Semiconductor Supply Chain Analysis

aranca

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Executive Summary

01

Global semiconductor supply chain concentrated in one region

- The US has the strongest chip design ecosystem with a higher share in the global designing market.
- Manufacturing activities and the OSAT market are concentrated in Asia, with a few companies dominating the space.
- A rise in the number of electronic devices across end applications boosts semiconductor demand.

02

Taiwan, South Korea, and China dominate global foundry market

- Manufacturing capacity over the past three decades has shifted from the US and Europe to Asia.
- TSMC and Samsung Foundry together hold 70% market share.
- Advanced sub-7nm chip manufacturing is concentrated in Taiwan and South Korea.

03

Demand supply imbalance to persist in mid-term

- Communications and PCs/computers are expected to account for a lion's share in semiconductor demand.
- Covid-19 has accelerated demand, innovation, and automation, resulting in demand supply imbalance.
- Supply constraints prevail mainly due to an oligopolistic industry and foundry capacity shortage, supported by generic business-specific risks

04

Major countries, companies take steps to address global supply chain disruption

- The US and EU governments have introduced reforms to attract more investment and expand chip production capacity.
- China and South Korea are focused on becoming self-sufficient and doubling exports over the next decade.
- Top semiconductor companies are investing heavily to improve the overall output capacity.

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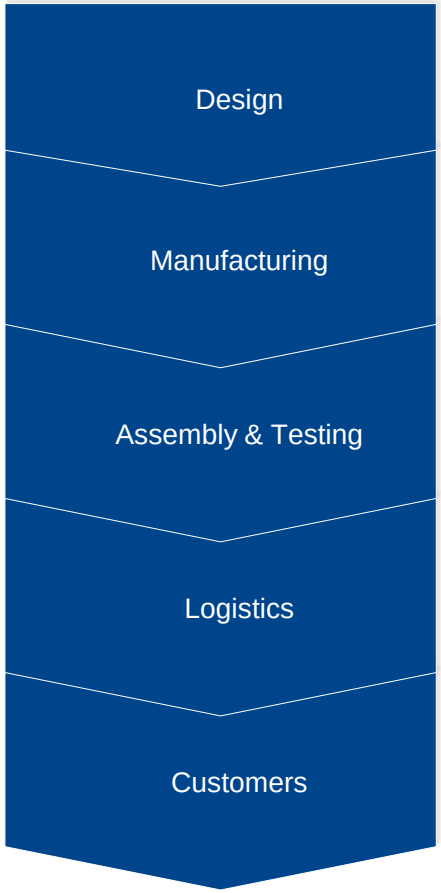
Global Semiconductor Supply Chain

Fragmented market with regional dominance across the semiconductor supply chain

No country has the entire production stack in its own territory. Manufacturing semiconductor devices requires multiple steps that are performed in specialized facilities known as foundries or fabs. The US remains the global leader in semiconductor design, though a sizable portion of chip manufacturing also occurs in Asia.



- Historically, the US has had the strongest chip design ecosystem.
- US chip design companies account for 64% of the global market.
- Top companies in the IC design space include Qualcomm, NVIDIA, and Intel.

- Front-end manufacturing that involves the manufacturing of chips is carried out by foundries in their fabrication plants.
- Fabless companies, such as Qualcomm, NVIDIA, and HiSilicon, closely collaborate with foundries.
- The foundry market is dominated by a few top players concentrated in Taiwan and South Korea.

- Back-end manufacturing involving assembly, testing, and packaging requires limited innovation and a small value add.
- Assembly, testing, and packaging are mostly outsourced to Asian countries (China being the largest OSAT* market).
- The OSAT market is highly competitive with several major players such as ACE, Amkor, and JCET.

- The semiconductor industry requires logistics solutions that are as integrated and precise as the microchips.
- Semiconductor wafers need careful handling as they are hyper-sensitive.
- A few logistics companies service top global chip makers including Nippon Express, DHL, and Kuehne+Nagel.

- Semiconductors power all kinds of electronic devices and play an indispensable role in today's economy.
- Global application includes mobile phones, consumer electronics, PCs, ICT infrastructure, industrial, and auto.
- Mobile phones and ICT infrastructure constitute 50% of global semiconductor sales, followed by PCs (19%).

