The INSIGHT Partners

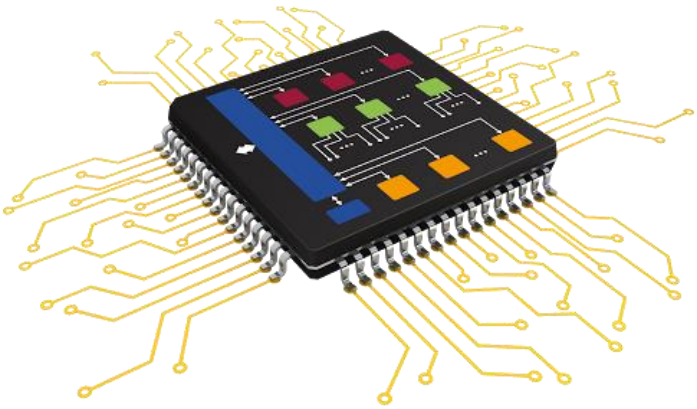
Semiconductor Industry and Advancements in Semiconductor Chips

OVERVIEW

Semiconductor chips are memory chips or microprocessors used in electronic devices. These semiconductor chips are made from silicon or germanium and can be of various types, such as logic, memory, discrete, optoelectrical, and analog. In the last decade, the sales of semiconductor chips worldwide doubled to US$ 602 billion in comparison to previous decade due to the rising usage of digital technology and connected devices in major industries such as healthcare, automotive, retail, consumer electronics, and manufacturing.

The rise in technological advancements is contributing to the development of the semiconductor industry. Manufacturers are making strides in enhancing the overall performance of semiconductors by developing chips with denser circuits and using new materials and architecture. For instance, NAND flash, an advanced memory chip, uses new architectures for long-term storage of videos and music. Also, next-generation power management chips use new materials called compound semiconductors, such as silicon carbide, for vehicle electrification.

The semiconductor chip supply chain consists of chip designing and fabrication, assembly, and testing. In early 2022, manufacturers witnessed a scarcity of chips, which forced manufacturers to temporarily shut down their assembly line operations. Supply chain resiliency is one of the important factors in the production of chip technology. Many US-based companies offer various services, such as chip designing and semiconductor manufacturing equipment & software designing. Further, other services such as wafer fabrication and assembling, testing, and packaging are majorly provided by companies based in Asia Pacific countries such as Taiwan, China, Japan, and South Korea.



The semiconductor industry continues to improve its computational performance, primarily by reducing the dimensions of key electronic features printed on the chip. According to Moore's law, approximately every two years, the number of transistors on a given integrated chip area is doubled by the industry, thereby delivering higher processing power at nearly the same cost.

Further, to improve computing performance, many semiconductor companies started investing in different methods such as dimensional scaling that involve the use of multicore processors, specially designed chips, new materials and architectures, and advanced packaging techniques. With the rising complexity of electronic features on chips and the rising cost of successive nodes, companies are adding new strategies to improve chip performance for certain products.

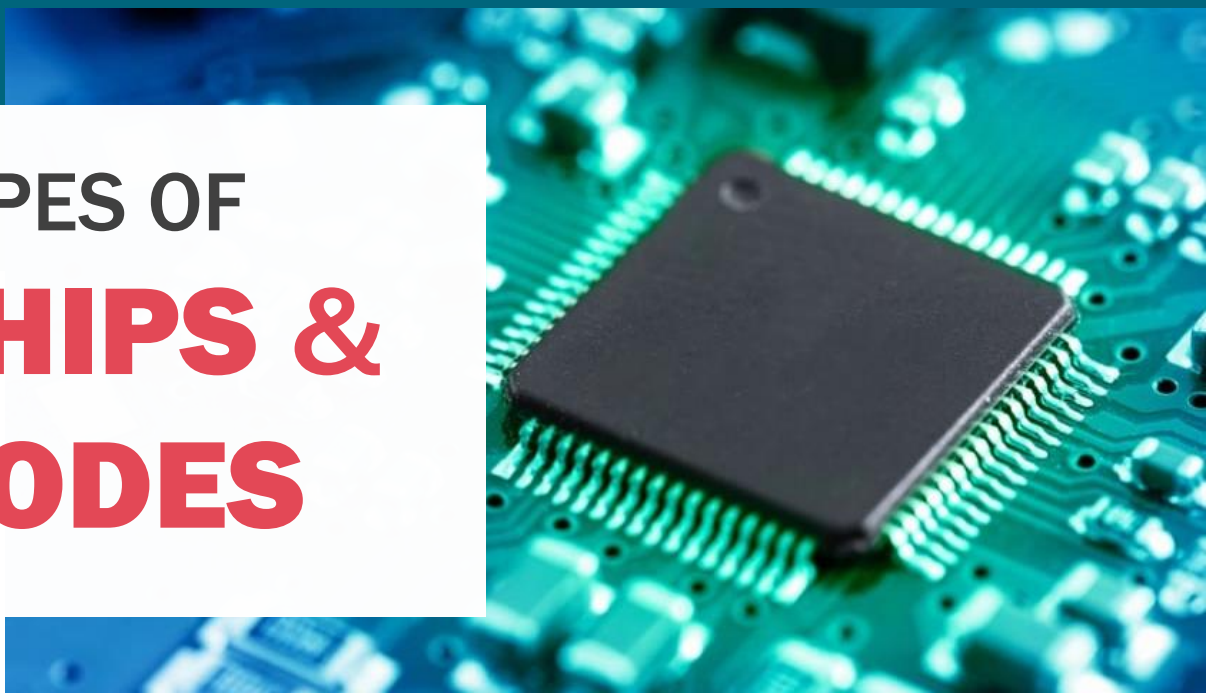
For instance, integrated circuits (IC) that are equipped with 3D transistors and chip architectures such as 3D NAND chips, with layers of stacked memory cells and new materials, including compound semiconductors. In addition, in an IC, the node size continues to decrease with new advancements in semiconductor technology. However, for some types of chips, process or technology nodes might not be the most appropriate metric to record advancements in performance.

