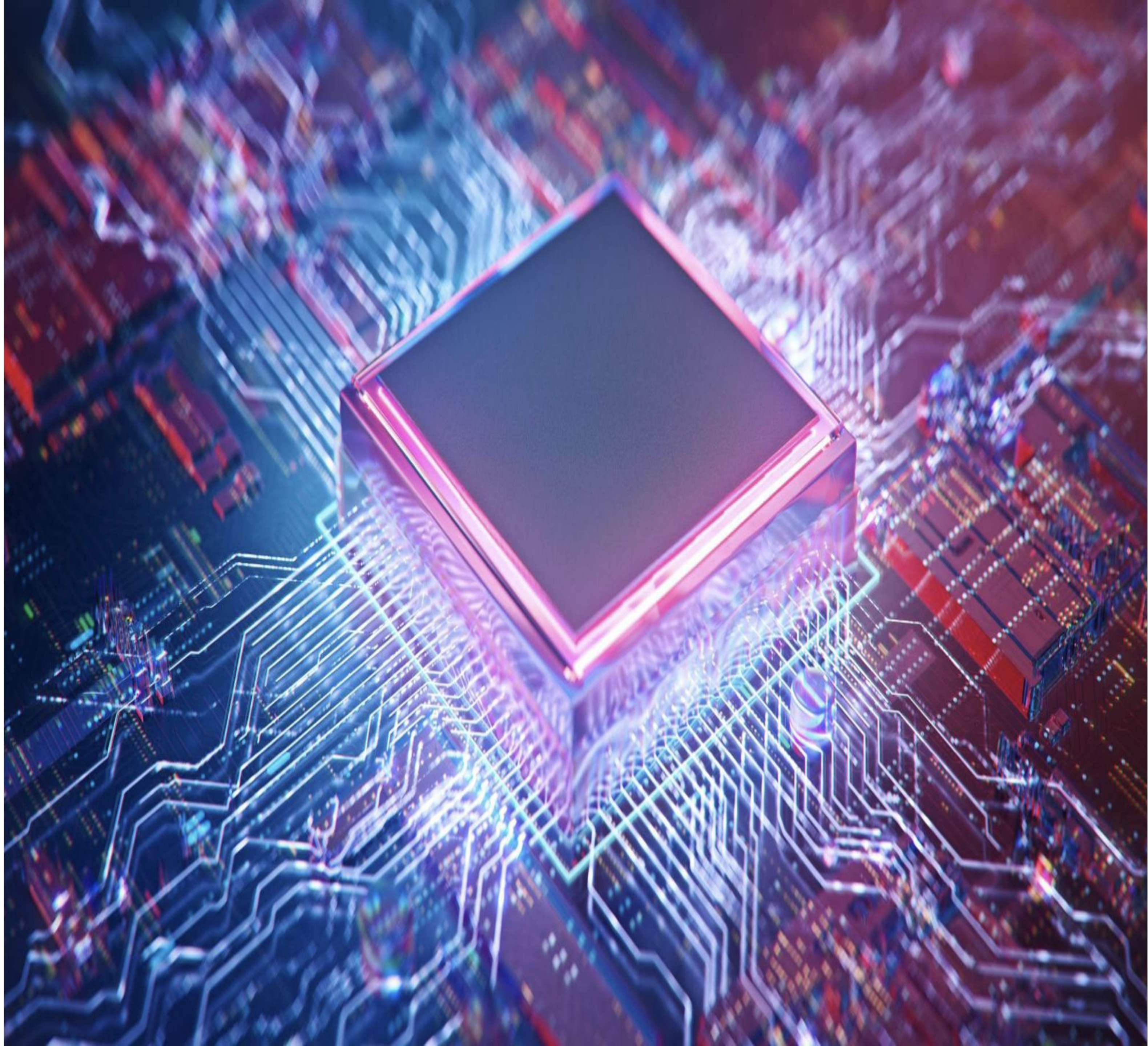
Semiconductors

The Next

Near-shoring Frontier

U.S.-MEXICO FOUNDATION



Semiconductors: The Next Near-shoring Frontier

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1. Introduction
2. History
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4. Efforts to boost the Semiconductor Industry
5. Challenges in the Industry
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1. Introduction to semiconductors
What are they?

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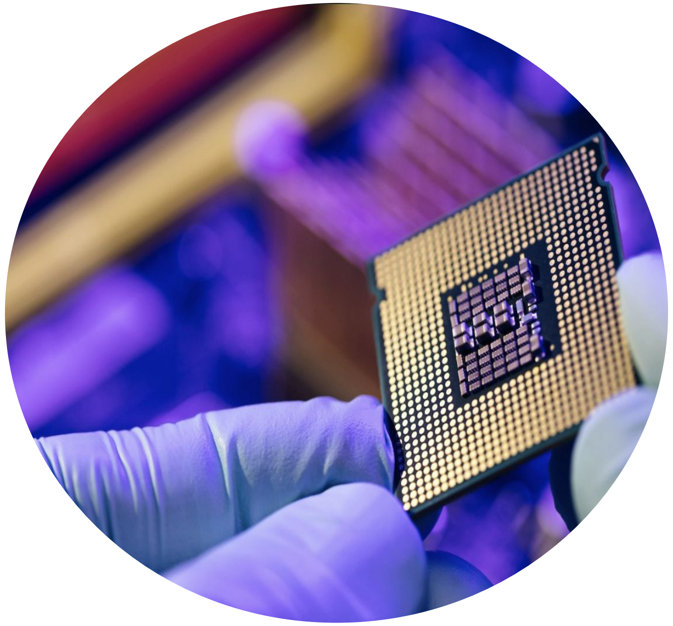
Semiconductors or microchips, are key components that enable electronic devices to process, store and transmit data.[1]

They control electrical currents within all kinds of devices:

- When exposed to heat, light or voltage they conduct electricity (due to their gold, silver, and copper components).
- When exposed to low temperatures they insulate electricity (due to their rubber, glass, and ceramic components).[2]



[1] "Strengthening the Global Semiconductor Supply Chain in an Uncertain Era".
[2] International Roadmap for Devices and Systems.

