capital expenditure, and value added that each accounted for in 2019.



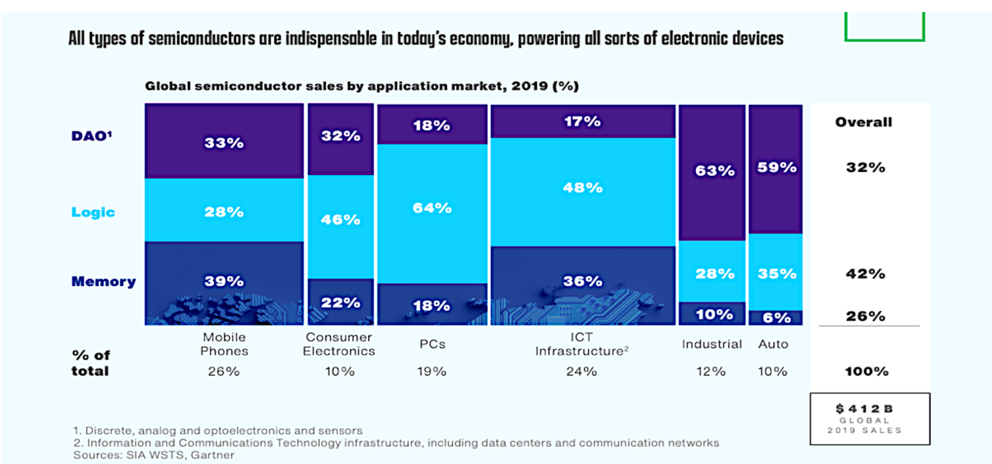
Source: SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

b. Indicate the technology nodes (in nanometers), semiconductor material types, and device types with which this organization is capable of operating (design and/or manufacture).

Industry Data on Technology Nodes

Advances in manufacturing process technology are generally described by referring to “nodes.” The term “node” refers to the size in nanometers of the transistor gates in the electronic circuits. Over time it has lost its original meaning and has become an umbrella term to designate both smaller features and different circuit architectures and manufacturing technologies. Generally, the smaller the node size, the more powerful the chip, as more transistors can be placed on an area of the same size. This is the principle behind “Moore’s Law”, a key observation and projection in the semiconductor industry, which states that the number of transistors on a logic chip doubles every 18 to 24 months. Moore’s Law has underpinned the relentless pace of simultaneous improvement in performance and cost for processors since 1965. Today’s advanced processors found in smartphones, computers, gaming consoles and data center servers are manufactured on 5 to 10-nanometer nodes. Commercial chip manufacturing using 3-nanometer process technology is expected to begin around late 2022.

While logic and memory chips used for digital applications greatly benefit from the scaling in transistor size associated with smaller nodes, other types of semiconductors – particularly those in the DAO (discrete, analog, and other) group described above – do not achieve the same degree of performance and cost benefits by migrating to ever smaller nodes, or simply use different types of circuits or architectures that would not work at more miniaturized scales. As a result, wafer manufacturing takes place across a wide range of nodes from the current “leading node” at 5 nanometers used for advanced logic to the legacy nodes above 180 nanometers used for discrete, optoelectronics, sensors, and analog semiconductors. What constitutes a “leading-edge” node varies for different types of semiconductors. For analog, for example, 45 nm would be considered “advanced” or “leading-edge.” While only 2% of global capacity is currently on nodes below 10 nanometers, demand for these types of advanced semiconductors is expected to increase rapidly in coming years.

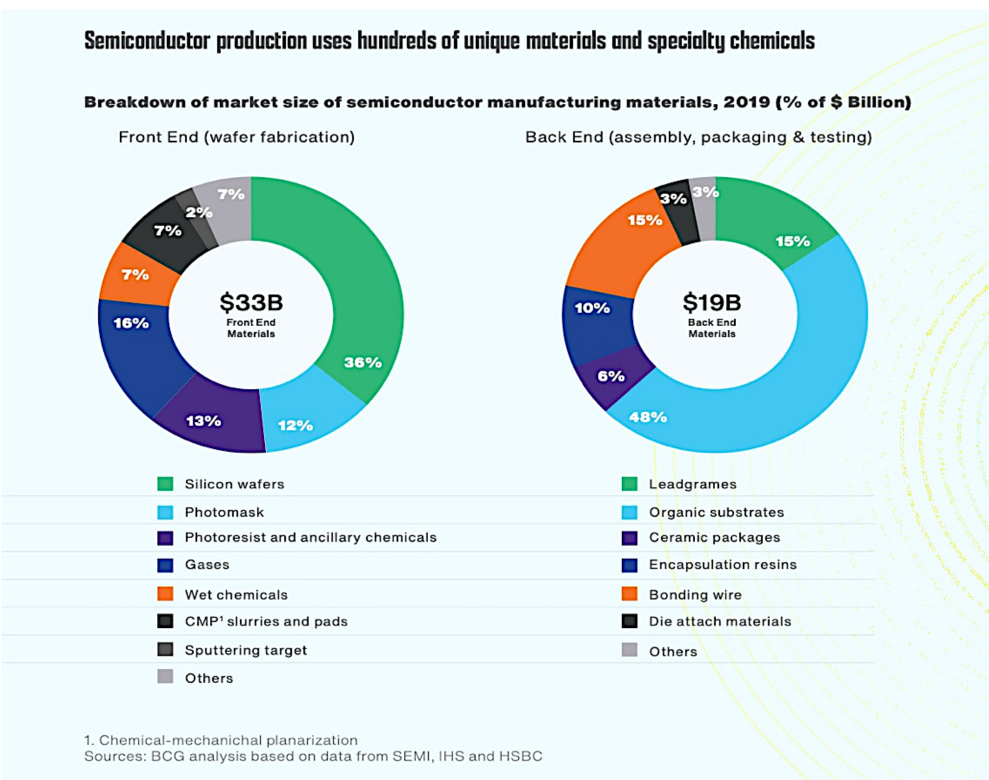


Source: SIAxBCG Report on “Strengthening the Global Semiconductor Supply Chain in an Uncertain Era” (2021)

Industry Data on Material Types

Firms involved in semiconductor manufacturing also rely on specialized suppliers of materials. Fabrication of semiconductors typically requires as many as 300 different inputs, including raw wafers, commodity chemicals, specialty chemicals, sputtering targets and bulk gases. Many of them also require advanced technology to produce. For example, the polysilicon employed to make the silicon ingot, which is subsequently sliced into wafers, is required to have a purity level that is 1,000 times higher than the level required for solar energy panels. Semiconductor-grade polysilicon is provided primarily by just four companies, with a combined global market share above 90%. Ultra Pure Hydrogen Fluoride (UPHF) is another key material used extensively throughout the semiconductor manufacturing process for wet etch and cleaning of semiconductor wafers. Only one manufacturer of UPHF has a facility in the U.S. Similarly, sputtering targets are provided by 4 primary suppliers constituting 90% of the market, most of which is outside the US. Only one manufacturer produces targets for advanced semiconductors in the US. Lastly, a large portion of the world's electronic polymers used in photolithography, masking, and spin on dielectric applications in the chip manufacturing process are supplied by companies based outside of the U.S. Only three companies make up U.S. based supply.

The chart shows the breakdown of the global sale of semiconductor manufacturing materials in 2019 across the key families used in front-end and back-end manufacturing.

