December 2022. Technology snapshot

Semiconductors in Catalonia

ACCIÓ Catalonia Trade & Investment

Generalitat de Catalunya
Government of Catalonia

CataloniaConnects

Semiconductors in Catalonia

ACCIÓ
Regional Government of Catalonia (Generalitat de Catalunya)

Execution
ACCIÓ Strategic and Competitive Intelligence Unit

Barcelona, December 2022

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1. Definition

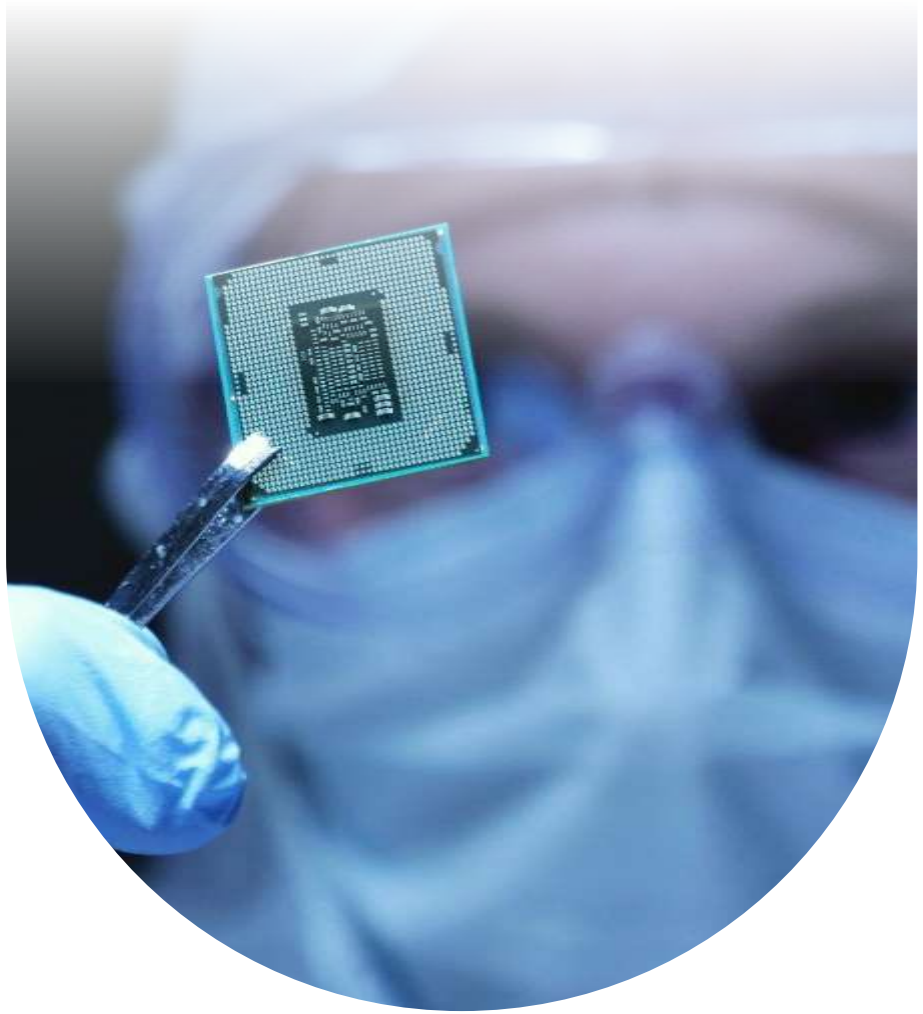
Definition

The semiconductor is a material that enables electric currents to be controlled very accurately.

The material is made up of a single element, usually silicon or a combination of elements, such as gallium arsenide (GaAs) and indium phosphide (InP), among others. Small amounts of impurities can be added to modify the material's conductivity. This process is called "doping" and can greatly increase the semiconductor's conductivity.

Chip semiconductor materials are specifically designed to provide integrated devices and circuits with the ability to process, store and transfer data.

Using semiconductor materials, electronic devices or circuits are manufactured to acquire, process, store and transfer information.