For example, in sophisticated and advanced end systems such as power management chips and sensors, mature node semiconductors are considered critical components to rate the overall performance.

Moreover, the semiconductor industry relies on chemicals, gases, and various manufacturing equipment suppliers. Also, a semiconductor chip acts as a building block of emerging technologies such as 5G, artificial intelligence, and quantum computing. With the rising adoption of 5G technology, there has been a rise in the manufacturing of wireless devices that are needs to be operated at new frequencies, and enhanced data storage capabilities, which requires next-generation semiconductor chips.

Also, introduction of Artificial intelligence technology has led path for improvement in semiconductor chip in terms of reduction in design time, cost reduction and upgradation of technological infrastructure.

TYPES OF CHIPS & NODES



Semiconductor chips are of various types based on their functions such as processing, storing, sensing, and power management. The sales of logic, memory, and analog chips are major contributors to the revenue growth of the semiconductor industry. The remaining revenue is collected from the sales of optoelectronics, sensors, and discrete semiconductors. In 2022, the major application areas for semiconductors included the communication sector (30%), computers (26%), automotive (14%), consumer electronics (14%), industrial (14%), and government (2%).

A wide range of technology nodes is being widely produced, including logic chips that are equipped with advanced nodes (3 nm started producing in 2022) and mature generation nodes (250 nm). These mature generation nodes recorded significant demand in various applications such as 5G and smart devices. Companies in major countries such as China, Taiwan, and South Korea are focusing on the development of mature generation nodes as well as the production of advanced nodes.

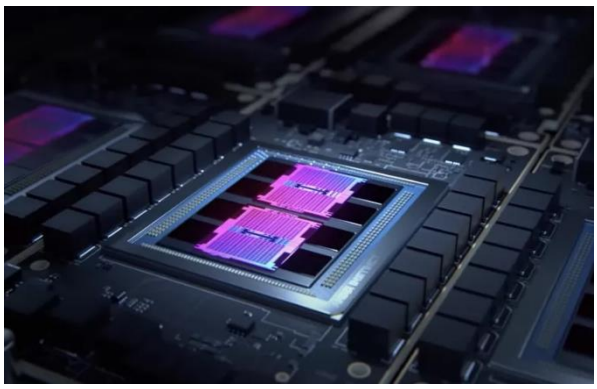
Similarly, the US, which is one of the major countries in the semiconductor industry, is also taking several measures to improve its positioning in the semiconductor chip production capacity. For instance, in July 2022, The CHIPS and Science Act was implemented with an aim to strengthen US-based semiconductor manufacturing, designing, and research. Under the act, ~US$ 280 billion in new funding will be provided to boost domestic research and manufacturing of semiconductors in the US.

Similarly, the European Union implemented the EU Chips Act to boost its chip industry. Under this act, an aid of US$ 47 billion of public-private partnership investment is provided to the industry that is focused on improving supply chains, reducing shortages of semiconductors, and promoting investment opportunities in the industry. This act aims to double the EU's global market share in semiconductors from 10% in 2022 to 20% by 2030. Also, under this act, US$ 6.83 billion is invested in the chip industry to promote the development of innovative technologies and establish competence centers for skill development.

ADVANCED PACKAGING

The advanced packaging segment of the semiconductor supply chain can offer improved device performance for chip applications, which provides more economic feasibility. The advanced packaging segment accounted for 40–45% of the packaging market share in 2022 and is expected to reach 60–65% by 2030. The US is having major market share in the global advanced packaging production capacity owing to the presence of Intel and Amkor. Similarly, Taiwan leads in advanced packaging production capacity as the country is a hub for many major companies such as ASE Group, TSMC, Chipbond, and ChipMOS.