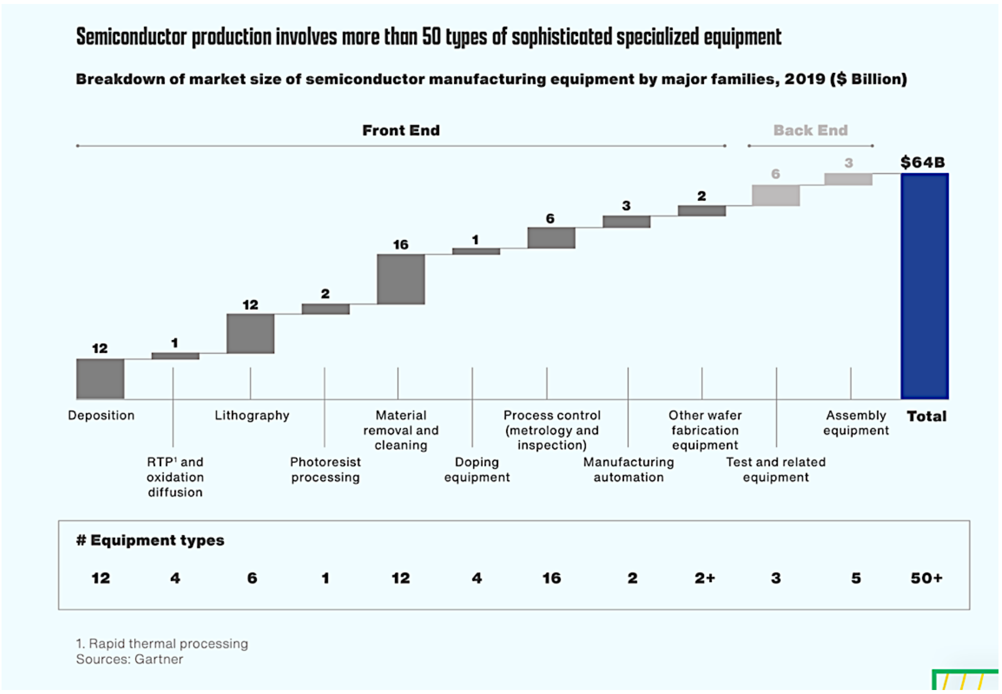


Source: SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

SEMICONDUCTOR INDUSTRY ASSOCIATION

Industry Data on Device Types

Semiconductor manufacturing uses more than 50 different types of sophisticated wafer processing and testing equipment provided by specialist vendors for each step in the fabrication process. Most of this equipment, such as lithography and metrology tools, incorporates hundreds of technology subsystems such as modules, lasers, mechatronics, control chips, and optics. The highly specialized suppliers involved in semiconductor design and fabrication are often based in different countries.



Source: SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

Lithography tools represent one of the largest capital expenditures for fabrication players and determine how advanced of a chip a fab can produce. Advanced lithography equipment, specifically those that harness Extreme Ultra-Violet (EUV) technology are required to manufacture chips at 7 nanometers and below. A single EUV machine can cost $150 million. Metrology and inspection equipment are also critical for the management of the semiconductor manufacturing process. Because the process involves hundreds of steps over one to two months, any defects that occur early in the process will waste all work undertaken in the subsequent time-consuming steps. Strict metrology and inspection processes using specialized equipment are therefore established at critical points of the semiconductor manufacturing process to ensure that a certain yield can be confirmed and maintained.

Modern fabs also use advanced automation and process control systems for direct equipment control, automated material transportation and real-time lot dispatching, with many of the newest facilities almost entirely automated. Semiconductor manufacturing equipment also incorporates many subsystems and components with specific functionality, such as optical or vacuum subsystems, gas and fluid management, thermal management or wafer handling. These subsystems are provided by hundreds of specialized suppliers. Developing and fabricating such advanced, high-precision manufacturing equipment requires large investments in R&D. Semiconductor manufacturing equipment companies typically invest 10% to 15% of their revenues in R&D. Overall semiconductor equipment manufacturers suppliers accounted for 9% of the R&D and 11% of the value added of the industry in 2019.

c. For any integrated circuits you produce--whether fabricated at your own facilities or elsewhere--identify the primary integrated circuit type, product type, relevant technology nodes (in nanometers), and estimates of annual sales for the years 2019, 2020, and 2021 based on anticipated end use.

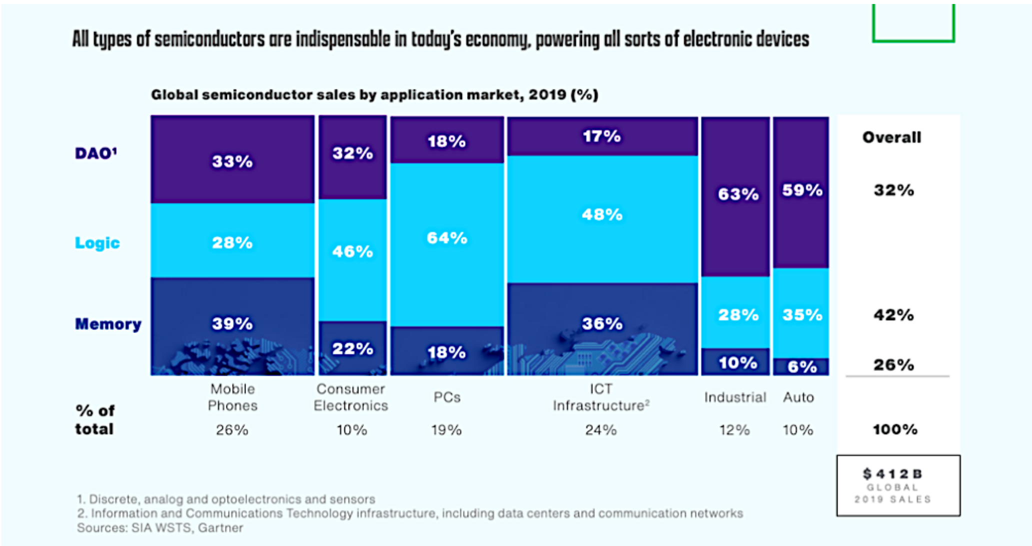
Industry Information on Product Categories

Semiconductors are highly specialized components that provide essential functionality for electronic devices to process, store and transmit data. Most of today's semiconductors are integrated circuits, or "chips." A chip is a set of miniaturized electronic circuits composed of active discrete devices (transistors, diodes), passive devices (capacitors, resistors) and the interconnections between them, layered on a thin wafer of semiconductor material, typically of silicon. Industry taxonomy usually describes more than 30 types of product categories that can be broadly classified into (i) logic; (ii) discrete, analog, and other (DAO); and (iii) memory. Logic, which accounts for 42% of industry revenue, are integrated circuits functioning on binary codes that serve as the fundamental building blocks in computing. This category includes microprocessors, general purpose logic productions, microcontrollers (MCUs), and connectivity products that allow devices to connect to networks. DAO accounts for 32% of industry revenue and encompass semiconductors that transmit, receive, and transform information dealing with continuous parameters such as temperature and voltage. Lastly, memory, which accounts for 26% of industry revenue, are semiconductors used for storing information to perform computation.[5] Computers process information stored in their memory, which consists of various data storage or memory devices. Two of the most common semiconductor memories in use today are Dynamic Random-Access Memory (DRAM), which is used for temporary storage, and NAND memory, used for permanent storage.[6]

The chart below decomposes global semiconductor sales to major consumers by product category.

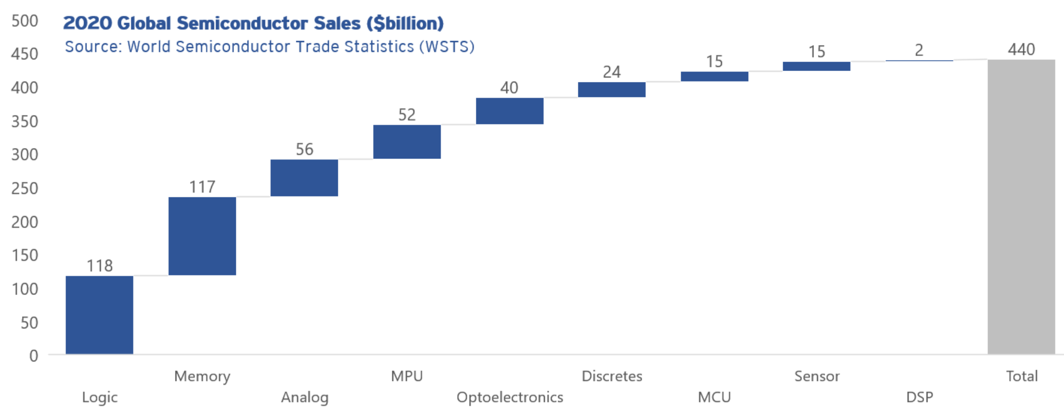
[5] World Semiconductor Trade Statistics, December 2020 Bluebook

[6] SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

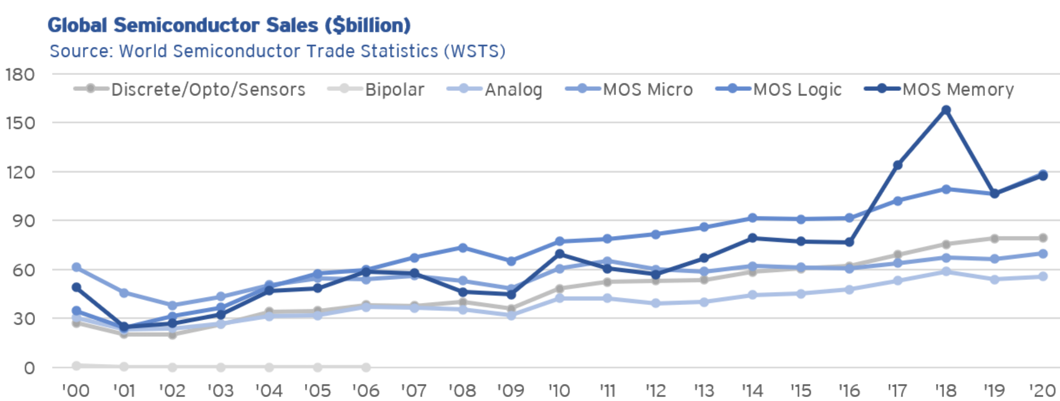


Source: SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

In recent years, the largest segments of the worldwide semiconductor industry have been memory, logic, analog, and MPU. In 2020, these products accounted for $343 billion, or 78%, of semiconductor industry sales.