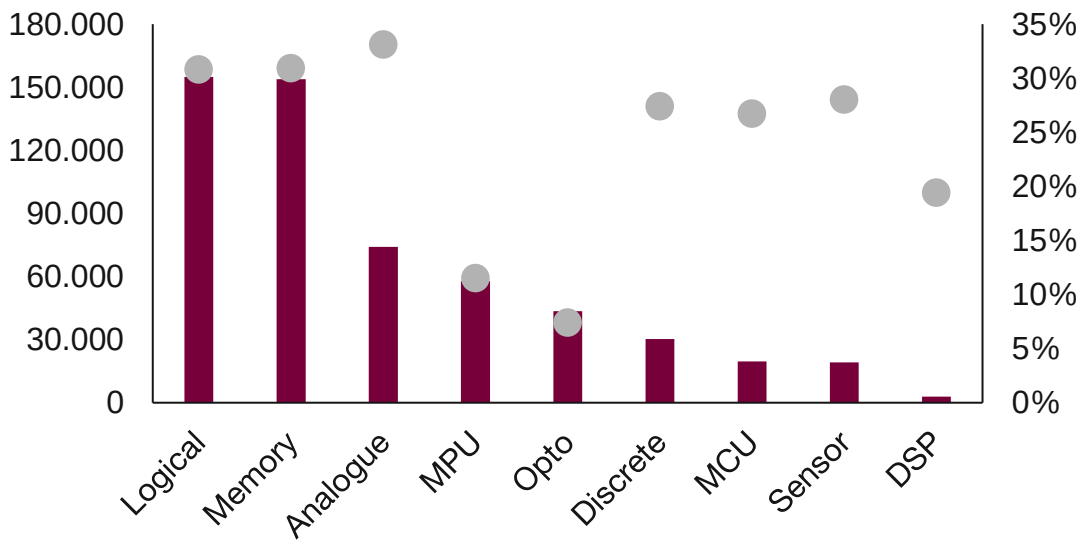
Classification

A chip is a set of miniaturised electronic circuits consisting of active and passive devices and the interconnections between them, layered on a thin wafer of semiconductor material, typically silicon.

Types of semiconductors most in demand

- **Logical:** They work in binary codes (0 and 1) that serve as fundamental computing blocks or "brains", such as microprocessors, micro-controllers or connectivity products.
- **Memory:** They are used to store the information needed to perform calculations. An example is DRAM (used in PCs, servers and smartphones, and there is a growing need for mobility) and NAND (on hard drives for laptops or digital cards).
- **Analogue:** They translate analogue signals, such as voice, into digital signals. It also includes integrated power management circuits and radio frequency semiconductors, which enable smartphones to process radio signals.

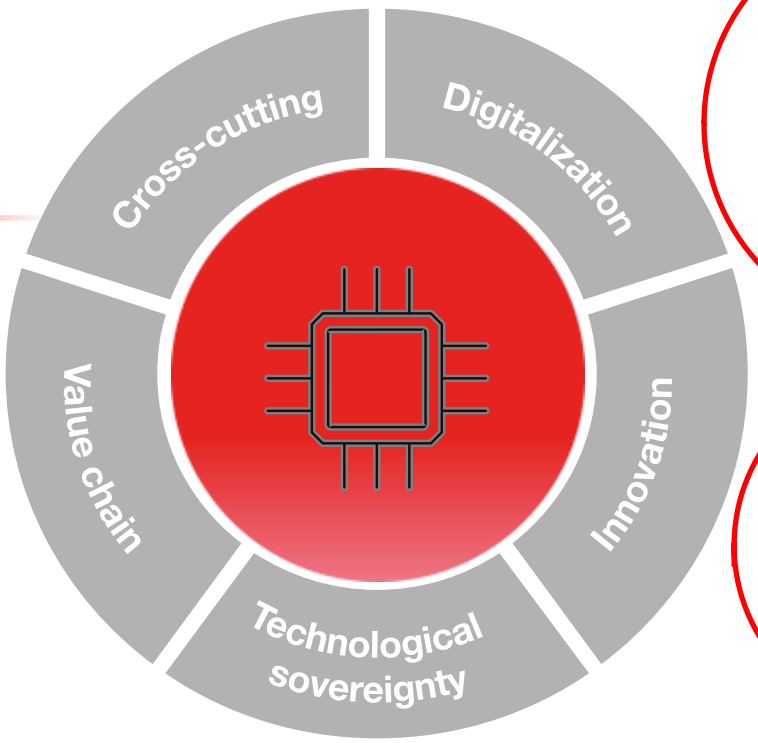
Distribution of global semiconductor sales by product segment in 2021 ($M and % growth compared to 2020)