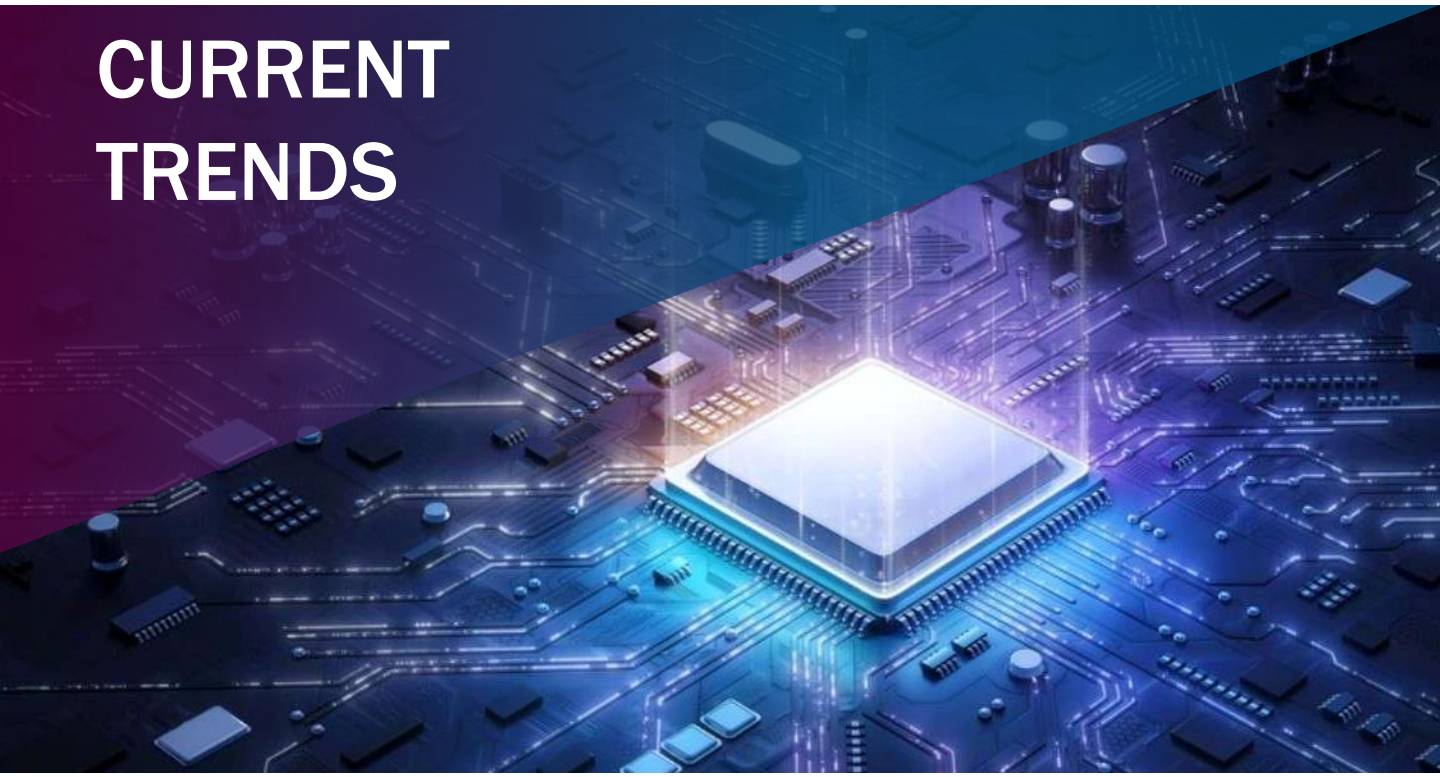
CHIPLETS



Consumer electronics such as smartphones and tablets require complex electronic functionalities with small footprints. To fulfill this necessity, semiconductor companies are working on integrating multiple elements of computing systems such as CPU, GPU, USB controllers, and network interfaces on a silicon-based system on a chip (SoC).

In addition, with increased functionalities and a rise in the cost of chips, manufacturers faced several challenges in integrating all features on the most advanced nodes. Hence, the semiconductor industry is widely using separate building blocks called chiplets. The usage of chiplet can foster innovation when strategies for improving performance are expensive. The semiconductor industry of China is progressively working towards the production of chiplets with the help of manufacturers such as VeriSilicon and Chipuller.

CURRENT TRENDS



The usage of automotive semiconductors in various application areas such as power control, central control, Internet of Vehicles, audio and video, and AI functions is increasing rapidly. Further, the demand for automotive chips with advanced processes is expected to record a CAGR of 20–22% in the coming years, owing to the rising need for computing power to perform advanced functions such as self-driving, ADAS, and real-time road monitoring.