Global semiconductor sales have grown steadily across all product categories over the past 20 years.



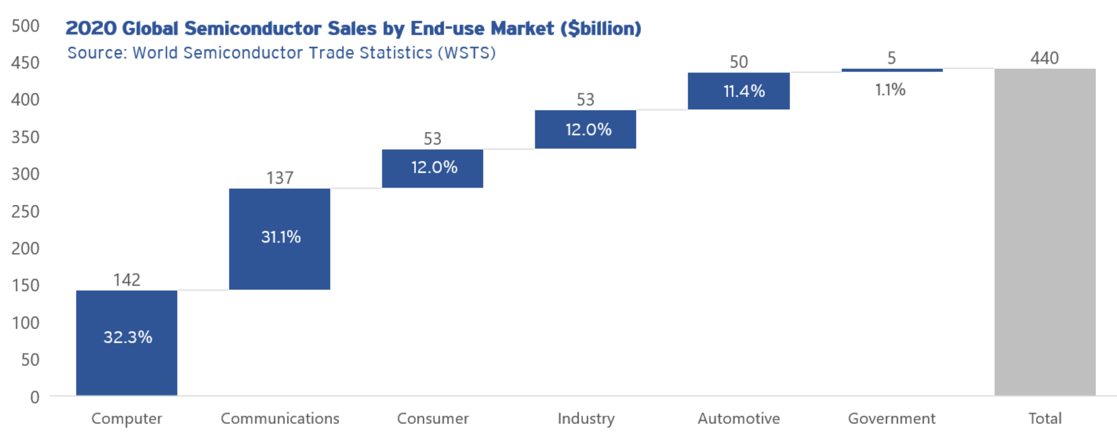
Technology Nodes

Today's wafer manufacturing takes place across a wide range of nodes from the current "leading edge" at 5 nanometers used for advanced logic to the legacy nodes above 180 nanometers used for discrete, optoelectronics, sensors, and analog semiconductors. The U.S. currently produces 28% of the global capacity in advanced nodes (10 nanometers or below), but currently lacks capacity to produce at the leading edge (5 nm and below).[7]

d. For the semiconductor products that your organization sells, identify those with the largest order backlog. Then for the total and for each product, identify the product's attributes, sales in the past month, and location of fabrication and package/assembly.

i. List each product's top three current customers and the estimated percentage of that product's sales accounted for by each customer.

Semiconductors are used in all types of electronic devices across multiple applications spanning the major sectors of the economy. The information and communications technology (ICT) industry is currently the largest consumer of semiconductors, which are used to power laptops, cellular devices, data-centers and broadband networks, as well as varied software applications, AI technologies, and other emerging technologies. In the future, the expanding content of semiconductors in automotive applications, such as advanced driver-assistance systems (ADAS) and sensors, is expected to drive substantial growth in the automotive end market. The compound annual growth rate of sales to the automotive market has been 7% over the past 10 years, from $25.6 billion in sales in 2011 to $50 billion in 2020.[8]



[7] SIAxBCG Report on "Government Incentives and US Competitiveness in Semiconductor Manufacturing" (2020), available at https://www.semiconductors.org/wp-content/uploads/2020/09/Government-Incentives-and-US-Competitiveness-in-Semiconductor-Manufacturing-Sep-2020.pdf
[8] World Semiconductor Trade Statistics, 2011 and 2020 End Use Survey

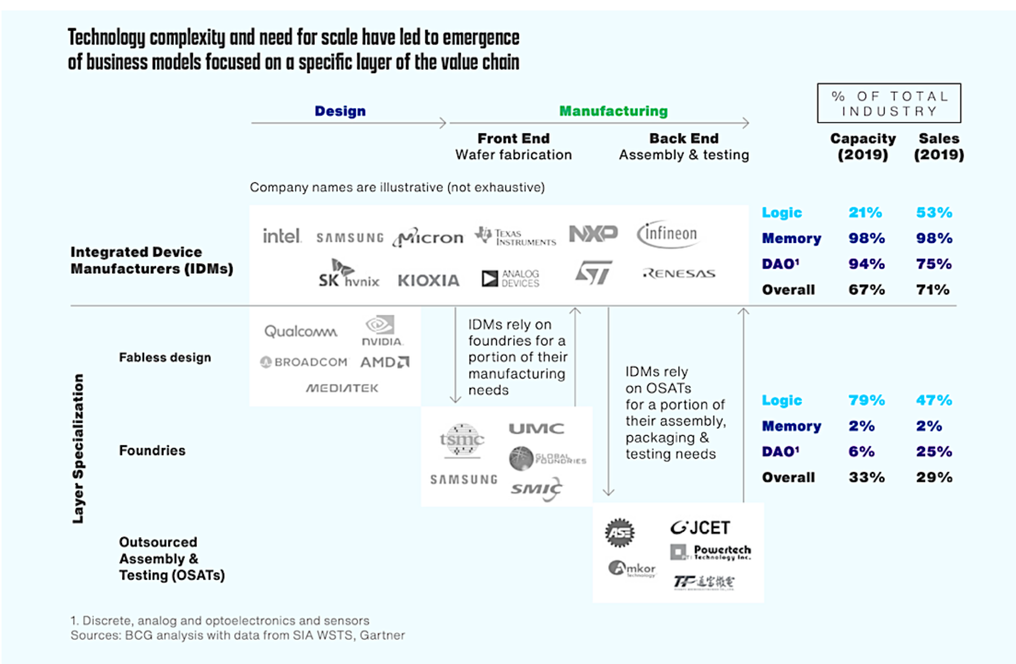
e. For each phase of the production process, identify whether your organization carries out the step internally or externally. For your organization's top semiconductor products, estimate each product's (a) 2019 lead time and (b) current lead time (in days), both overall and for each phase of the production process. Provide an explanation of any current delays or bottlenecks.

Wafer Fabrication Lead Time

The fabrication process is intricate and requires highly specialized inputs and equipment to achieve the needed precision at miniature scale. There are 400 to 1,400 steps in the overall manufacturing process semiconductor wafers, depending on the product. The average time to fabricate finished semiconductor wafers, known as the cycle time, is about 12 weeks, but it can take up to 14 to 20 weeks to complete for advanced processes.[9] Chip manufacturing utilizes hundreds of different inputs, including raw wafers, commodity chemicals, specialty chemicals as well as many types of processing and testing equipment and tools, across several stages. These steps are often repeated many hundreds of times, depending on the complexity of the desired set of electronic circuits.

Production by Foundries v. Integrated Device Manufacturers (IDMs)

Technological complexity and need for scale have led to emergence of business models focused on a specific part of the value chain.



Source: SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

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9 SIAxBCG Report on "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era" (2021)

Integrated Device Manufacturers (IDMs) are vertically integrated across multiple parts of the value chain, performing design; fabrication; and assembly, packaging and test activities in-house. In practice, many IDMs have hybrid “fab-lite” models where they outsource some of their production and assembly. In the early decades of the industry, the IDM model was predominant, but the rapidly increasing size of the investments in both R&D and capital expenditure created the need for both scale and specialization, which led to the emergence of the fabless-foundry model. Currently the IDM model is more common for firms focused on memory and DAO products, which are largely general-purpose components and more scalable. IDMs accounted for approximately 70% of global semiconductor sales in 2019.[10]

As the industry moves to small technology nodes, development costs continue to rise. With escalating costs at cutting edge nodes, fewer and fewer IDMs have continued to develop process technology at leading nodes, relying instead on foundries for leading edge fabrication.