Source: *Semiconductor Industry Association, AMD, Globalnewswire, Counterpoint Research, Financial Times, BCG; *OSAT – Outsourced Semiconductor Assembly and Test*

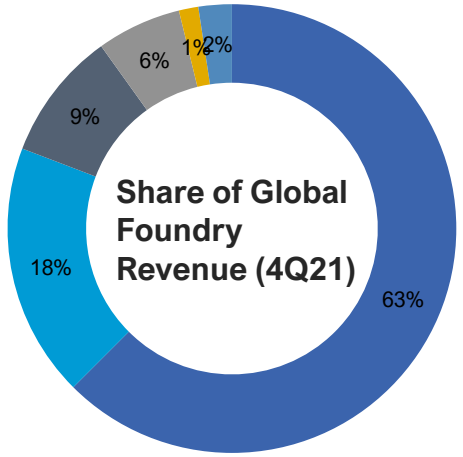
Geographic Analysis

More than 85% of global foundry market concentrated in Taiwan, South Korea, and China

Fabless chip makers design chips and outsource chip production to foundries mainly located in Asia. The semiconductor manufacturing base has shifted to Asia in the past three decades. As a result, the US and Europe's share in global manufacturing capacity dropped from 81% to 21% in 2020.

Global Foundry Market

Foundries are pure-play players that only manufacture devices for other companies and are not engaged in designing them.



About 100% of most advanced chip (<10 nm) manufacturing capacity is concentrated in Taiwan (92%) and South Korea (8%).

Rank	Company	Market Share	Geography	Company Description
1	TSMC	52.1%	Taiwan	TSMC is the world's largest contract manufacturer of semiconductor chips.
2	Samsung Foundry	18.3%	South Korea	Samsung Foundry is one of the three leading edge foundry offerings on the market.
3	UMC	7.0%	Taiwan	UMC is a leading global semiconductor foundry company. It serves all the major sectors of the electronics industry.
4	GlobalFoundries	6.1%	US	GlobalFoundries is one of the world's leading semiconductor foundries with a global footprint in the US.
5	SMIC	5.2%	China	SMIC is the largest contract chip maker in Mainland China and the fifth largest globally.
6	HuaHong Group	2.9%	China	HuaHong is a global leading pure-play foundry with specialty process platforms.
7	PSMC	2.0%	Taiwan	PSMC is a manufacturer of ICs and discrete components offering foundry, design, and wafer testing services.
8	VIS	1.5%	Taiwan	VIS is a leading specialty IC foundry service provider.
9	Tower	1.4%	Israel	Tower serves high-growth markets and has facilities in the US and Asia.
10	Nexchip	1.2%	China	Nexchip is a semiconductor foundry specializing in IC production.

Source: *Visualcapitalist, BCG and SIA, Gartner, Koreaherald, Company Websites; Note: Market share as of 4Q21*

Case Study

NVIDIA, AMD adopt fabless manufacturing strategy

NVIDIA employs world-class suppliers for all phases of the manufacturing process including wafer fabrication, assembly, testing, and packaging. It focuses on product design, additional quality assurance, marketing, and customer support.

Semiconductor Wafer Production	Assembly/Testing/ Packaging
▪ Taiwan Semiconductor Manufacturing Co Ltd ▪ Samsung Electronics Co. Ltd.	▪ Amkor Technology ▪ King Yuan Electronics Co. Ltd. ▪ Omni Logistics, LLC ▪ Siliconware Precision Industries Co. Ltd. ▪ Wistron Corporation

- Semiconductor wafer production, assembly, testing, and packaging are carried out by third parties located outside the US.
- About 84% of revenue in FY21 was derived from sales outside the US.

AMD initially manufactured its own processors but later outsourced manufacturing and adopted a fabless manufacturing strategy. After spinning off its chip foundries into GlobalFoundries, the company focused on designing products to be manufactured at for-hire foundries.

Semiconductor Wafer Production (=<7nm)	Semiconductor Wafer Production (>7nm)	Assembly/Testing/ Packaging
▪ Taiwan Semiconductor Manufacturing Co Ltd	▪ GlobalFoundries Inc.	▪ Carried out by third-party manufacturers in Asia Pacific; majority of ATMP* conducted through a JV with Tongfu Micro Electronics Co. Ltd.

- Semiconductor wafer production, assembly, testing, and packaging are carried out by third parties located within and outside the US.
- About 72% of revenue in FY21 was derived from sales outside the US.