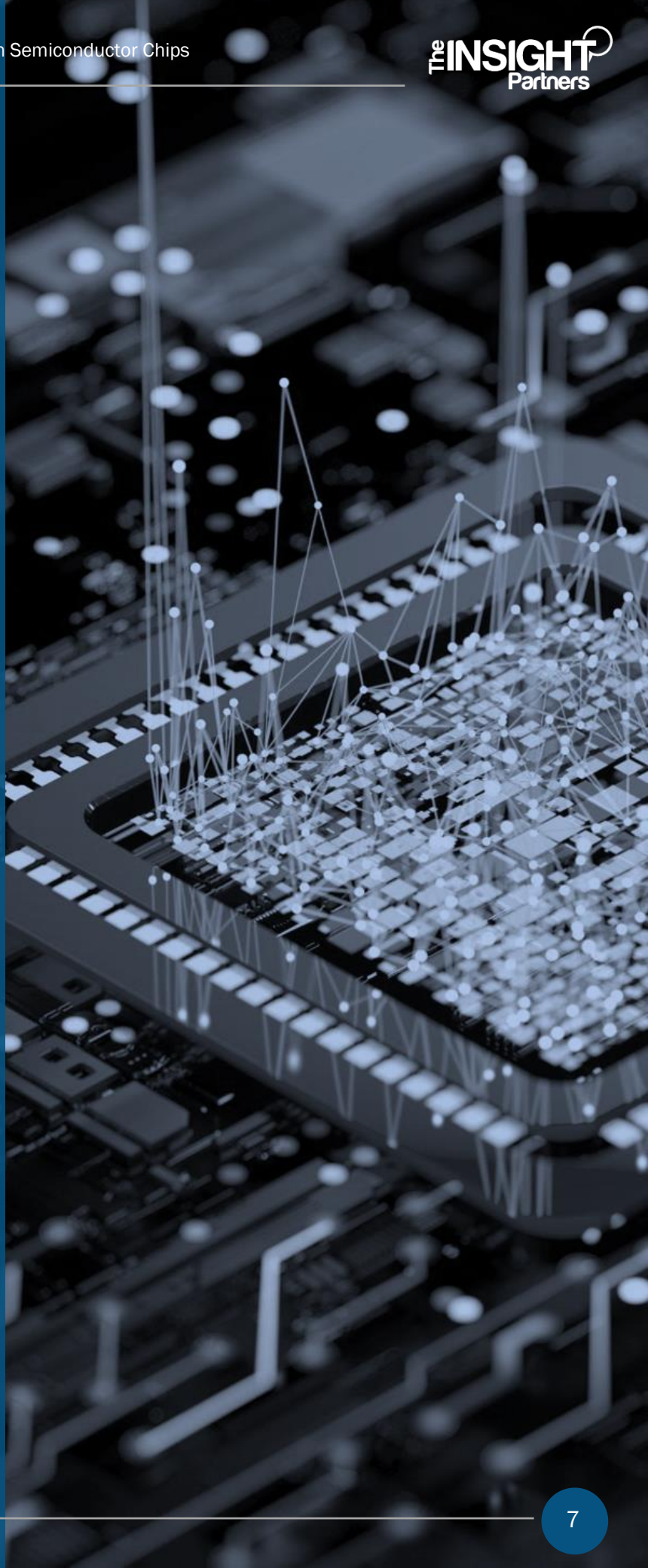
In the coming years, automotive OEMs might directly collaborate with foundries as well as participate in the supply chain. For instance, Volkswagen is focused on working with Qualcomm, a chip design company, and foundries such as TSMC and Global Foundries.

In 2022, CARIAD, the Volkswagen Group's software company announced that it will look to Qualcomm Technologies, Inc. to supply system-on-chips (SoCs) for CARIAD's software platform designed to enable assisted and automated driving functions up to Level 4.