1. Introduction to semiconductors

What are they made from?

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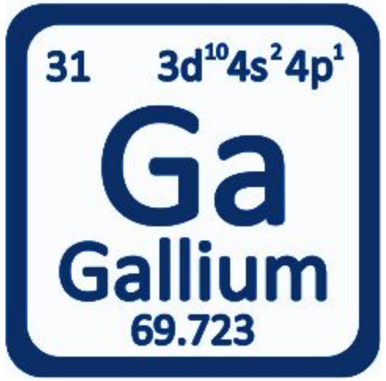
Semiconductors are usually made from

Silicon



Gallium arsenide

Germanium

1. Introduction to semiconductors

What types are there?

There are 3 main semiconductor type:

DAO (Digital-Analog-Optical), ideal for audio and video processing applications.

Logic, used to build microprocessors, memory chips, and other digital logic devices.

Memory, are used to store digital data and there are two main types:

1. Random Access Memory (RAM) chips: requires power to maintain its stored data.
2. Read-Only Memory (ROM) or Flash Memory chips, retain its stored data even when power is turned off.

1. Introduction to semiconductors

What types are there?

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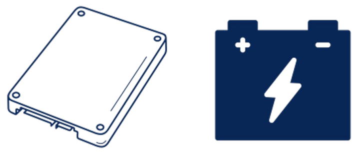
Semiconductors are divided in 1st, 2nd and 3rd generation:

1st generation

- For applications requiring low to moderate frequencies and power levels.
- Employed in microprocessors, memory chips, and analog circuits.
- They power computers, smartphones, and various consumer devices.

2nd generation



- Excel in high-frequency and optoelectronic applications.
- Allow for faster switching speeds and higher operating frequencies.
- Employed in high-speed digital circuits, microwave devices, LEDs and lasers.
- Used in power electronics, RF amplifiers, high-power transistors, and solid-state lighting.

3rd generation

- Possess exceptional properties, including higher breakdown voltages, higher operating temperatures, and higher switching frequencies compared to traditional semiconductors.
- Enable more efficient and compact power conversion, reducing energy losses.
- Used for power electronics, electric vehicles, renewable energy systems, and sensors.

1. Introduction to semiconductors
How are they made?

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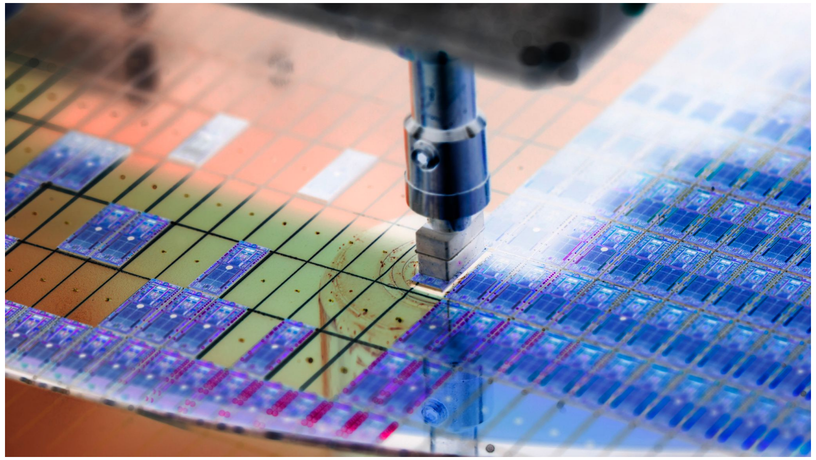
Semiconductor production requires the use of hundreds of complex materials and speciality chemicals.

- As many as 300 different inputs, many require advanced technology to be produced. For example:
  - Polysilicon used to make silicon that is sliced into wafers requires a purity level 1,000 times higher than the required for solar panels.
- This complexity translates into many challenges for the industry:
  - Supply chain dynamics and risks (pandemics, geopolitical tensions).
  - Market concentration and competition (risk of inflation).



Source: BCG analysis based on data from SEMI, IHS, and HSBC and Semiconductor Manufacturing by Country 2023.

1. Introduction to semiconductors
What industries use them the most?

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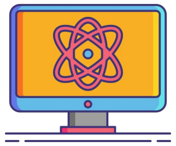
Semiconductor demand from high-tech industries in key sectors is expected to continue increasing:

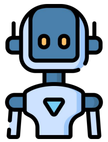
- They represent an **essential input** for all kinds of industries across all sectors (with an annual growth rate of more than 20% in sectors like electronics, communication, automotive, consumer, industrial and govt, etc.).
- **Are increasingly relevant for technological development of the future** (EVs, robotics, AI, clean energy, etc.).