Foundries address the fabrication needs of design and other fabless firms and IDMs alike, as most IDMs do not have sufficient installed manufacturing capacity in-house to cover all their needs. This business model enables foundries to diversify the risk associated with the large upfront capital expenditure required to build modern fabs across a larger customer footprint of design firms and IDMs. Most foundries are focused purely on manufacturing for third parties, which in turn, allows design firms and IDMs to focus on investing in cutting-edge research and development. Leaving memory aside, foundries have added 60% of the incremental capacity in the industry for DAO and logic products during the past five years. Currently foundries account for 35% of the total industry manufacturing capacity, or 50% if memory is excluded. Their share rises to 78% in advanced (14 nanometers or below) and trailing nodes (20 to 60 nanometers) using the more advanced 12”/300mm wafer size. Furthermore, the only two companies that can currently manufacture at the leading 5 nanometer node are foundries.[11]

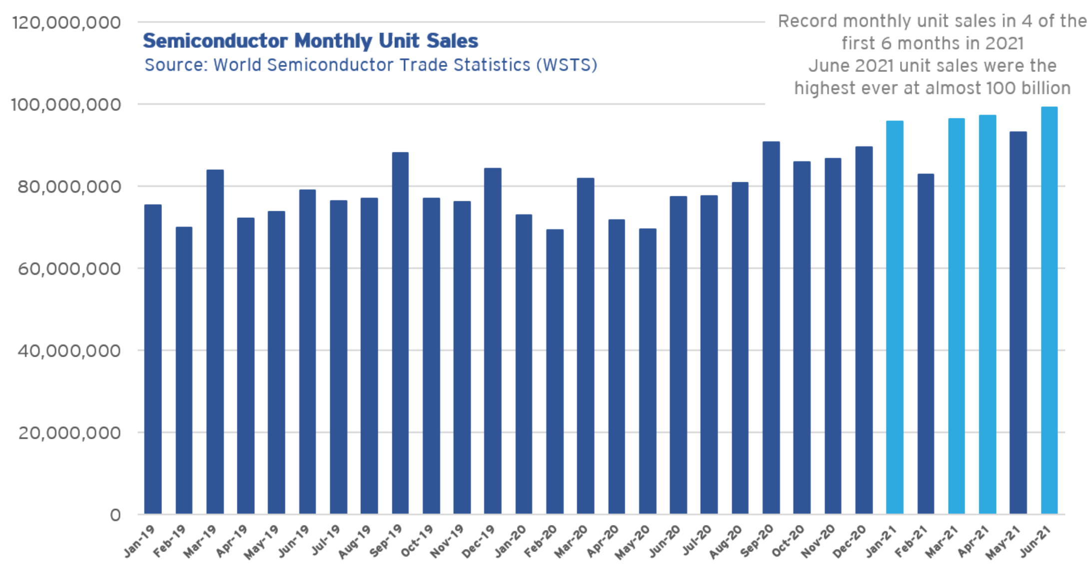
[10] SIAxBCG Report on “Strengthening the Global Semiconductor Supply Chain in an Uncertain Era” (2021)

[11] SIAxBCG Report on “Strengthening the Global Semiconductor Supply Chain in an Uncertain Era” (2021)

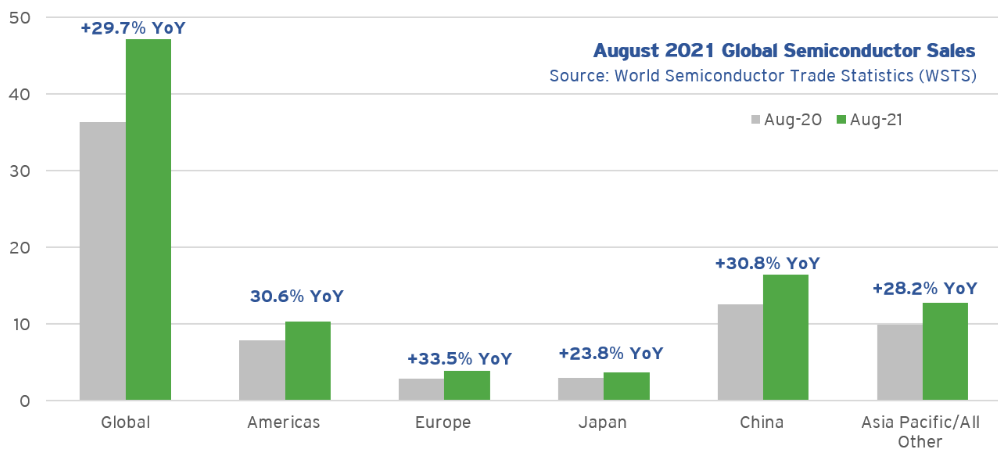
f. For your organization's top semiconductor products, list each product's typical and current inventory (in days), for finished product, in-progress product, and inbound product. Provide an explanation for any changes in inventory practices.

SIA does not have data on the levels of inventory held by individual companies or the industry as a whole. We are, however, able to provide data on industry output in response to the pandemic.

In response to increased demand, chipmakers increased output to historically unprecedented levels in 2021. Global semiconductor sales reached $47.2 billion in the month of August 2021, which represents an increase of 29.7% over $36.4 billion in August 2020 and a year-to-year increase across all regional markets and major product categories. Domestic sales by U.S.-headquartered semiconductor companies grew 27.6% from December 2020 to August 2021. Sales to overseas markets increased by 16.7% during the same period.



From April to June 2021, the industry sold more units, including units for automotive application-specific ICs, than in any other three-month period on record. June 2021 unit sales were the highest ever at almost 100 billion units sold. Monthly unit sales from January to April set new records each month.



Semiconductor companies sell a significant portion of products through distributors, who resell to original equipment manufacturers (OEMs) and to electronic manufacturing service providers and other companies in a range of industries. Distributors often provide the most effective way for manufacturers to reach the "long tail" in many countries—the tens of thousands of small customers whose orders would be more expensive to serve with a full-time, in-house sales force. Many semiconductor manufacturers also have distributors manage mature customers and product lines that do not require internal sales or technical support, since they provide a low-cost solution for maintaining the business.[12] Use of the distribution channel varies by company. According to semiconductor companies' 2020 annual reports, sales generated through distributors range from 25% to 85% of total revenues. On average, distributors handle 50% of the semiconductor industry's revenues.[13]

[12]https://www.mckinsey.com/~/media/mckinsey/industries/semiconductors/our%20insights/creating%20mutually%20beneficial%20partnerships%20with%20distributors/creating_mutually_beneficial_partnerships.pdf.
[13] Company annual reports

g. What are the primary disruptions or bottlenecks that have affected your ability to provide products to customers in the last year?

Supply chain disruption in the COVID-19 era has been an economy-wide phenomenon. Ninety-four percent of Fortune 1000 companies reported supply chain disruptions from COVID-19 and 75% of companies have had negative or strongly negative impacts on their businesses, according to Accenture.[14] From manufacturing to consumer products, no sector has escaped the effects of lockdowns on facilities and workforce around the world. Massive dislocations in global logistics and transportation networks have contributed to port congestion, to delayed production and delivery, and to rising consumer prices. Manufacturing shortages in raw materials, intermediate goods, and key components produced rippling downstream effects on numerous end markets. Supply and demand shocks exposed vulnerabilities in global supply chains already strained by geopolitical friction and lean production strategies pre-dating COVID-19. In an economy as interconnected as ours, disruptions to the global value chain have created a perfect storm, and the semiconductor supply chain has not been immune to these dynamics.

- **COVID-19 Outbreaks**

Border controls, mobility restrictions, and closures of factories and ports to contain COVID-19 have left no part of the global economy untouched. In September, one leading automotive company cut its annual production target by 300,000 vehicles as rising COVID-19 infections slowed output at factories in Vietnam and Malaysia.[15] Outbreaks at the Chinese ports of Yantian in Shenzhen and Ningbo-Zhoushan, among the world's five largest ports, led to multi-week partial closures that affected trading volumes halfway around the world in the Port of Los Angeles. Vietnam, second only to China as the largest supplier of apparel and footwear to the United States, forced factories to shut down or operate at severely reduced capacity to manage outbreaks of the Delta variant beginning in July, forcing major American retailers to grapple with unanticipated delays and shortages in addition to skyrocketing shipping costs. As of October, one apparel company reported its Vietnamese factories at "100 percent lockdown" and delays of four to eight weeks. A large manufacturer, which produced 51% of its footwear in Vietnam in 2020, anticipated 10 weeks of lost production time in Vietnam between July and October.[16] Malaysia, a major hub for packaging, assembly and testing of devices for smartphones, car engines, and medical equipment, experienced multiple factory closures and staffing shortages due to an outbreak of COVID-19 cases.[17] An estimated 7% of global semiconductor supply passes through Malaysia, and the U.S. imports more chips directly from Malaysia than from any other country.[18]

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[14] https://www.accenture.com/us-en/insights/consulting/coronavirus-supply-chain-disruption.
[15] https://www.reuters.com/business/autos-transportation/toyota-cuts-annual-auto-production-target-shortage-chips-parts-2021-09-10/.
[16] https://www.nytimes.com/2021/09/29/business/supply-chain-vietnam.html.
[17] https://www.wsj.com/articles/covid-19-surge-in-malaysia-threatens-to-prolong-global-chip-shortage-11630234802.
[18] Ibid.