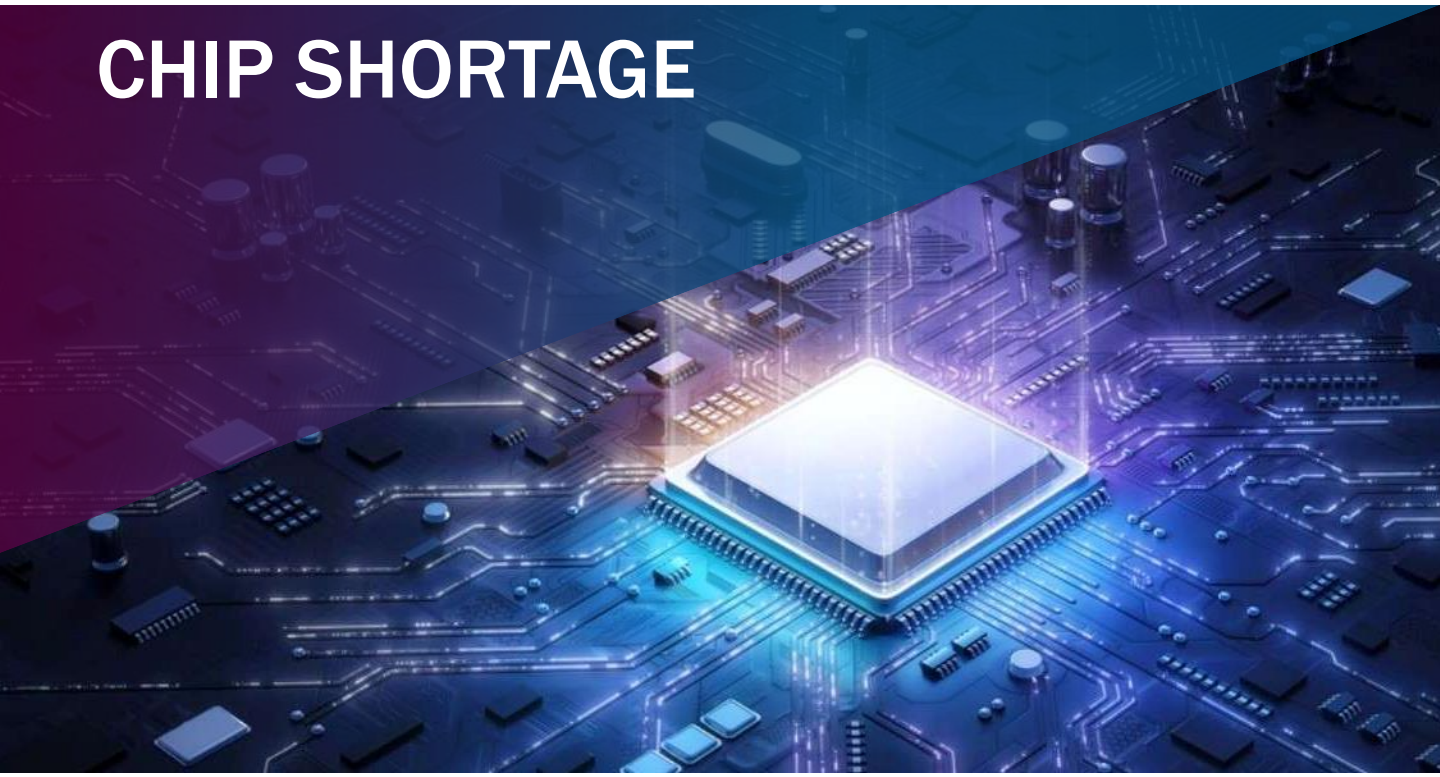
The demand for customized chips is increasing among key technology companies such as Amazon, Apple, Facebook, Tesla, etc. Hence, major brands are developing their customized chips rather than relying on semiconductor companies. Massive businesses such as OPPO, Xiaomi, and Media are also building their semiconductor manufacturing teams.

Global wafer manufacturers such as Wolfspeed and STMicroelectronics and Coherent are actively promoting the commercialization of 8-inch SiC wafers. The significant growth of applications, such as 5G communications, electric vehicles, and data centers, also helps the production capacity of SiC and GaN wafers.

The disrupted supply chain is one of the major challenges faced by the semiconductor industry after the onset of the COVID-19 pandemic as well as the Ukraine-Russia War. However, chip supply improved in late 2022 with the relaxation in COVID-19 restrictions, resolution of supply chain issues which is expected to continue improving in 2023. Further, to face current market dynamics, many companies that use semiconductors are already reassessing their long-term procurement strategies. A few of them are shifting to adopting the strategy wherein they order semiconductors in advance to avoid any future supply issues as well as to remain competitive in the market.



CHIP SHORTAGE



With the COVID-19 pandemic, semiconductor chip industry. The chip shortage begun with the impact on automotive production companies which saw a downfall in 2021.

Further, COVID-19 pandemic and closure of production plants has caused near-term supply issue triggering and global shortage. This has increased the time duration of chip delivery up to 15-22 weeks for the order placed by the companies. The largest chip manufacturing companies TSMC and Samsung also faced shortage to fulfill the demand in the market during 2021. Furthermore, the rising usage of semiconductor chips in industries such as automotive, computing, consumer electronics, communication, military, aerospace and others has led to the high demand of these semiconductor materials and triggered the issue of supply and demand in the industry

In early 2022, the imbalance can be seen for 200 mm wafers, from which lower end chips were manufactured. These lower-end power management chips and ICs are being demanded by automotive sector. However, due to shortage of supply, many carmakers and consumer electronics providers halted their operations causing unavailability of end-products in the market.

The Logic chip, which is generally used by companies like Qualcomm, NVidia or Apple are designed by these companies and manufacturing happens at foundries. The shortage of chip from these foundries also impacted these major electronic companies making them incapable to fulfill the market demand.