Sources: Stiftung Neue Verantwortung (2020) "The global semiconductor value chain" and SIA Factbook 2022

The importance of semiconductors in the industry

Semiconductor chips impact a wide range of industries: communications, electrical and electronic equipment, vehicles, robots and industrial machinery, and even medicine and medical equipment.



Semiconductor chips are essential for digital transformation. The process of digitising the economy and society is necessary to incorporate control and efficiency measures in the process and has grown rapidly as a result of the pandemic; the need for all ranges of semiconductors and chips has also increased worldwide.

The complex and global semiconductor and chip value chain has been threatened and pressured by different geopolitical balances and the effects of the pandemic. Creating and bringing the value chain together will help to strengthen and give stability to a whole range of semiconductor-dependent industries to manufacture their products.

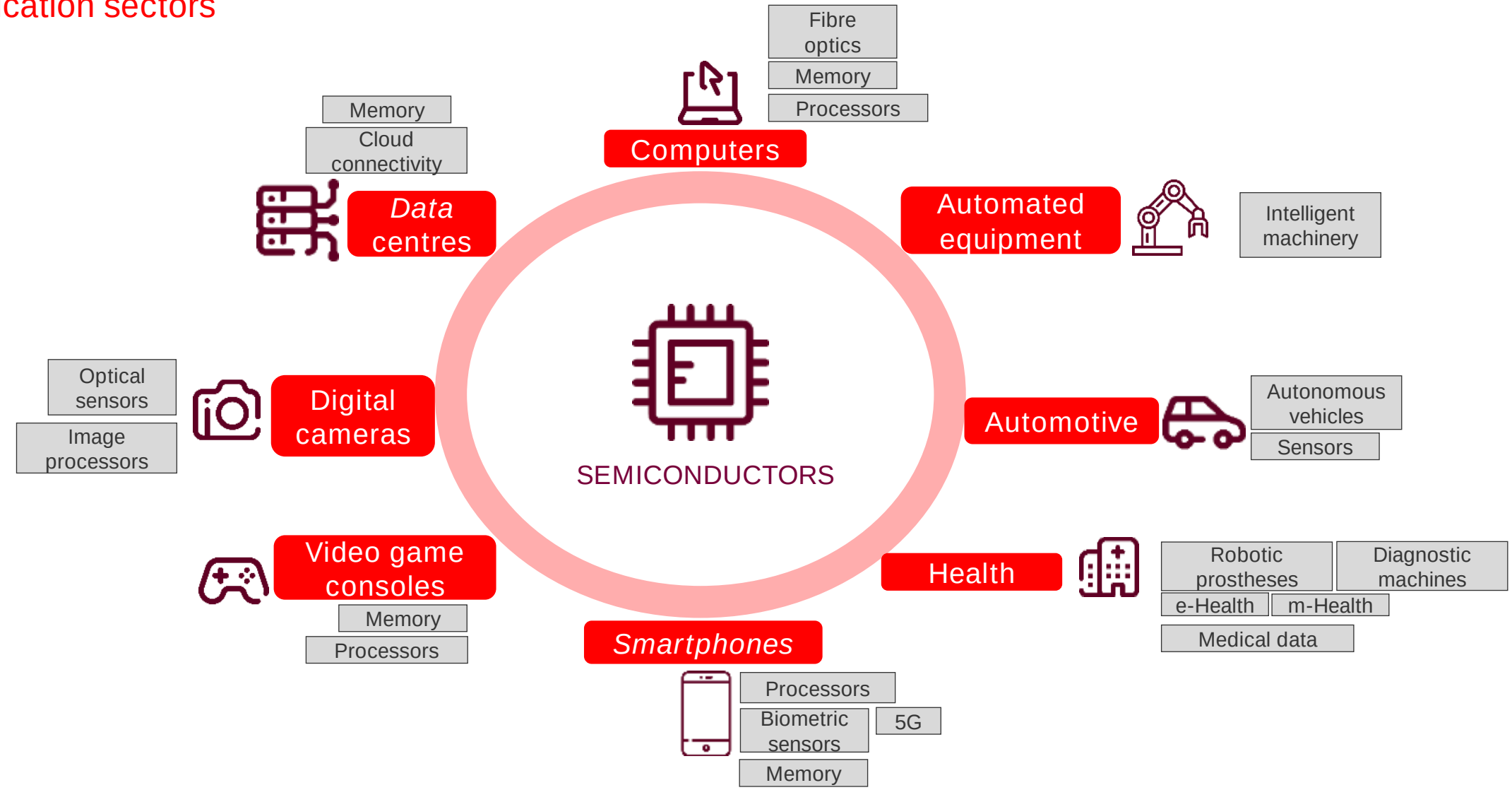
The process of making semiconductor chips is extremely complex. Work is underway to research and innovate new materials and processes to improve capabilities, performance and processes. There is high growth potential, and it covers different knowledge areas.