- **Factory and Port Closures from Weather Events**

Multiple factory and port closures have been attributable to unanticipated weather events globally. In February, cold weather and surging demand for electricity caused power and ultimately water outages across Texas, forcing closures across factories and stores. Chipmakers, including auto chip makers (NXP Semiconductor, Infineon Technologies AG, and Samsung) were among those forced to shut down production plants in Austin.[19] In March, a fire broke out at Renesas Electronics' flagship factory in Naka, Japan, damaging 17 plating machines and shutting down production lines that mass-produce 300-mm semiconductor wafers for three months. The company holds nearly 20% of the global market share for microcontrollers used in cars and other machines.[20]

h. What is your organization's book-to-bill ratio for the past three years? Explain any changes.

SIA does not have data on the book-to-bill ratio of individual companies or the industry as a whole.

i. If the demand for your products exceeds your capacity, what is the primary method by which your organization allocates the available supply?

SIA cannot address the manner in which individual companies allocate available supplies when demand exceeds supply. We can, however, provide additional context on drivers of demand and future demand growth for the industry.

Demand for semiconductors is rapidly increasing and is expected to continue to increase. Throughout the pandemic, the semiconductor industry has played a critical role in the pandemic response and subsequent efforts towards economic recovery and resiliency. Semiconductors provide user input, display, wireless connectivity, processing, storage, power management, and other essential functions. This includes healthcare and medical devices, telecommunications, energy, finance, transportation, agriculture, manufacturing, aerospace and defense. Semiconductors also underpin the IT systems that make remote work possible and provide access to essential services across every domain, including medicine, finance, education, government, and food distribution. The industry has been key to developing solutions to numerous problems in the economic and public health sphere, including life-saving medical devices, ventilators, public testing and tracing, vaccine development, and communication networks and capabilities needed to battle the global pandemic.

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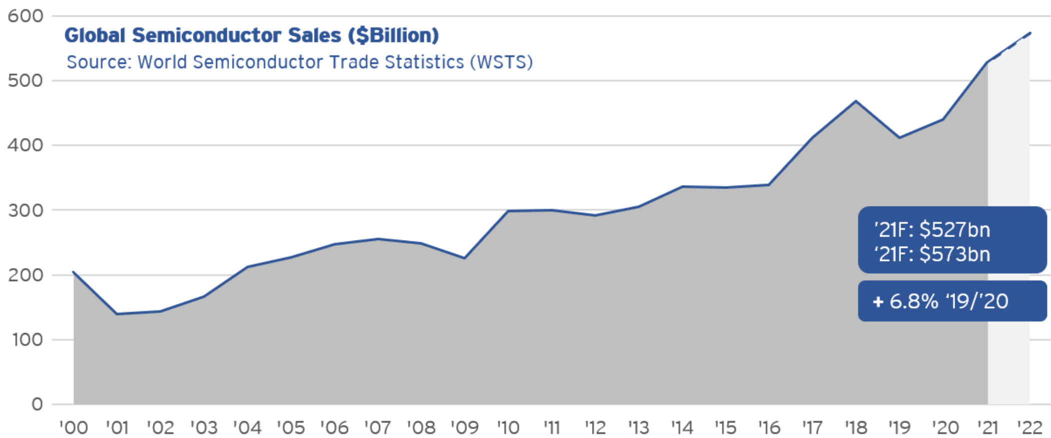
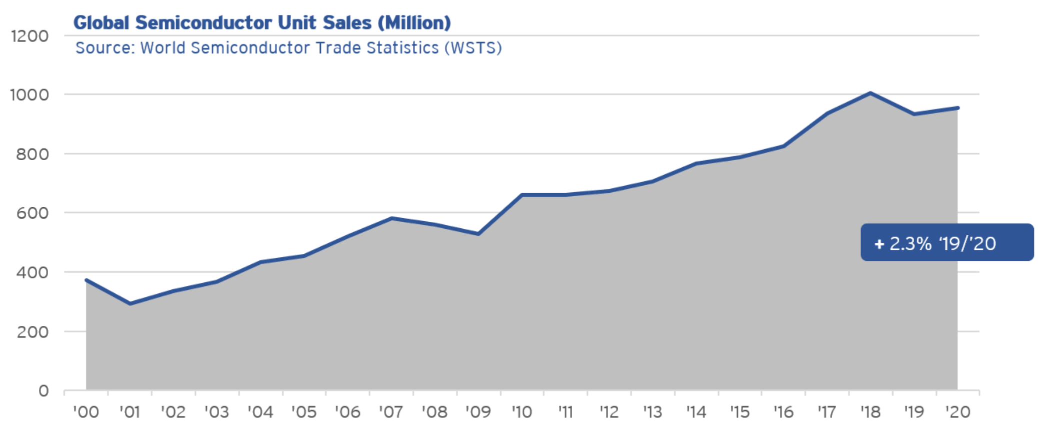
[19] https://www.bloomberg.com/news/articles/2021-02-17/texas-power-failure-shuts-chip-factories-squeezes-tight-supply.
[20] https://asia.nikkei.com/Business/Tech/Semiconductors/Renesas-expects-bigger-damage-from-fire-at-its-chip-factory.

In 2020, global chip sales increased by 6.8 percent from $412.3 billion in 2019 to $440.4 billion, largely driven by demand growth spurred by the Covid-19 pandemic. The World Semiconductor Trade Statistics (WSTS) Semiconductor Market Forecast released in June 2021 projected worldwide semiconductor industry sales will increase to $527 billion in 2021, an upward revision from its Fall 2020 forecast for 2021. WSTS forecasts global sales will grow to $573 billion in 2022. For context, worldwide semiconductor sales increased from $204.4 billion to $440.4 billion at a compound annual growth rate of 3.91% per year from 2000 to 2020.



In 2001, the per unit cost was $0.98 and declined to $0.68 in 2020. This reflects a CAGR of -1.81% over this period. Increased output and not inflationary pressure is responsible.



Over the next decade, further innovation in semiconductor technology will enable the proliferation of a host of transformative technologies, including 5G, artificial intelligence (AI), autonomous electric vehicles, and the internet of things (IoT). The relationship between semiconductors and the markets they serve is symbiotic, as innovations in semiconductors help to spur market demand and open new markets. For example, successive generations of cellular technology have been made possible by advances in semiconductors, leading to the recent introduction of 5G. Demand drivers in the short-term experienced some unexpected shifts, brought on by societal changes from the COVID-19 pandemic, but these shifts have resulted in a sustained increase in demand as society leans ever increasingly on semiconductor-enabled technologies. Long-term growth drivers for semiconductor demand are firmly in place, and the industry is a key growth sector in the global economy for the foreseeable future. The industry, however, must first navigate broader supply chain disruptions in the short term and take steps to have more resilient supply chains in the long term.

j. Does your organization have available capacity? If yes, what is preventing the filling of that capacity?

The U.S. share of global semiconductor manufacturing has experienced a steady decline from 37% in 1990 to 12% in 2020, despite a 7% annual growth rate in U.S. manufacturing capacity over the last 30 years.[21] Fab economics explain this decline: government incentives and labor costs. The rise in U.S. installed capacity has been outpaced by that of several Asian countries, whose governments have ambitiously invested in domestic manufacturing through favorable grants, tax incentives, and other government incentives.