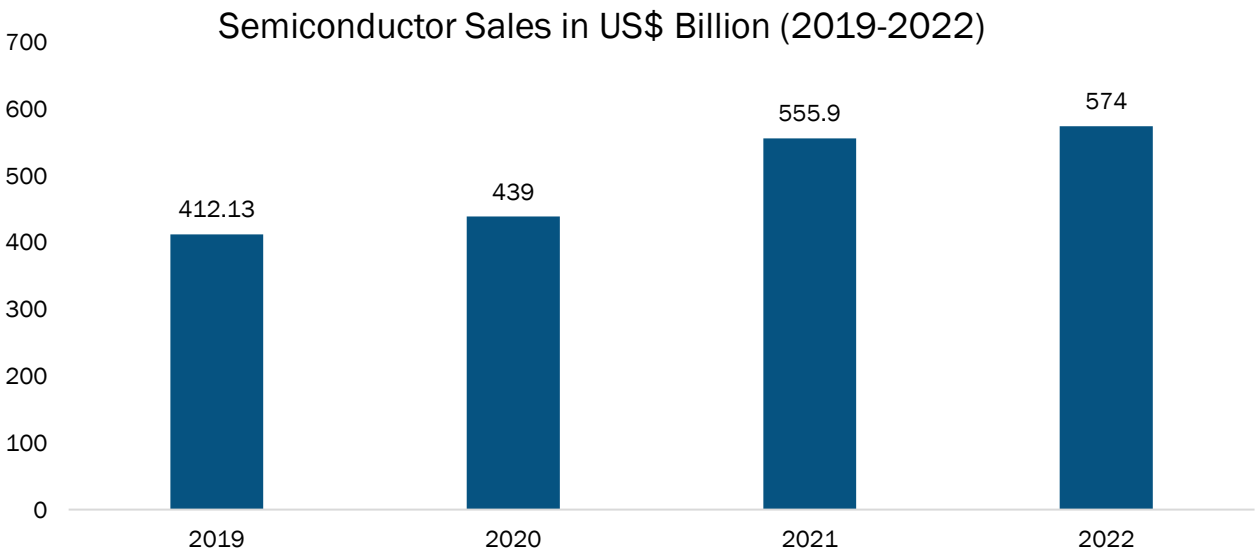
However, to resolve this issue, Intel, which is one of the largest chipmaker by revenue has planned to set up their own foundry so as to produce chip for other companies as well. This plan will help intel and other semiconductor companies in fulfilling the growing market demand globally.

Impact of Chip Shortage

The companies at regional and global level are pushing advanced logic chip manufacturing which can be seen; South Korea government planned to invest US$ 450 billion in coming ten years, similarly, EU is also planning to invest up to US$ 160 billion in its semiconductor sector. The US is also putting efforts to improve semiconductor industry with its new CHIPS act worth US$ 52 billion. Further, to improve the supply of ICs, chip industry is adding 38 new 300 mm volume fabs in between 2020 to 2024. This will help in increasing fab capacity by about 1.8 million wafers to reach over 7 millions by the end of 2024 and will help in coping up from the supply shortage.

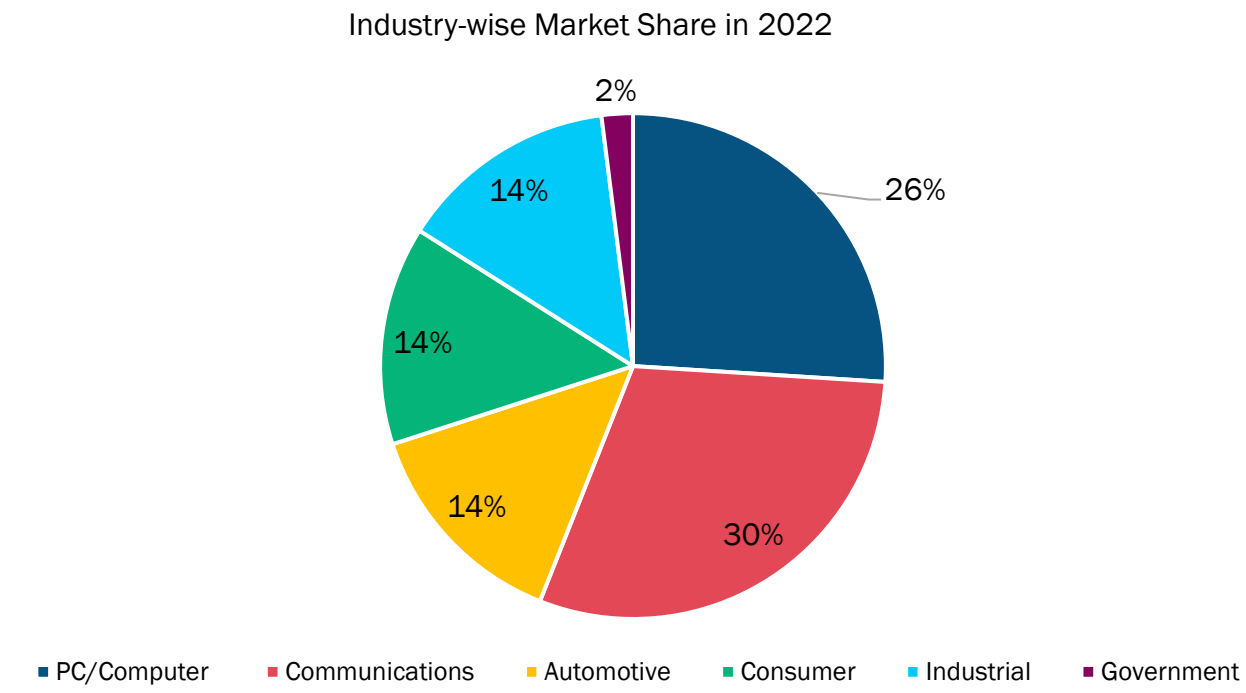
China is constantly increasing its share in 300 mm chips from 8% in 2015 to approximately 20% in 2024. At the same time companies in Japan region experiencing downfall from 19% in 2015 to 12% in 2024. Similarly, US, also witnessing some dip from 13% in 2015 to 10% in 2024. However, Taiwan and South Korea are still giving stiff competition to China based companies with their high investments in 300 mm fabs.