Semiconductors are at the centre of a new technological battle on a global scale. Europe needs to become an active player and define its own model and strategies for digital transformation.

Source: compiled by author

2. Application sectors

Application sectors

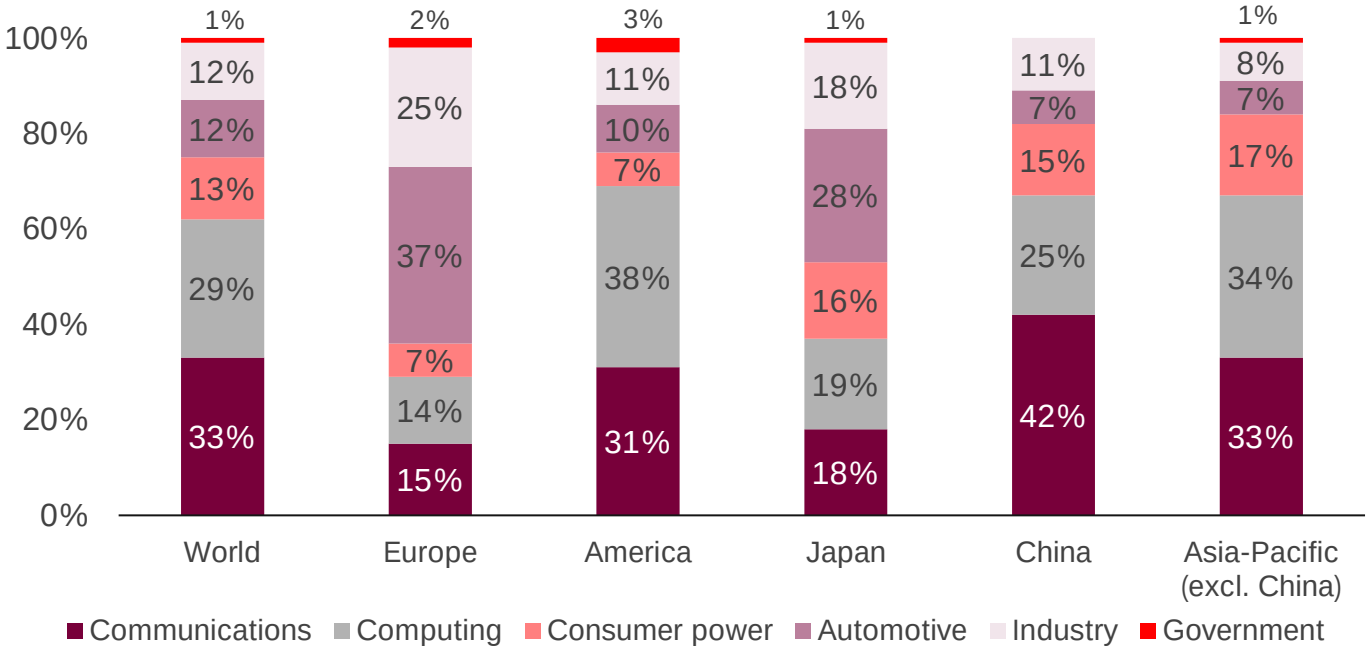


Segmentation of the semiconductor market by region

While global demand for semiconductors is mainly for communications (33%) and computing (29%), automotive (37%) and industry (25%) stand out in Europe.