Source: *Annual Reports (NVIDIA & AMD); *ATMP – Assembly, test, mark, and pack*

Demand Analysis

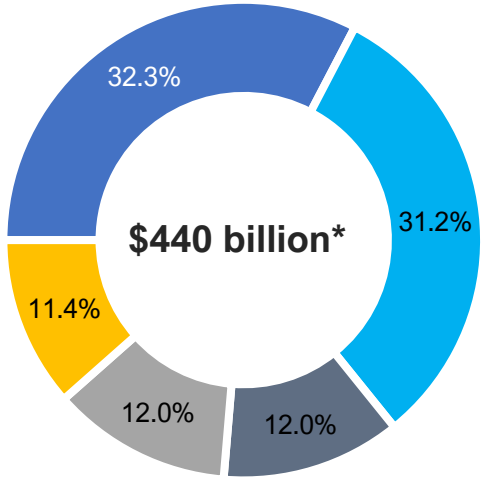
Global semiconductor chip industry expected to grow 10% in 2022 as end market demand spikes

Rising demand for products powered by semiconductors has in turn pushed demand for semiconductor chips higher. Smart electric cars, mobile devices, communication infrastructure and IoT devices in particular are responsible for driving the semiconductor industry to its all-time high revenue of $556 billion in 2021 and is further expected to touch $600 billion in 2022.

Percent of Semiconductor Demand by End Use (2020)

PC/Computer

- PC/Computer comprised 32.3% of the total end-use market in 2020.
- Covid-19 accelerated demand for personal computing, driven by work-from-home policy, remote learning, and other trends.
- Demand is expected to sustain, led by new segments (education/healthcare) and geographies.



Communications

- Communications comprised 31.2% of the total end-use market.
- Growth drivers related to smart mobile devices include improved functionality, speed, and performance.
- Communications infrastructure and data centers are projected to witness growth from 5G wireless infrastructure, data center applications, and satellite communications.

Automotive

- Automotive comprised 11.4% of the total end-use market.
- The number of semiconductor devices per car is likely to double between 2016 to 2027 to over 2,000 ICs per car.
- Innovation in the segment, such as electric and autonomous vehicles, advanced infotainment, connectivity, and security would fuel growth.

Consumer

- Consumer represented 12% of the total end-use market.
- The pandemic stimulated demand for digital consumer electronics.
- High-end segments, such as mini-LED, OLED, HFR 4K, and smart TVs, are anticipated to drive growth.

Industrial

- Industrial accounted for 12% of the total end-use market.
- Growth in the segment was driven by factors such as factory automation, test and measurement, smart city, healthcare, and connected home.

Source: *Gartner, IHS Markit, Deloitte; * 2020 Total Global Semiconductor Market*

Supply Analysis

Strong demand, limited supply, and supply chain disruption result in current chip shortage

Supply chain shocks that affect global production and last at least a month occur on average every 3.7 years, resulting in companies losing 47% of a year's earnings every decade. A Deloitte report released last year stated that customers were waiting between 20-52 weeks for multiple kinds of semiconductors leading to huge revenue losses.

Natural Disasters

Texas snowstorm, Japan plant fire

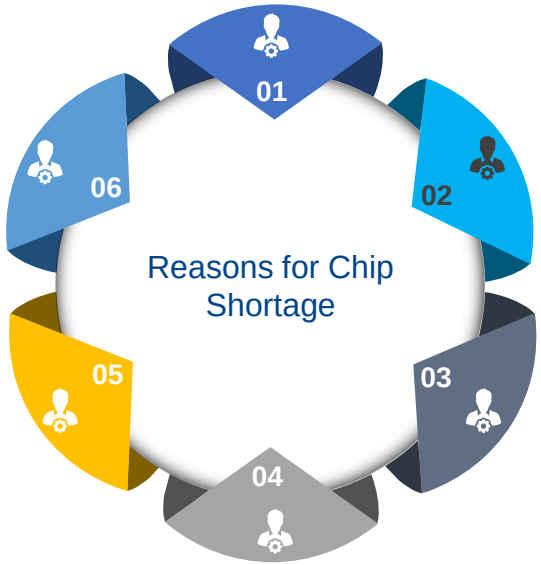
Covid-19 resurgence in Southeast Asia and China

Drought in Taiwan affecting manufacturing of wafers that require pure water

Foundry Capacity Shortages

Pent-up demand in various sectors

Peak utilization levels across process nodes



Infrastructure Slowdowns

Poor power availability across China

Backlogs at various ports

Mobility restrictions across the board

Oligopolistic Industry

Semiconductor industry dominated by few players

Lack of advanced/standard semiconductor foundries

Covid-19 Pandemic

Covid-related factory shutdowns

Worker and health safety

Restrictions on mobility/travel ban

Geopolitical Conflicts

China-Taiwan looming conflicts

US-China trade dispute; sanctions against China

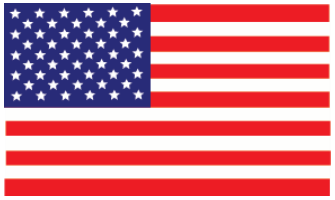
Russia-Ukraine war impacting select inputs exports