Companies that uses semiconductor chips, are reconsidering their order to procure material for long term. Many of the companies are moving towards the “just in time” ordering model to minimize the cost of procuring the material.



Source : Semiconductor Industry Association

Industry Trends



Source : Semiconductor Industry Association

At industry level, automotive segment is expected to witness fastest growth with rising demand for autonomous driving and Electric vehicles. By the end of this decade, the automotive industry might account for 12-15% of demand for semiconductors, With the rising usage of semiconductor chips within automotive segment, the category might account for up to 20-22% of market growth in the coming years.

Along with automotive industry, PC/Computer and communication segment is expected to propel the growth of semiconductor chips with the rising usage of smartphones and wireless communication devices which is further supported by the roll out of 5G technology.

During the COVID-19 pandemic, work from home concept has increased the sale of computer, monitor and other data storage systems. Entire education system got shifted to virtual learning which led to the increase in demand of laptops and tablets. Spending on Home entertainment such as smart TVs, gaming consoles also got amplified. Thus, increasing the demand for semiconductor chips in these sectors and creating a push for increasing the building IC capability globally and increasing investment in semiconductor foundry.

Key Players

Within semiconductor industry, the companies are competing in terms of providing smaller and faster chips in order to create affordable technology-based products in the market. ‘

Setting up a foundry can require investment above billion of dollars because of which it is not feasible for most semiconductor companies to produce semiconductor chips in house. Hence, a rising number of fabless semiconductor companies, such as Qualcomm, NVIDIA, and Broadcom, are outsourcing their entire manufacturing requirements to foundries such as Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Corporation. Mostly fabless semiconductor companies avail foundry services. In a fabless model, the company saves on investments in construction of a foundry and instead can utilize the funds in research and development. Such a model aids foundry service providers in gaining business, and hence is beneficial for both type of players.

Various industries, including automotive and consumer electronics, are investing in semiconductor MEMS technologies to strengthen their capabilities with advanced machinery and offer enhanced services to customers. The rising demand for advanced electronic devices and miniaturization of components will fuel the need for MEMS solutions. The increasing adoption of electric vehicles in recent years is fueling the demand for MEMS sensors. In addition, the demand for consumer electronic devices, such as smartphones, laptops, tablets, and wearables, is boosting the requirement for MEMS sensors. To cater to the rising demand of MEMS sensor for consumer electronic devices, MEMS foundries in countries such as Taiwan, the US, Germany, and the UK are developing innovative MEMS solutions.

Some of the key company are :

TSMC : *The company operates in the semiconductor industry and offers designing, developing, and manufacturing services to semiconductor market players. The company has the largest semiconductor foundry in world and manufactures more than 10,761 different types of products utilizing more than 272 unique technologies for more than 500 distinct customers across the world. TSMC offers an industry-leading specialty technologies portfolio that complements its advanced technology leadership. Additionally, the Company's comprehensive specialty technologies meet specific customer needs and include MEMS, CMOS Image Sensors, Embedded NVM, RF, Analog, High Voltage, BCD-Power processes, and more.*

Key Players

Intel : *Intel is known as the developer of processors for PCs and enterprise servers. The company also provide its solutions in retail, healthcare, industrial, memory and storage products, programable semiconductors and others.*

The company is in the business of producing motherboard chipsets, network interface controllers and ICs. The company is planning to invest in foundry business in order to reduce the chip supply issue.

Qualcomm : *Qualcomm is another key player of electronics and semiconductors industry. The company is known for its wireless communication products and services. Telecommunication industry is one of the major customer of Qualcomm for its CDMA patented technology which is used for wireless communication.*

The company also provide its snapdragon chipsets that are used generally in smart phones.