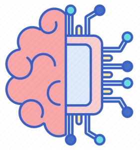
2021 DEMAND BY END-USE

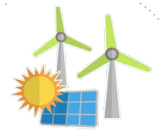
End-Use Category	Computer	Communication	Automotive	Consumer	Industrial	Government
Annual Growth	23.1	24.0	37.9	28.9	26.6	26.4
Total Value ($B)	175.0	170.6	69.1	68.4	66.9	5.8


Electric vehicles


Quantum computing


Robotics


Artificial Intelligence


Clean energy


Internet of Things

Source: SIA State of the US Semiconductor Industry Report 2021.

2. History of semiconductors

Summary

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Early Days (Pre-1950's)

Theories developed in the 17th-19th centuries, but limited technology impeded testing until the Second Industrial Revolution.

First Expansion Period (1950's-1980's)

The period witnessed substantial growth in the semiconductor industry, marked by the rise of Silicon Valley.

Space Race and the Japanese Business Model (1950-1991)

The Cold War era witnessed a technological race against the USSR, followed by a subsequent competition with Japan.

Industry consolidation (1960–2023)

In the last decades, the semiconductors market consolidated its growth, with a notable increase in **Asian participation led by TSMC.**

2. History of semiconductors

Early days - pre 1950's

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The 2nd Industrial Revolution triggered creativity. Between 1865-1880 the U.S. developed more than 400 individual patents[3].

With the interwar expansion, the American industry experienced growth. DoD financed 80% of R&D.

USGov guided the early years of semiconductor industry using supply incentives, demand supports, and regulatory coordination.

In 1946, UPenn built the first general purpose computer using vacuum tubes; the ENIAC[4].

[3] "History of Semiconductors" Journal of Telecommunications and Information Technology. January 2010.
[4] "The world's first general purpose computer turns 75", University of Pennsylvania, February 2021.

2. History of semiconductors

First Expansion Period: 1950's - 1980's[7]

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The 50's pinned the born of Silicon Valley. In 1955, William Shockley opened Shockley Semiconductor, in Mountain View.

The "traitorous eight," including Moore, split from Shockley in 1957 and formed Fairchild.

The industry experienced growth surpassing $100 million by 1957. The Moore's Law by Gordon Moore in 1965 marked a milestone in industry.

The 1970's represented a golden age for U.S. domestic semiconductor firms. This period end with the Japanese licensing model in the 80's.

Source: "The Global Might of the Tiny Chip" The New York Times. November, 2020

2. History of semiconductors

The Space Race

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During the Cold War, the semiconductor industry in the United States and the USSR exhibited contrasting characteristics. Silicon Valley prioritized commercial applications, driving innovation with a strong emphasis on R&D and a robust global supply chain. In contrast, the USSR[5]:

Soviet distribution channels were centralized and hierarchical[6], limited by institutional barriers.

The Soviet Union failed to miniaturize computer power for consumer use.

Soviet chip development was focused on military purposes.

[5] "The Peculiar History of the Computers in the Soviet Union" The Wilson Center. August, 2015
[6] "Chips War" Chris Miller, October, 2022

2. History of semiconductors

The Japanese Business Model

The Japanese model was based on acquiring licenses, innovating, designing for consumer needs, and effective marketing.

Japan's electronic equipment manufacturers released calculators one after another, leading to fierce "calculator wars" until the end of the 1970s (they opt for licensing Texas Inst. patents).

Japan had used the same types of policies that the U.S. had to rapidly build out capacity and dominate global markets: centralized regulatory guidance, supply agreements, cheap financing.

1980s, when the U.S. lost market and technological dominance to Japanese firms guided by industrial policy from the Ministry of International Trade and Industry.

Source: ibid "Chips War" Chris Miller, October, 2022

2. History of semiconductors

Industry consolidation 1960–2023

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The semiconductor market has increased concentration risks in recent decades, exemplified by ASML's advanced lithography, China's share in semiconductor manufacturing, and Taiwan's crucial role as a chip producer.

These concentration trends raise concerns regarding reliance on a single entity, the importance of intellectual property protection, and the necessity to diversify production for a more resilient and sustainable industry.

The Dutch Ally

ASML, leads the semiconductor lithography technology, commands the market with a substantial 80% share.

Chinese footprint

China accounts for over 50% of global semiconductor manufacturing, making it the largest producer worldwide.

Taiwanese Commitment

Taiwan is the sole manufacturer of over 60% of the world's semiconductors, including 92% of the most advanced ones.

Source: Advanced Microchip Production Relies on Taiwan, Forbes.