Semiconductor chip market segments by region

2019



When analysing the semiconductor market segment distribution in different world regions, it is noted that:

- In China, communications stand out, with 42% of the total, and computing, with 25%.
- In America, the largest segments are computing, with 38%, and communications, with 31%.
- The demand by segment in Japan is more balanced than in other regions; the automotive sector stands out (28%).
- In Asia-Pacific, excluding China, the largest segments are computing (34%) and communications (33%).

The European market has high potential in the automotive and industrial sectors, where it is a world leader in innovation and more and more semiconductors are needed.

Communications (5G/6G/*Open RAN*) in Europe should be given greater emphasis, if we are to lead and have technological sovereignty in this area.

Source: ZVEI (2021) "Semiconductor Strategy for Germany and Europe"

Semiconductors and Sustainable Development Goals

3. Health and well-being

Semiconductors and chips are essential for developing new medical devices that help to detect and control diseases, as well as in personalised medicine and the advancement of digital health.

7. Affordable and clean energy

The energy transition involves developing renewable energies, although it also involves connecting them to distribution networks and digitising them, whereas it is in this context that chips and semiconductors are gaining importance.

8. Decent work and economic growth

The semiconductor market will experience strong growth in the coming years, which is an opportunity for all value chain and application industries with the creation of skilled jobs.

9. Industry, innovation and infrastructure

Development of new structures, architectures and more efficient topologies, with lower energy consumption and for new applications. Research into new materials, greater versatility and less dependence.

11. Sustainable cities and communities

Developing semiconductors will foster sustainable mobility and the deployment of technologies that can make cities more inclusive.

12. Responsible consumption and production

Approaching and strengthening the value chain.

3. Production process

Value chain

Each step in the semiconductor chip production process (design, manufacture and assembly) depends on specific inputs from suppliers.

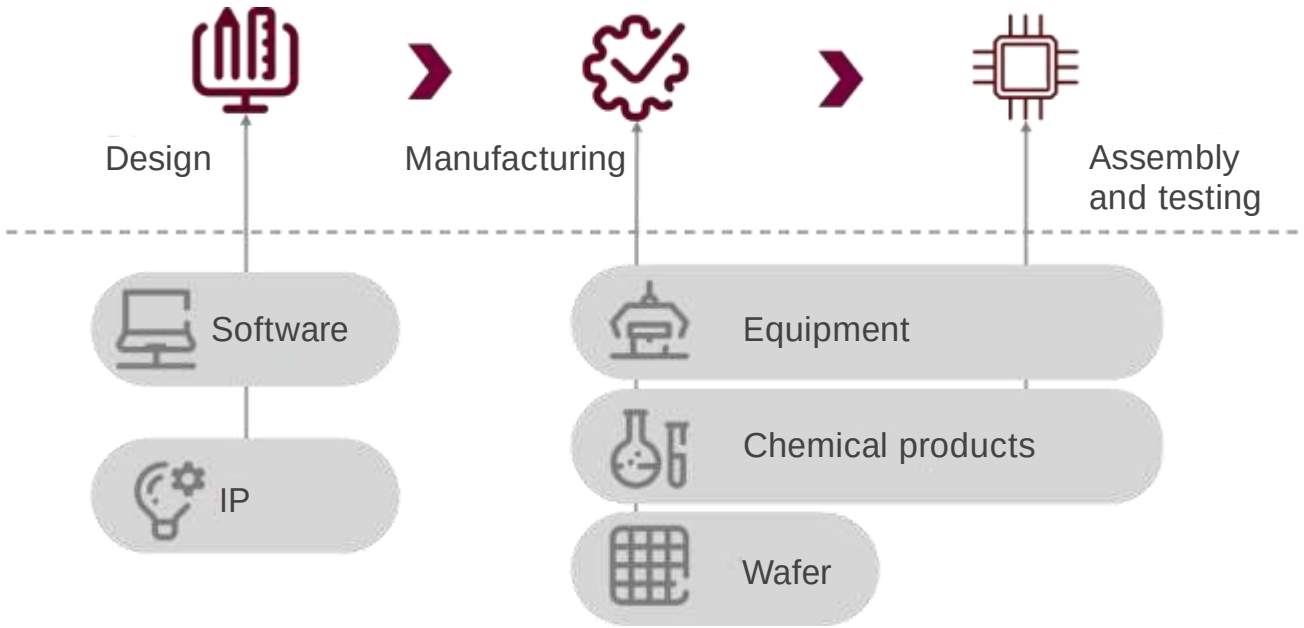
Chip designers (“fabless”) are based on design and intellectual property software (IP blocks).