ROHM CO., LTD. *: the company is engaged in the business of design and production of integrated circuits, semiconductors, and other related electronic components. These products are used in various applications in domains such as automotive, consumer electronics, communications, energy, medical & healthcare, communication infrastructure, security, robots, and other industrial sectors. The product portfolio of Rohm comprises of Integrated Circuits (ICs), discrete semiconductors, power devices, passive devices, modules, opto devices, and commercial products.*

X-FAB Silicon Foundries SE : *The company is one of the global leading foundry group for analog or mixed-signal semiconductor applications. The company offers foundry services by combining solid, specialized expertise in advanced analog and mixed-signal process technologies with excellent service, a high level of responsiveness and first-class technical support. The company is specialized in providing analog Mixed-Signal, high voltage CMOS with non-volatile memory (NVM), MEMS, OPTO, silicon carbide, SOI, and sensors. X-FAB silicon foundries mainly manufactures wafers for automotive, industrial, consumer, medical, and other applications on modular CMOS and BiCMOS processes in geometries ranging from 1.0 to 0.13 µm, and special BCD, SOI and MEMS long-lifetime processes.*

Atomica Corporation : *The firm has been developing and manufacturing microelectromechanical systems (MEMS) and related microsystems for over 20 years. Additionally, the company offers platforms and experience in photonics, sensors, biochips, and custom MEMS. The firm utilizes a uniquely collaborative approach to development and manufacturing; Atomica collaborates with innovative companies to deliver breakthrough MEMS-based solutions in cloud computing, autonomous vehicles, cell therapy, molecular diagnostics, genomics, 5G, the Internet of Things, and more. Furthermore, Atomica is the largest MEMS foundry in the USA, serving customers from its 130,000 ft2 manufacturing campus in Santa Barbara, California.*

Road to Recovery

In 2020, the COVID-19 pandemic disrupted several industries, including automotive and electronics & semiconductors. In January 2021, Electronics Component Industry Association published a report stating that the pandemic hindered the supply chain, canceled trade events, delayed product releases, and disrupted many industry activities, which created pressure on worldwide trade. The electronics & semiconductors industry players had to halt their operations temporarily due to the imposition of lockdowns and shutdown of businesses. Further, the manufacturers of various electronics and semiconductor products experienced delays in lead time, which restrained the market growth in 2020 and 2021.

Further, In 2021, roughly 80 percent of all semiconductor wafer fabrication capacity in the U.S. was accounted for by U.S.- headquartered firms. Semiconductor firms headquartered in the Asia Pacific region accounted for most of the balance of capacity in the U.S. at 10 percent.

The tension between US and China has also resulted in bottlenecks faced by many key players. Both countries relied on each other's technology, however, with the recent circumstances at political level and the supply chain issues, gave rise to the trade war between the countries leaving semiconductor and electronics companies facing new trade policies and looking out new markets for production.

With the start of 2023, global chipmaker including Intel and Samsung seems positive about the end of semiconductor supply issue, but the forecast for demand of semiconductor material from the industries is still questionable due to the weakening of global economy, high inflation, rising interest rates and including cellphones, PCs, and data centers, that have contracted this year.

There has been a sluggish recovery in the semiconductor industry due to the production cut, less demand from industries and the rising production of high-end chips that are used for supporting AI based chips.

The shortage is not expected to end quickly, however, with the continuous efforts, and rising fab volumes, production units and usage of advanced technology will help in reducing the semiconductor chip scarcity.

Research Team

Nivedita is currently working as a Project Manager in the Semiconductor and Electronics domain of The Insight Partners. She has rich experience of more than 9 years in working and managing various Syndicated, Custom, Subscriptions and Consulting research assignments.

She has a profound understanding in Market Research and Business Consulting and has been instrumental part of various critical projects in delivering data-driven analysis and actionable insights. During her tenure, Nivedita has worked with a wide range of electronics and semiconductors companies, studying the entire process undertaken for the project, analyzing the industry/market for new trends in process.

Nivedita holds MBA degree in Management from IMS, Dehradun. Prior to joining The Insight Partners, she has previously worked in Markets & Markets, Pune, Future Market Insights, Pune, and at various research positions.

Nivedita Upadhyay

Project Manager

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About Us

The Insight Partners is a global research and consulting company that teams up with industry players to address their most pressing business difficulties and explore growth opportunities. We are a one-stop shop for providing qualitative and quantitative insight gleaned through industry research.

Through our market intelligence services our clients can better identify its market segment, market penetration, and overall opportunity with the aid of multi-level information in the analyses. Inclusion of competitor intelligence, focusing on details about a company's description, competitors, products and services, latest developments, and financial information can help strategy and marketing leaders choose the right decision based on the underlying information.

Our team of subject matter experts and consultants are dedicated to offering our clients the best possible research and analysis at an affordable cost. Our success depends on a culture of close cooperation and a large, diversified global community that is committed to improving the world and one another every day. Our success depends on a culture of close cooperation and commitment to improving decision making for business growth and prosperity.

Contact us

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