3. Current Context of the semiconductor industry

Globalization

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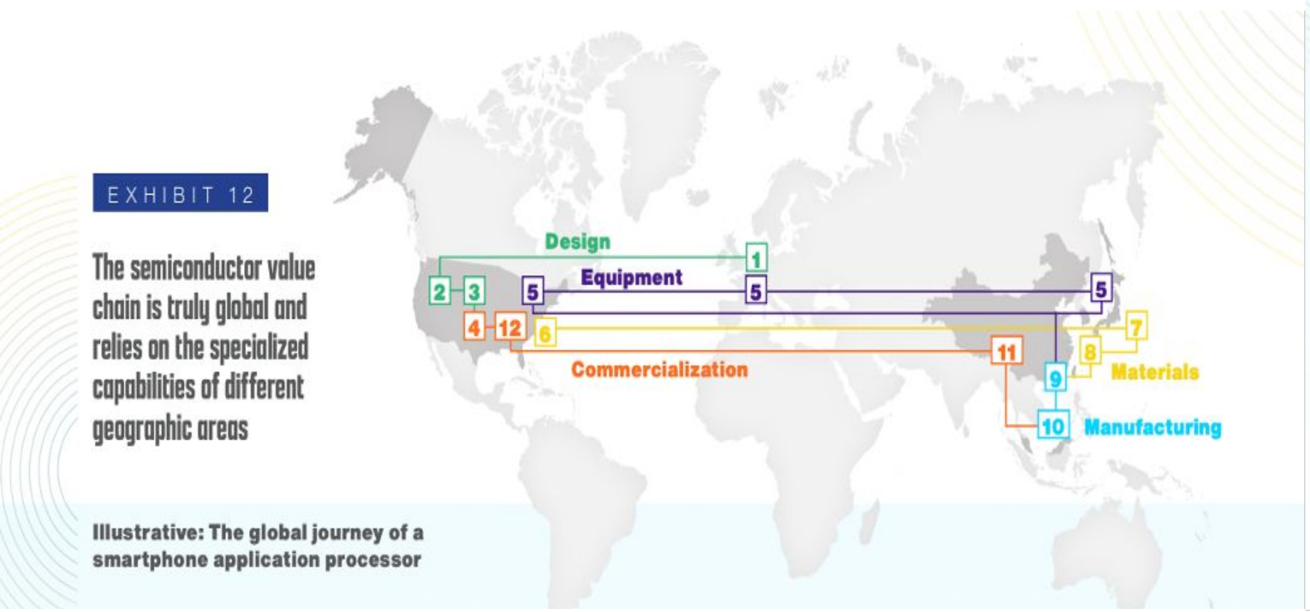
Globalization has led to a multinational semiconductor supply chain, which relies on many countries from different regions that are directly involved in their production, assembly and distribution processes.



Source: Strengthening the Global Semiconductor Supply Chain in an Uncertain Era, Boston Consulting Group (BCG) and Semiconductor Industry Association (SIA)

3. Current Context of the semiconductor industry
Market share

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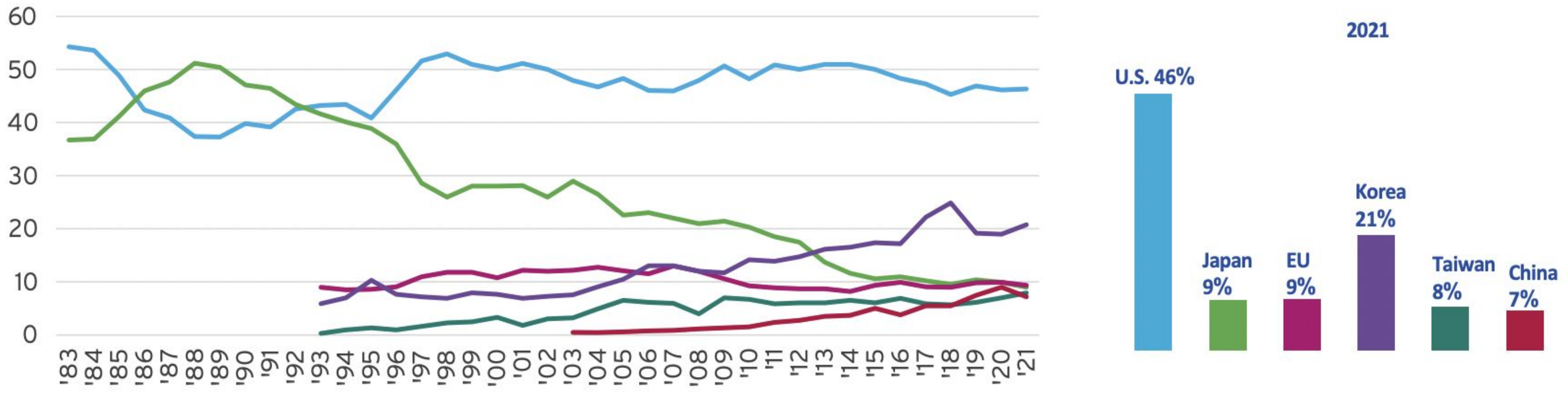
The U.S. continues to hold the biggest global market share.

In 2021, **U.S. held 46% of the global market share**, its companies maintain a competitive edge in microprocessors and other leading-edge devices as well as in R&D, design, and process technology.

Korea held 21%, Japan and the European Union 9% each, followed by Taiwan and China with 8% and 7% respectively.

Semiconductor global market share



Source: World Semiconductor Trade Statistics (WSTS), Omdia, and SIA Estimates.

Source: Strengthening the Global Semiconductor Supply Chain in an Uncertain Era, Boston Consulting Group (BCG) and Semiconductor Industry Association (SIA).