The manufacturing process (foundries, fabs) depends on manufacturing equipment, chemicals and silicon wafers to produce chips.

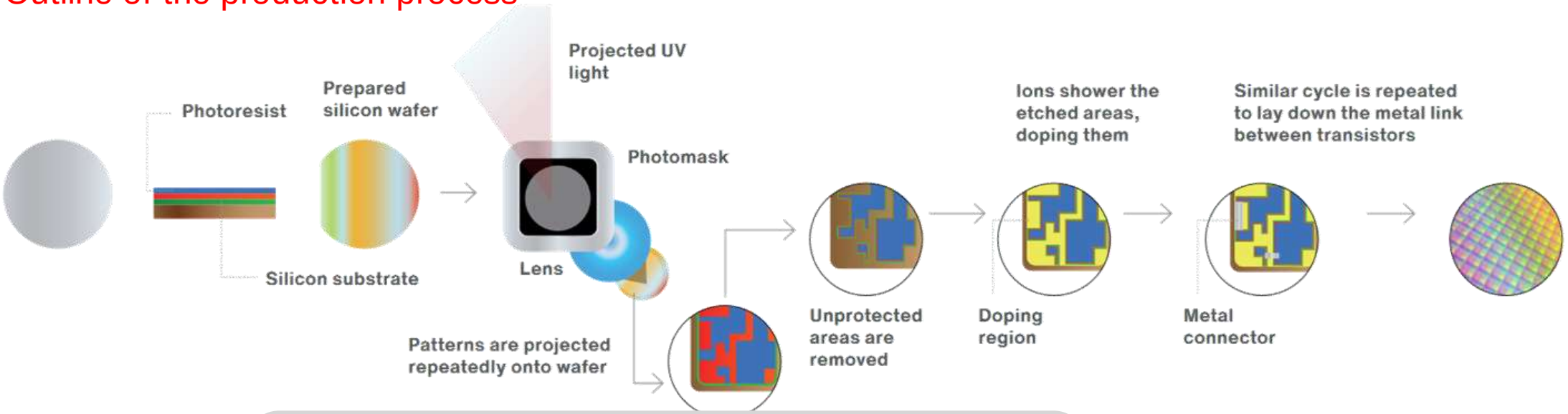
The assembly phase (IDM or OSAT) requires equipment and chemicals.

The semiconductor chip value chain is characterised by high labour division, highly concentrated market niches and pressure to constantly innovate and invest.

At this time, no country concentrates the entire production process in its own territory. The chain is highly innovative and efficient, although not resilient.



Outline of the production process



Steps 1 through 4 are repeated hundreds of times with different chemicals to create more layers, depending on the desired circuit specifications.

1 Silicon wafers. At first, the silicon wafers are white and pure, in a non-conductive state.

2 Oxidation and coating. Layers of insulating and conductive materials are applied over a silicon wafer. The wafer is then covered with a uniform layer of light-sensitive material (photoresist).

3 Lithography. Integrated circuit patterns are specified in the design on a glass plate called a photomask. Ultraviolet (UV) light is applied to transfer the patterns to the coating of photoresist material on the wafer surface. Photosensitive material that has been exposed to light can now be chemically removed.

4 Etching. Layers not protected by photoresist are removed and cleaned using gases or chemicals.

5 Doping. The plate is irradiated with ion beams that modify the properties of the new layer and add a known amount of impurities, such as boron and arsenic. Subsequent annealing spreads these impurities to obtain a more uniform density.