The result of these investments has led to approximately 75% of the world's semiconductor manufacturing capacity being concentrated in East Asia, but there are important distinctions. For example, U.S. allies and partners currently account for the majority of leading-edge production, with Taiwan accounting for 47% of the global capacity in leading and advanced nodes, 10 nanometer and below, used for advanced logic devices and South Korea producing over 40% of the global capacity of memory, which accounts for an estimated 30% of total semiconductor demand.[22]

China has grown significantly as an important producer of mature semiconductor technologies but continues to lag at the leading edge. However, the Chinese government continues to prioritize the semiconductor industry as a driver of economic growth and technological leadership and is expected to add about 40% of new global capacity through 2030.[23] Conversely, current data on planned fab constructions indicates that only 6% of new capacity currently in development will be located in the U.S. without incentives such as those in the CHIPS for America Act and an expanded FABS Act.[24]

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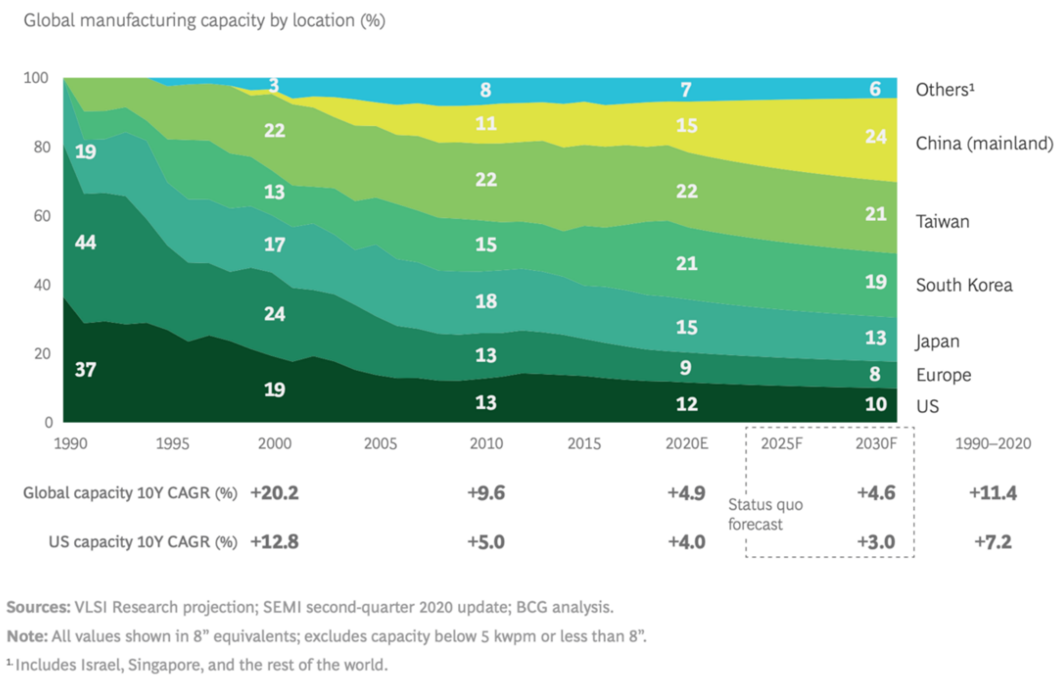
[21] SIAxBCG Report on "Government Incentives and US Competitiveness in Semiconductor Manufacturing" (2020)
[22] Ibid
[23] Ibid
[24] Ibid



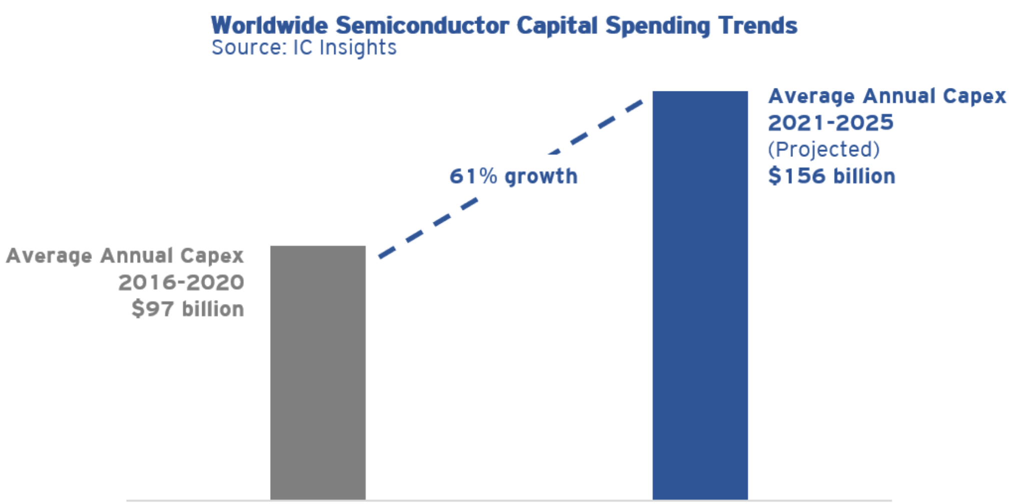
Source: SIAxBCG Report on "Government Incentives and US Competitiveness in Semiconductor Manufacturing" (2020)

k. Is your organization considering increasing its capacity? If yes, in what ways, over what timeframe, and what impediments exist to such an increase? What factors does your organization consider when evaluating whether to increase capacity?

The semiconductor industry is investing heavily into capacity-building to meet future demand and enhance supply chain resiliency. The industry's total annual levels of investment in capital and R&D are high in comparison to most other industries. R&D and capital expenditures by U.S. semiconductor firms, including fabless companies, totaled $74.2 billion in 2020. From 2000 to 2020, the compound annual growth rate of R&D and capital expenditures was approximately 5.6%[25].

In 2020, total U.S. semiconductor industry investment in R&D alone totaled $44 billion.[26] The industry annually directs roughly one-fifth of its revenues back into R&D. It was second only to the U.S. pharmaceuticals & biotechnology industry in terms of the rate of R&D spending as a percent of sales, based on the 2021 data published by NYU Stern School of Business. U.S. semiconductor industry R&D spending as a percent of sales is unsurpassed by any other country's semiconductor industry.

For increasing production two and more years out, capital spending rates serve as good indicators of industry progress, and there is a clear trend toward increased and sustained levels from 2021. Capital spending (capex) by the global semiconductor industry in 2021 is forecasted to reach its highest level on record at $148 billion and to grow by 30 percent compared to 2020 levels.[27] Annual industry capex forecasted over the next five years also indicates a significant jump from previous annual levels, averaging $156 billion from 2021-2025 compared to $97 billion from 2016-2020. This represents an increase in capex growth of 61%.[28]



[25] 2021 SIA Factbook
[26] Ibid.
[27] IC Insights, The McClean Report 2021
[28] Ibid

In 2021, the global semiconductor industry is on target to bring more than two dozens of new fabs online globally, with another 15 IC fabs under construction.[29]

The table below shows top semiconductor firms' new or expanding fab construction projects from 2021.

Company	Fab Location	Product Type	Technology Node	Year of Initial Production
Bosch	EU	DAO	28-90nm	2021
GlobalFoundries	Singapore	Logic/DAO		2023
Intel	US, EU	Logic	<=10nm	2023/2024
Kioxia	Japan	Memory	Memory	2022
Micron	US	Memory	Memory	2021
Nanya	Taiwan	Memory	Memory	2024
Nexperia	China	DAO	>=110	2022
Powerchip	Taiwan	DAO	28-90nm	2023
Rohm	Japan	DAO	>=110	2021
Samsung	Korea, China	Memory/Logic	<=10nm	2021/2023
SMIC	China	Logic/DAO	28-65nm	2021-2025
Silan	China	DAO	28-90nm	2022
SK Hynix	Korea	Memory	Memory	2021/2025
STMicroelectronics	EU	DAO	28-90nm	2021
TSMC	US, Taiwan, Japan	Logic	2-28nm	2021-2025
Texas Instruments	US	DAO	28-90nm	2022
Winbond	Taiwan	Memory	Memory	2022
Wolfspeed	US	DAO	>=110nm	2022

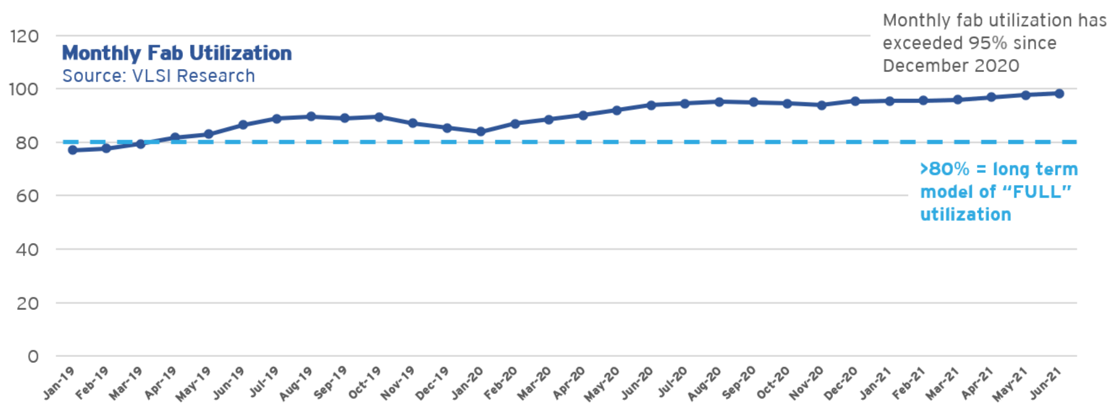
Source: IC Insights Fab Database, SIA

The industry has overcome a confluence of disruptive events to keep semiconductor supply chains operational and *expanded* capacity to meet critical needs. This included efforts by SIA and counterparts to designate semiconductor and supply chain operations as "essential infrastructure" and /or "essential business" around the world to ensure continued operations in the face of government lockdowns and other restrictions on the movement of people.