3. Current Context of the semiconductor industry

Market concentration

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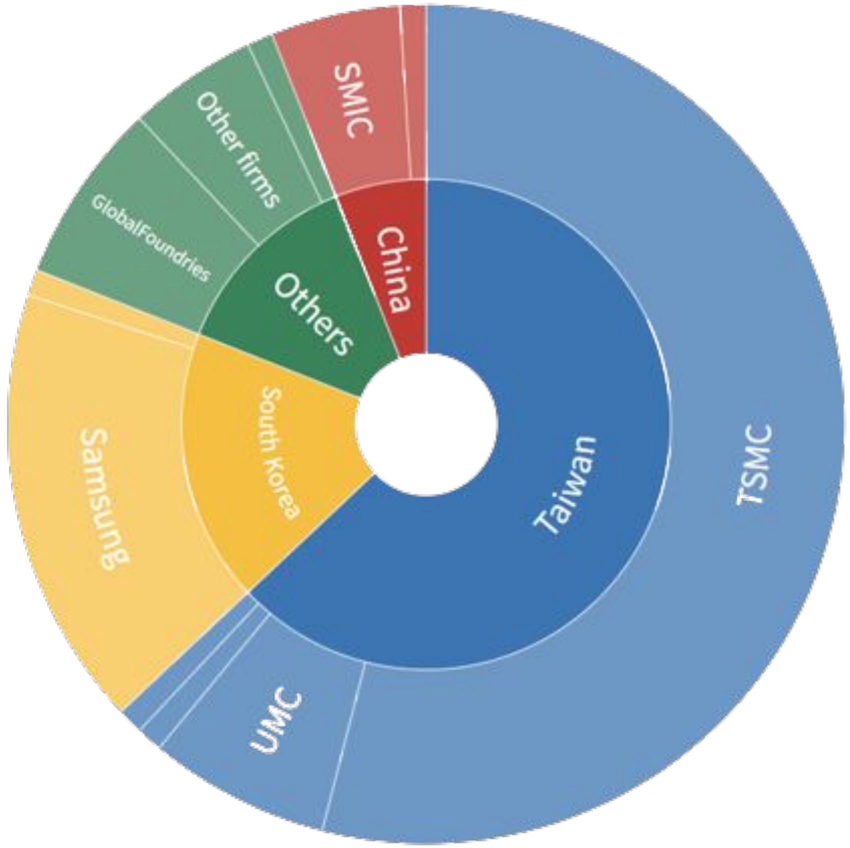
Third generation semiconductor manufacture is highly concentrated in Taiwan, where one company (TSMC) produces 92% of these holding substantial market power.

- The remaining 8% of 3rd generation semiconductors are manufactured by Samsung in South Korea.
- South Korea produces 44% of memory semiconductors, while Taiwan produces 11%, they make up 55% of the market.
- About 75% of semiconductor manufacturing capacity, as well as many suppliers of key materials are concentrated in China and East Asia.



3. Current Context of the semiconductor industry

Supply chain disruption 2018 - 2022

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The semiconductor industry has experienced significant disruptions in its supply chain, leading to short-term shifts in demand. As a result, the global semiconductor revenue is projected to decline by 6.5% in 2023, amounting to $562.7 billion.

However, the market is anticipated to rebound in 2024, with a forecasted growth of 16.3% to reach $654.3 billion USD in revenue.

U.S.-China Trade War

Pandemic

Figure 1. Annual semiconductor revenue growth history and forecast: Peaks and troughs[6]

Note: Chart created by Deloitte based on Gartner research.
Source: Gartner Semiconductor and Electronics Forecast, 4Q22 update, presentation materials

3. Current Context of the semiconductor industry

Expected growth

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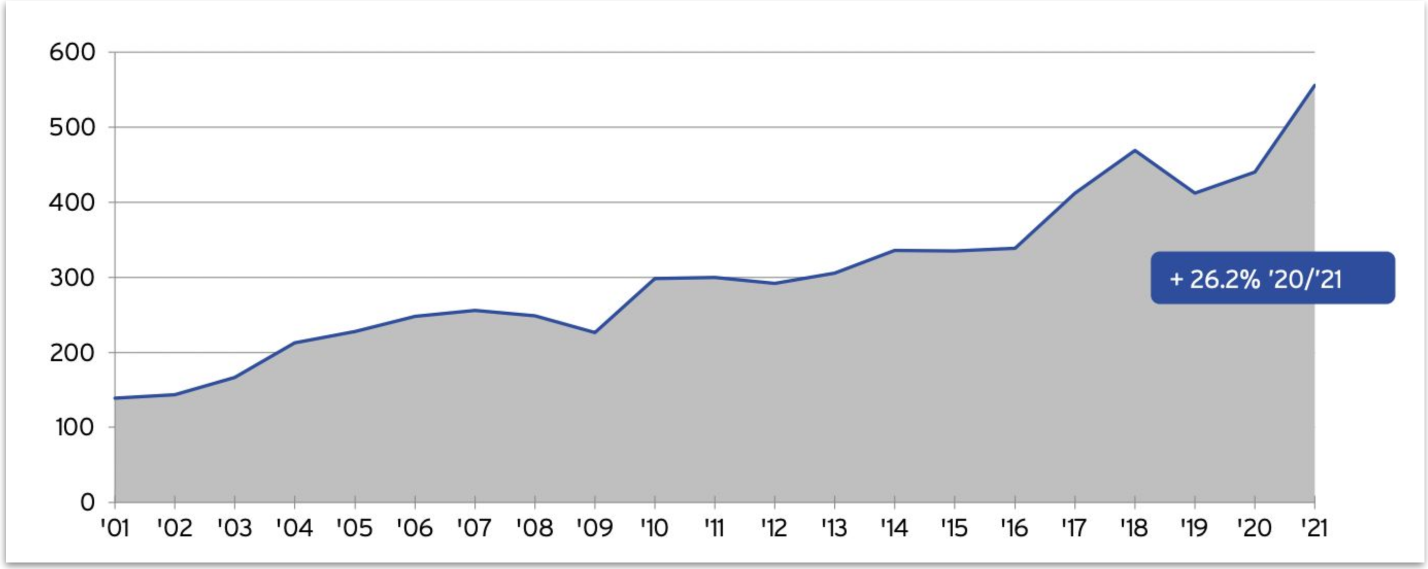
Despite recent supply chain shocks, the semiconductor industry is expected to keep growing.

Past 20 years: From 2001 to 2021, global semiconductor sales increased 7.2% per year (from $139 to $555.9 billion).