Source: *Various Articles and Press Release, Company Reports, Deloitte*

Mitigation Steps…1/2

Major countries take steps to address global supply chain disruptions

Any permanent disruption to Taiwan could create global economic disruptions requiring a minimum of 3 years and $350 billion investment to build capacity in the rest of the world as a replacement for Taiwanese foundries. Building local supply chains in each region would require significant incremental investment of ~$1 trillion with a resulting 35-65% rise in semiconductor prices.



US

- Congress passed the CHIPS* Act in January 2021 to promote R&D and manufacturing of domestic chips.
- The USICA# Act in June 2021 and Americas COMPETES Act in February 2022 include a $52 billion investment in the sector.
- Congress is considering legislation known as the FABS Act to establish a semiconductor investment tax credit.

Europe

- The European Commission announced a new European Chips Act involving $49 billion in public and private funding.
- This broad initiative would boost Europe's R&D innovation and bring leading-edge manufacturing to the region.
- The goal is to double the EU's share in global chip production from 9% to 20% by 2030.

China

- China implemented several policies, including tax reduction and funding support, to boost the semiconductor sector.
- Since 2015, China has allocated at least $180 billion in support of this industry.
- By 2025, China aims to achieve 70% self-sufficiency in high-tech industries.

South Korea

- The government revealed the "K-Semiconductor Strategy" where chip makers pledged investments of over $451 billion by 2030.
- Tax deductions and infrastructure packages were also planned to encourage chipmakers' competitiveness.
- This could lead to annual semiconductor exports increasing to $200 billion, which is twice the amount in 10 years.

Source: *Chinadaily, Intel, Nikkei Asia, KBS World, Forbes, SIA; *CHIPS Act – Creating Helpful Incentives to Produce Semiconductors Act, #USICA – United States Innovation and Competition Act*

Mitigation Steps...2/2

Major semiconductor companies increase investments to address rapid growth in demand

The global semiconductor industry is projected to enhance the overall output capacity to an unprecedented level. The three largest players are expected to incur capital expenditure exceeding $200 billion through 2023. Global wafer starts are expected to be 50% higher by the end of 2023 compared to 2020.

Semiconductor Companies	Planned Investment	Rationale	Duration/Start
intel	$85 billion	Intel's IDM 2.0 strategy aims to create a next-generation European chip ecosystem and address the need for a more balanced and resilient supply chain. The company plans to become a major provider of US- and EU-based foundry capacity in order to meet surging global demand for semiconductors.	Over the next decade
SAMSUNG	$205 billion	Samsung intends to expand its foundry production capacity by 3x by 2026 amid global chip shortage. It would expand its production lines in Pyeongtaek, Seoul, and build a new factory in the US. A part of the $205 billion would be used for semiconductor expansion.	Through 2026
tsmc	$100 billion	TSMC plans to invest $100 billion for increasing its manufacturing capacity in its plants in order to meeting the growing need of semiconductors over the next three years.	2026
Micron	$150 billion	The company aims to build cutting-edge memory manufacturing technology and R&D over the next 10 years. The investment would also include fab expansion in the US.	Over the next decade
SK hynix	$106 billion	SK Hynix plans to construct a 4.15 million sqm industrial cluster that would accommodate four new semiconductor fab plants and scale up the production capacity.	2026

Source: *Chinadaily, Deloitte, Company Reports, Company Press Release, Nikkei Asia*

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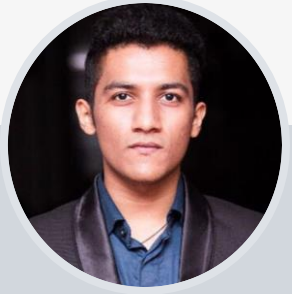
Connect with our Team

Clarence Menezes
Senior Manager – Investment Research

+91.22.3937.9999
clarence.menezes@aranca.com



Rishi Kabra
Analyst – Investment Research

+91.22.3937.9999
rishi.kabra@aranca.com

Nikhil Salvi
AVP – Investment Research

+91.22.3937.9999
nikhil.salvi@aranca.com

For more details: *www.aranca.com* | *https://www.linkedin.com/company/aranca* | *https://www.aranca.com/knowledge-library*

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