[29] IC Insights IC Fab Database

I. Has your organization changed its material and/or equipment purchasing levels or practices in the past three years?

Since the first quarter of 2019, quarterly fab capacity utilization has run well above the "full" rate of 80% and has reached over 95% in recent periods[30]. Utilization rate is the time systems are utilized relative to the time that they are available for production. "Full" utilization in semiconductor fabs is generally 80% utilization of capacity to allow for preventive maintenance, repairs, upgrades, and qualification procedures to maintain output and quality. High utilization rates increase equipment productivity but raise the risk of costly failures down the road. This includes advanced nodes fabs, which fabricate cutting-edge chips for computing, server, and graphic processing applications, and mature nodes fabs, which produce semiconductors for automotive and consumer electronics.[31] Such levels of utilization have been critical to the semiconductor industry's effort to mitigate the short-term impacts of the chip shortage but prove unsustainable in the long-term.



By every measure, increased utilization has resulted in significant capacity expansion to meet the global spike in chip demand:

- **Ramped Up Wafer Starts:** Since 1Q2020, global IC fabs have added 545,000 wafer starts per month capacities.[32] It is estimated that the new capacities built up for manufacturing discrete, optoelectronics, and sensors – semiconductor devices that contain a single component but are increasingly critical to auto electronics - have doubled those at IC fabs during the same period.
- **Record Chip Sales:** More semiconductor units were sold in 2Q2021 than in any other quarter in history. Four of the six months during the first half of 2021 have set new records for monthly semiconductor units sold. June 2021 unit sales were the highest ever at almost 100 billion. Over 1 trillion semiconductors will be sold in 2021, which will be the highest on record.[33]

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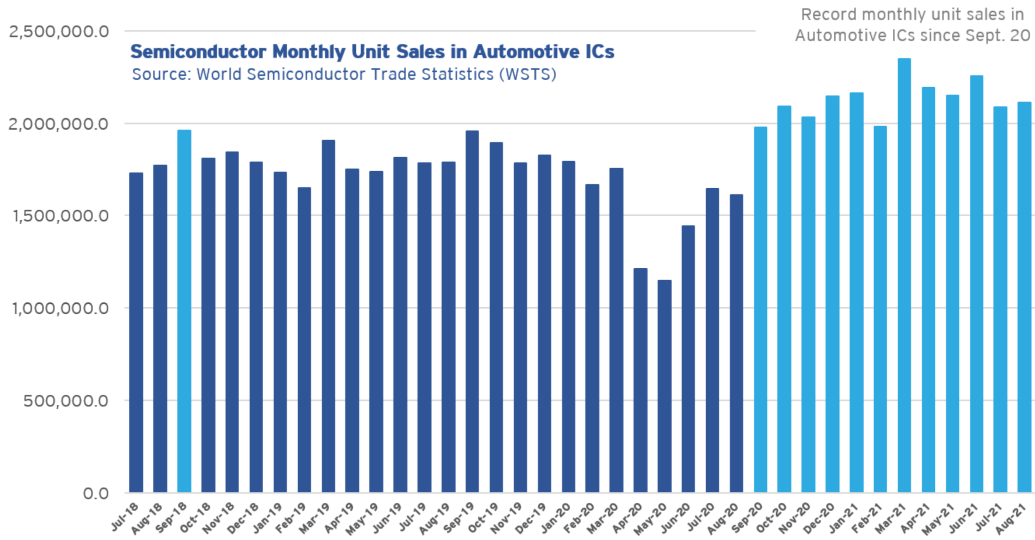
30 VLSI Research, Capacity Utilization Rates by Segment September 2021 Update
31 Ibid
32 IC Insights Fab Database
33 World Semiconductor Trade Statistics, June 2021 Bluebook

- **Record Auto Chip Sales:** From September 2020 to August 2021, the monthly total of automotive application-specific semiconductors sold has surpassed the previous record total set in September 2018.[34]



[34] World Semiconductor Trade Statistics, July 2021 Bluebook

m. What single change (and to which portion of the supply chain) would most significantly increase your ability to supply semiconductor products in the next six months?

The global semiconductor industry is working aggressively to meet demand, but there is no short-term solution that can immediately ease the current shortages. Overcoming the global chip shortage requires market foresight aimed at building long-term capacity and supply chain resiliency. There are several actions that can boost semiconductor production. These involve substantial government incentive programs and a transformation in supply chain management strategies by end markets and consumers.

1. **Funding the CHIPS Act and Enacting a Strengthened FABS Act to Incentivize Expanded Capacity in the U.S.**

At the heart of the problem, demand for semiconductors outstrips supply across all sectors of the economy. A solution to the chip shortage requires policy aimed at fundamentally strengthening the entire industry. The most constructive action that the government can pursue to this end is: (i) funding the CHIPS for America Act, which provides incentives for domestic chip production and research investments; and (ii) enacting a strengthened version of the FABS Act, which provides an investment tax credit for both semiconductor manufacturing and design. SIA and Oxford Economics have published a report in May detailing the impact of the CHIPS Act on U.S. workforce and GDP.[35]

In 2020, we estimated the size of the workforce at 277,000. Semiconductor integrated device manufacturers (IDMs), pure-play foundries, and other establishments involved in semiconductor manufacturing directly employed nearly 185,000 U.S. workers. In addition, we estimated the employment by fabless semiconductor design firms accounts for an additional 92,000 workers in the U.S.

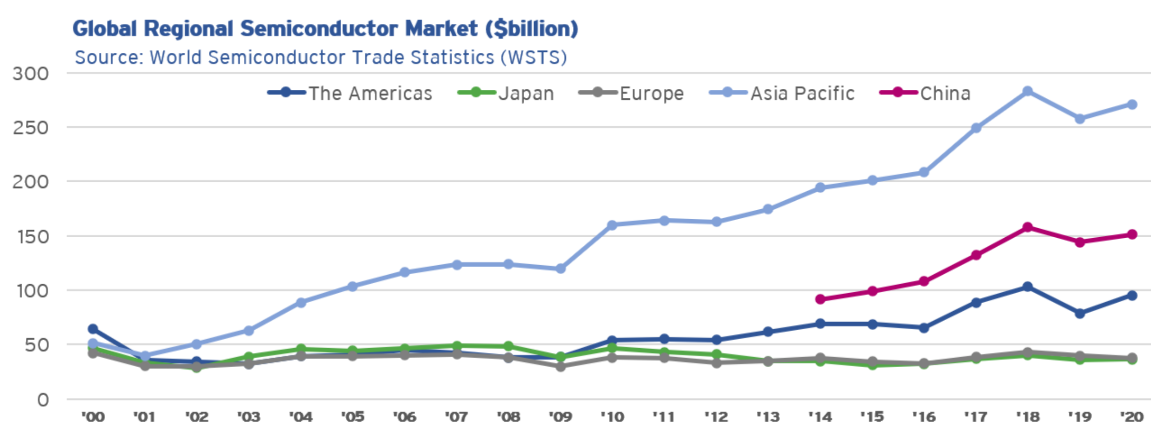
A $52 billion federal incentive program under the CHIPS Act will have an enduring impact on the nation's semiconductor industrial infrastructure and broader economy and workforce, including an additional $24.6 billion in GDP and creation of an average of 185,000 temporary jobs annually from 2021 to 2026. Over this six-year build-out period, the cumulative annual impact of such an incentive program on GDP and jobs would be $147.7 billion and 1.1 million, respectively. An investment of this magnitude would enable the construction of 19 advanced fabs in the U.S. over the next ten years, doubling the expected number of fabs to be built and increasing capacity located in the U.S. by 57%. These benefits would be magnified by the FABS Act, which would create a 25% investment tax credit for investments in semiconductor manufacturing, both for manufacturing equipment and the construction of fabs. An enhanced FABS Act would expand these incentives to design.

[35] SIAxOxford Economics Report on "Chipping In: The Positive Impact of the Semicondcutor Industry on the American Workforce and How Federal Industry Incentives Will Increase Domestic Jobs" (2021), available at https://www.semiconductors.org/wp-content/uploads/2021/05/SIA-Impact_May2021-FINAL-May-19-2021_2.pdf.