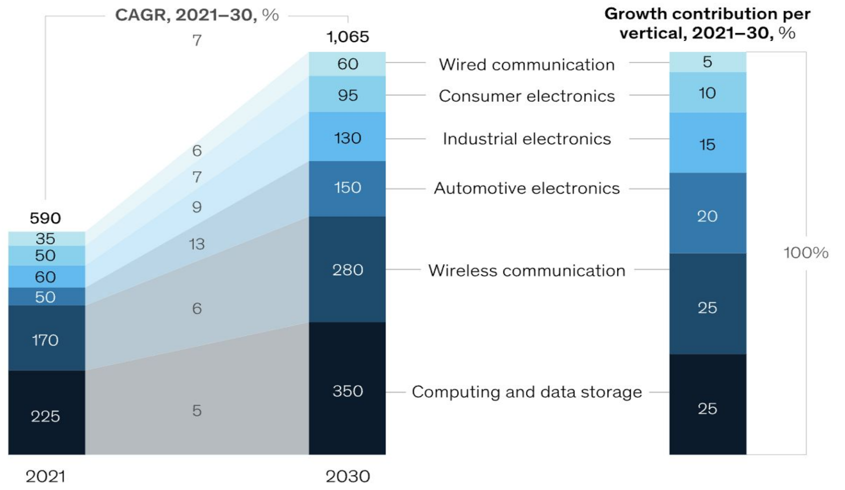
Source: World Semiconductor Trade Statistics (WSTS) and SIA Estimates.

Source: Strengthening the Global Semiconductor Supply Chain in an Uncertain Era, Boston Consulting Group (BCG) and Semiconductor Industry Association (SIA).

Next 10 years: global semiconductor sales are expected to increase at the same 7% rate surpassing $1 trillion per year.

The overall growth in the global semiconductor market is driven by the automotive, data storage, and wireless industries.

Global semiconductor market value by vertical, indicative, $ billion



Note: Figures are approximate.

Source: McKinsey & Company, "The semiconductor decade: a trillion dollar industry".

4. Efforts to boost the semiconductors industry

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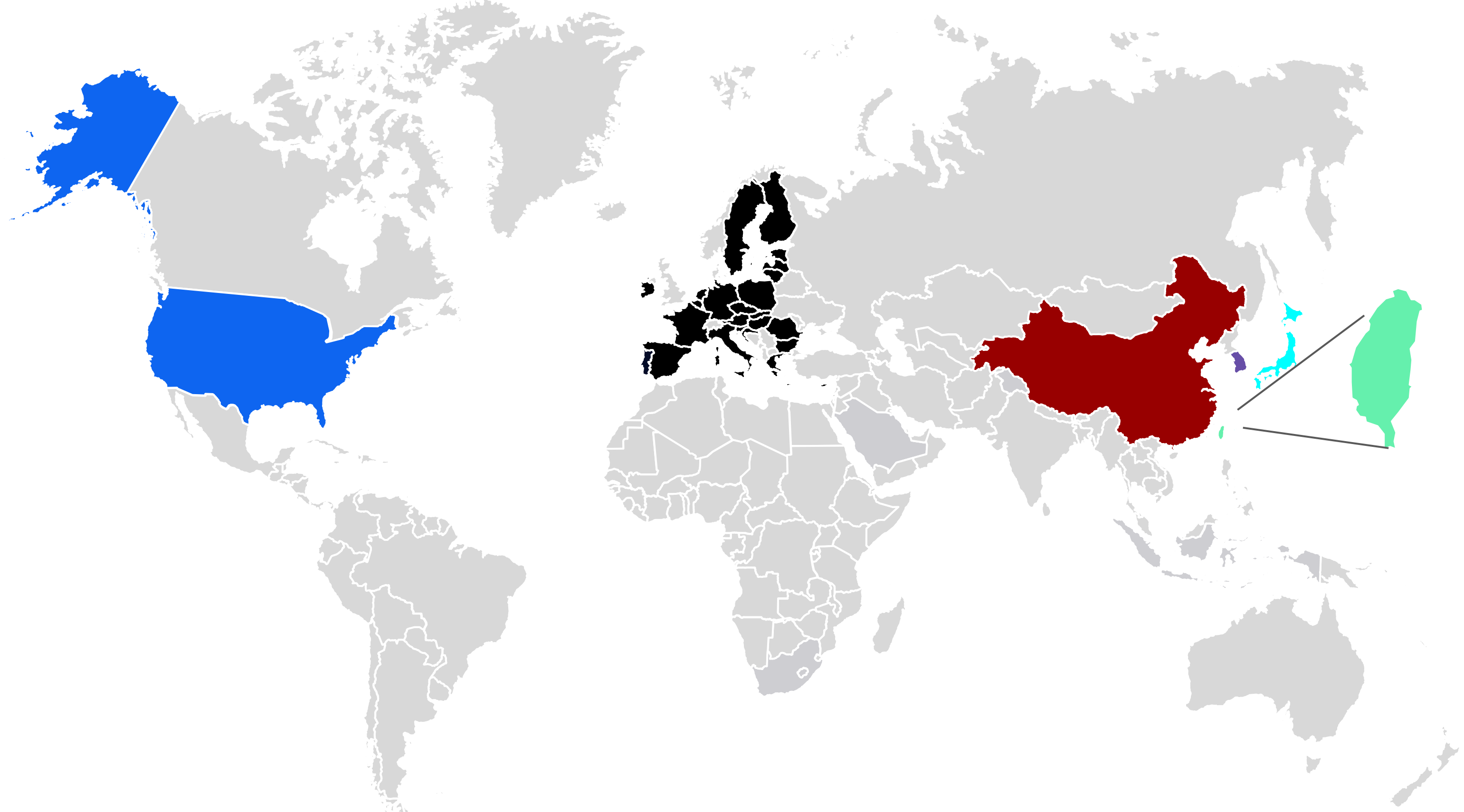
To take advantage of the expected growth and reduce risk from fragmentation in the supply chain, governments around the world have been detonating efforts to have more control over semiconductor production.

Countries are investing for "technological sovereignty"; fueling capex spend.



USA
Chips Act $52 Bn
FABS Act

China
Integrated Circuit Industry Investment $51.2 Bn

Taiwan
Tax credits
Land, water and Electricity

Japan
$4.42 Bn & subsidies

South Korea
Tax credits
Aimed to attract $430 Bn by 2030

EU
Chips Act $46 Bn

Source: "The resilience myth: Fatal flaws in the push to secure chip supply chain" Nikkei. Asia. July 2022.

4. Efforts to boost the semiconductors industry

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Advancements in Chip Design

New chip designs can enable higher performance, reduced energy consumption, and smaller form factors for electronic devices.

- 3D Stacking
- Nanophotonics
- Quantum Computing

Increased Connectivity & Automation

Semiconductors will be essential to enabling the next generation of connected devices and automated systems, from smart homes to fully autonomous vehicles.

- 5G Networks
- Machine Learning
- IoT Devices

Convergence of Technologies

Semiconductors will play a key role in integrating diverse technologies into unified systems to enable new applications, products, and experiences.

- AR/VR Technologies
- Robotics & Automation
- Biotechnology & Health Analytics

4. Efforts to boost the semiconductors industry

U.S.

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2021

Facilitating American-Built Semiconductors Act (FABS)

FABS aims to provide tax-based incentives towards the construction, expansion, or modernization of semiconductor fabrication plants. The legislation proposes 25% investment tax credit for investments in semiconductor manufacturing, expansion, or modernization of semiconductor fabrication plants.

2022

CHIPS and Science Act

In 2022, the federal government enacted the $52 billion CHIPS and Science Act restore domestic manufacturing of advanced semiconductors.

Its main objectives are:

1. Strengthen manufacturing, supply chains, and national security
2. Invest in R&D, science and technology, and the workforce

2022

Inflation Reduction Act

The Inflation Reduction Act of 2022 includes provisions that will benefit the semiconductor industry by promoting clean energy and providing funding for clean energy projects, including semiconductor manufacturing facilities that use clean energy sources.

4. Efforts to boost the semiconductors industry

North America

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HLED

High-Level Economic Dialogue

Focus on semiconductors in supply chain discussions emphasized near-shoring opportunities for Mexico.

- **Establishment of Supply Chain Working Group with a focus on the U.S.-Mexico semiconductor**, information and communications technology supply chain ecosystems.
- The Mexican Government signed a memorandum of understanding with Arizona State University to pave the way for an alliance of U.S. and Mexican universities along with microelectronics manufacturers to train workers and build semiconductor production in North America
- Mexico's Government hosted a forum on "Strengthening the Semiconductor and ICT supply Chains between Mexico and the United States"
- Developed the Mexican Talent for Economic Growth and Near-shoring to show with granular and geo-referenced data the professional and specialized profiles required by companies seeking to invest in Mexico or relocate their production to North America
- Mexico created an Investor's Single Window, an informational resource for companies looking to invest in Mexico

NALS

North American Leaders' Summit Agreement

Trilateral forum to adapt policies and increase investment in semiconductor supply chains across region.

- Convening industry and academic experts in semiconductors, ICT, biomanufacturing, and other key advanced manufacturing and logistics industries for design sessions on the skills required to develop the workforce North America will need in the next 5 years.
- Organizing the first-ever trilateral semiconductor forum with industry to adapt government policies and increase investment in semiconductor supply chains across North America
- Coordinating semiconductor supply chain mapping efforts to develop a collective understanding of unmet needs
- Expanding North American critical minerals resource mapping to collect details on resources and reserves.

5. Challenges for the industry

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Industry faces challenges from technology, pandemic, and climate change, while countries struggle to meet industry needs like infrastructure and skilled workforce.

- Miniaturization of semiconductors
- Supply Chain Disruption
- Environmental Concerns including availability of water and energy
- Lack of Infrastructure
- Lack of skilled workforce

There are also Future Geopolitical challenges that need to be considered in the industry.

China's Decoupling Strategy

Potential Taiwan Invasion

6. Opportunities for North America

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There is an opportunity for the North American Region to work as allies to build supply chain resiliency.

Regional Integration

A strong manufacturing sector, geographical proximity, and favorable terms of trade all uniquely position Mexico to join a regional global supply chain reshuffle.

Manufacture experience

Its established manufacturing industry makes Mexico an appealing destination for semiconductor manufacturing, with access to a wide market and reduced tariffs through several free trade agreements.

Demographic Complementarity in the workforce

Mexico has a large pool of skilled labor, particularly in engineering and technology. It has been trained with semiconductor companies and is familiar with the latest technologies.

R&D

Universities in Mexico offer semiconductor research programs and facilities, creating opportunities for industry-academia partnerships.

Regional Security

Given the shared regional democratic values, Mexico can provide opportunities for semiconductor research and production that benefit the U.S. and Canada.