The enactment of legislation is critical to addressing the chip shortage long-term and advancing U.S. technology leadership to future economic growth, national security, and supply chain resiliency. Given the size and scope of the CHIPS Act provisions, we strongly encourage the Commerce Department to begin standing up programs that will administer and manage the grants program, R&D efforts, and other related actions that will be required once the CHIPS Act funding is approved. Establishing these programs as soon as possible will shorten the lead time between ground-breaking and launch of commercial operations – and ultimately, shorten the time it takes to increase chip production in the United States, advance the cutting edge of semiconductor R&D, improve the resilience and security of supply chains, and meet growing consumer demand.

2. Trade Policy to Expand Global Markets

There are many other steps government can take beyond manufacturing incentives and investment tax credits to make stronger supply chains. That includes advancing trade policies that expand global markets and open them to be more attractive to our goods. The majority of semiconductor demand is driven by products ultimately purchased by consumers, including laptops and communication devices such as smartphones. Eighty percent of the chips industry's consumers are overseas. Increasingly, consumer demand is driven in emerging markets including those in Asia, Latin America, Eastern Europe, and Africa. In 2001, the Asia Pacific market surpassed all other regional markets in sales of semiconductors to electronic equipment makers, as equipment production shifted to the region. It has since multiplied in size from $39.8 billion to over $271 billion in 2020. By a large margin, the largest country market in the Asia Pacific region is China, which accounted for 56 percent of the Asia Pacific market and 34 percent of the total global market in 2020.[36]



[36] 2021 SIA Factbook

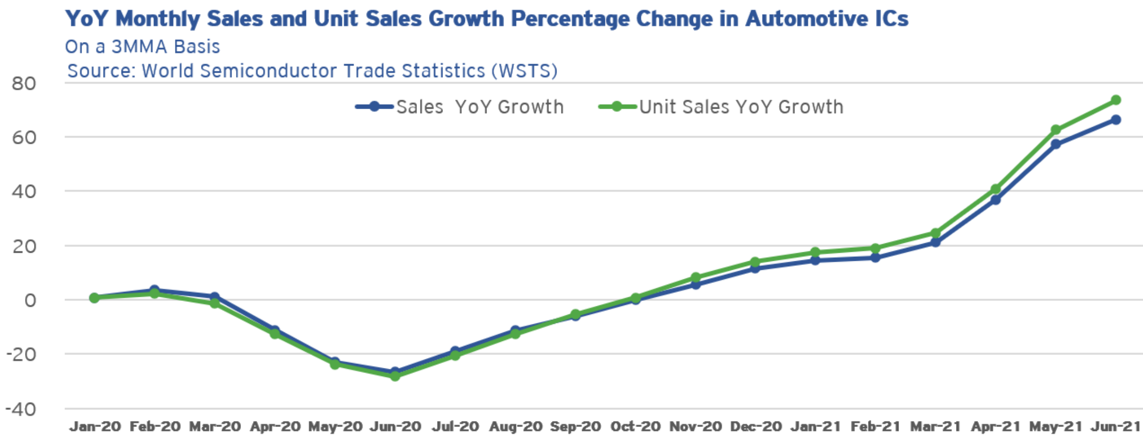
3. Demand Incentives for Leading Edge Technologies

The government has an influential role to play in stimulating demand in leading edge technologies, with ramifications for the nation's broader technology ecosystem, and SIA applauds the Commerce Department for looking at possible options in this area. Leading edge demand incentives for next-generation capabilities, such as new broadband, 5G services, and Greentech, can free up capacity in the legacy nodes underpinning auto production and other forms of manufacturing while creating broad economic value. For example, major forms of broadband, notably WiFi, cable, fiber, and DSL, are at a technology crossroads, with more and more broadband products containing leading edge semiconductors. Through its own purchases, grants and coordination with other governments, the U.S. government can accelerate the migration of broadband solutions to newer process nodes and represents one solution to the legacy chip shortage with the additional benefit of future-proofing the nation's broadband infrastructure with more energy efficient technologies.

4. Long-Term Non-Cancellable, Non-Returnable (NCNR) Contracts

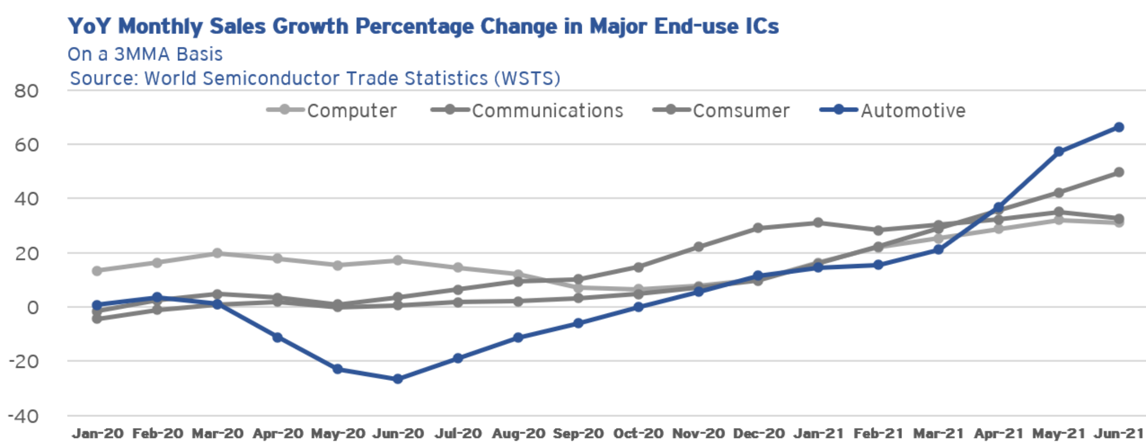
The cancellation of orders at the start of the pandemic was a major contributor to the current chip shortage in the auto sector. In the first half of 2020, some in the auto industry cancelled existing orders due to plant closures and forecasts of low customer demand, leading to an unprecedented reduction in the delivery of chips to the automotive sector. The decrease in monthly year-over-year (YoY) sales growth for application-specific chips used in the automotive market was sudden and precipitous in March and April of 2020. Equally dramatic was auto industry's reversal when auto plants resumed production and strong sales emerged during the second half of 2020. The abrupt and unprecedented increase in demand by the auto industry collided with production capacity already diverted to end markets that had boosted their orders at the beginning of the pandemic. Because it can take up to 6 months to produce a semiconductor, long-term contracts will help provide stability into the production process and help avoid future supply disruptions.

Despite these constraints, the semiconductor industry has met surging demand with historic levels of sales and shipment to the auto sector. Monthly YoY sales growth in automotive integrated circuits (ICs) experienced rapid recovery during Q3 and Q4 into positive territory. The chart below illustrates a V-shaped downturn and recovery in auto chip sales.



The momentum in sales to the automotive market has continued throughout 2021, soaring by 78% in Q2 of 2021. Automotive IC unit shipments have also grown at a similar and even faster pace in the first six months of 2021, indicating that the sales recovery and the following spike is not a result of a price increase.

Automotive sales reflect overall market dynamics. Year-over-year monthly chip sales (on a three-month-moving average basis) growth to all major consumers sectors has rapidly increased since the second half of 2020. The automotive sector has seen the largest growth from negative 27% to 66% between June 2020 and June 2021.



5. Modify Just-In-Time Inventory Practices

Relatedly, the adoption of just-in-time (JIT) inventory practices that prioritize cost minimization and increased efficiency proved ineffective in the face of the unanticipated supply chain disruptions generated by the pandemic. Industries that have adopted such practices should consider a reevaluation of their approach to inventory and supply chain management, building in a greater bias toward "just-in-case" approaches that build in greater resiliency.

6. WSTS: Leveraging Existing Industry Data

To improve transparency about the semiconductor supply chain, end users should leverage existing resources on industry data. The World Semiconductor Trade Statistics (WSTS) is the semiconductor industry's standard for semiconductor market data. The WSTS data provides monthly semiconductor sales by value, volume, and average selling price. It allows customers to track monthly trends in semiconductor sales for hundreds of semiconductor sub-products for all major end markets into all major country markets. The semiconductor industry has been running this sales tracking function since 1976, so it has gained significant experience and established a strong track record on tracking industry performance. The data is primary source data provided monthly by semiconductor companies themselves and aggregated so no individual company data is disclosed. SIA can provide more detail on the value of the WSTS data, the specific sales and market data collected through the WSTS program, and how the data collection program works.