6. Opportunities for Mexico

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There is an opportunity for Mexico and the North American Region to work to build supply chain resiliency.

Mexico has a large pool of STEM graduates, with 37.5% of students enrolled in science, technology, engineering, and mathematics (STEM) disciplines.

Mexico the second country with the most engineers in the OECD.

The current presence of at least 600 companies with participation in the global value chain.

Mexican talent for economic growth and nearshoring, Mexico City, 2023. https://www.gob.mx/se/

7. Recommendations for Mexico

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1. Fiscal and Financial Incentives
2. Talent Development & Education
3. Infrastructure and Industrial Park
4. Public-Private Collaboration
5. Intellectual Property Protection
6. Promoting Sustainability
7. Advance Gender Equality
8. Incentivise Innovation and Research
9. Access to Sustainable Energy
10. Development of Suppliers and SMEs

7. Recommendations for Mexico

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The Assembly, Testing and Packaging (ATP) segment of the semiconductor supply chain represents an attractive opportunity for Mexico to seize the near-shoring trend.

Existing capacity

- Texas Instruments, Infineon and Skyworks operate back end operations in northern and central Mexican states.

U.S. Supply Chain Gap

- U.S. efforts to bring semiconductor manufacturing to North America offers Mexico a reshoring blueprint.
- Lack of U.S. capacity in ATP/OSAT and ATP materials and high dependence in Asia.

Competitive Advantages

- Geographic proximity to the U.S.
- USMCA trade agreement rules of origin make Mexico a preferential comercial partner.
- Deep integrated concentration with U.S. in chip intensive sectors (i.e. autos, auto parts, ICTs and electronics).

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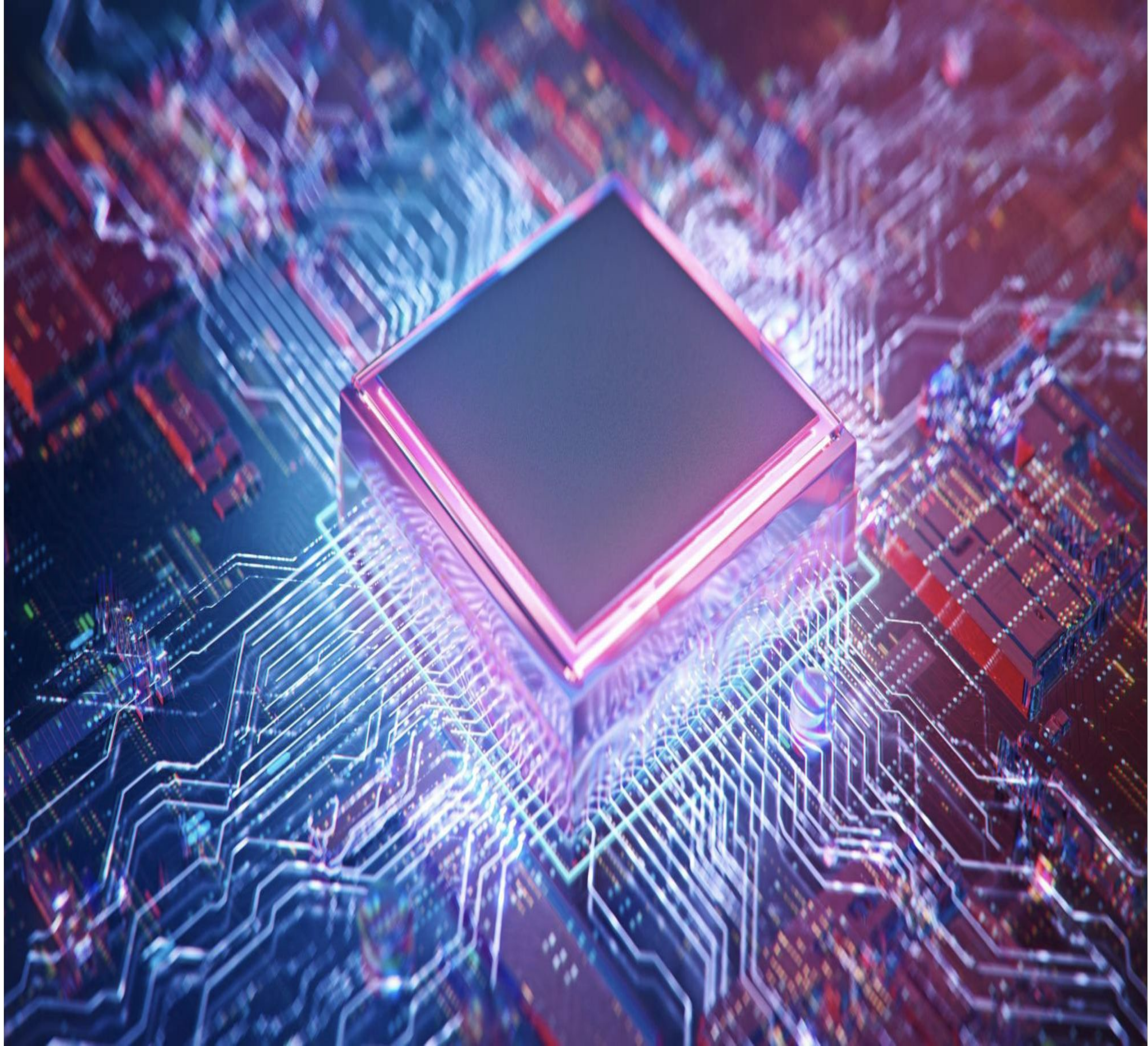

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