Metal deposition and etching. Connections between transistors are established through this process.

Complete wafer. Each complete board contains hundreds of identical integrated circuits. The boards are sent to the back-end manufacturing processes (assembly, packaging and testing).

Source: BCG & SIA (2021) "Strengthening the global semiconductor supply chain in an uncertain era"

4. Global market

Global semiconductor market

In 2021, the global semiconductor industry revenue was $583.5 billion, an increase of 25% compared to 2020. The global semiconductor industry is expected to exceed $600 billion by 2022.

Growth will be driven by the technological convergence of connectivity and artificial intelligence, which will be at the core of all vertical product development activities.

The deployment of 5G, the increasing use of smartphones around the world, the increase in electronic content in the automotive industry, the migration to electric and connected vehicles, factory automation and the proliferation of IoT devices in smart homes are key trends that will drive the medium- and long-term growth of the market.

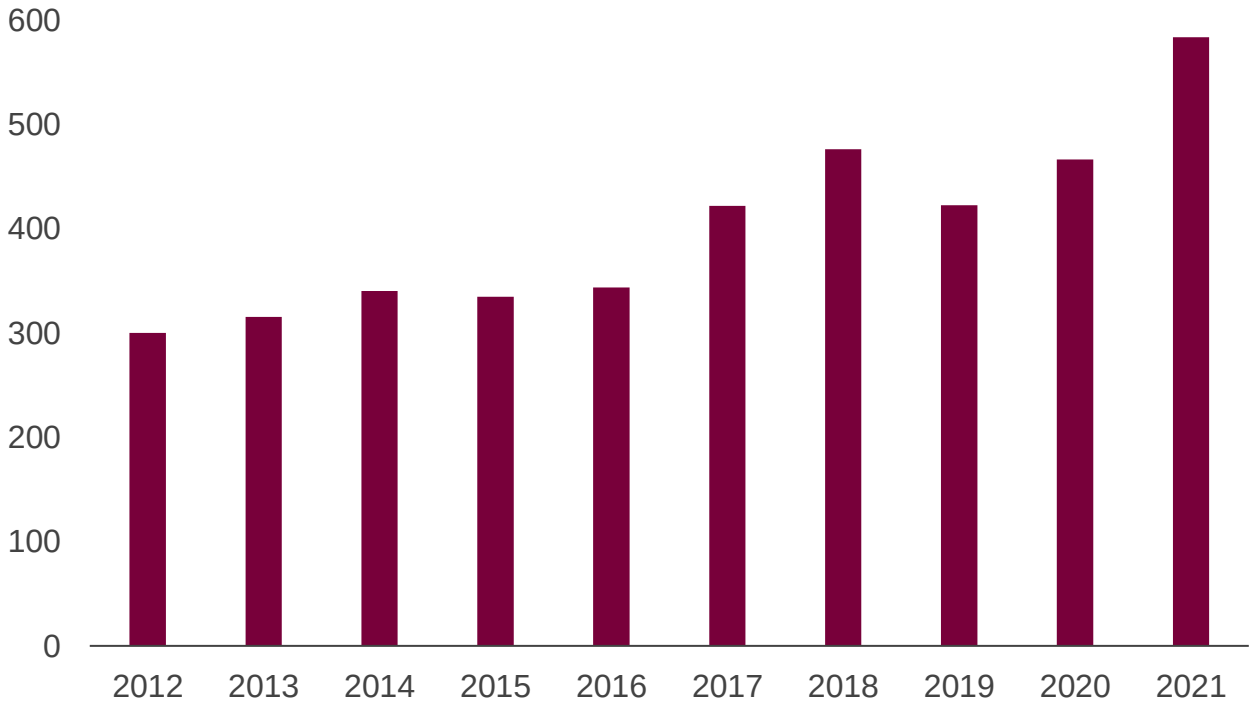
+6-8%

Estimated annual growth up until 2030

About 70% of growth will be driven by three industries: mobility, computing and data storage, as well as communications (5G).

Semiconductor industry turnover (billions of $)

2012-2021



Sources: Statista and McKinsey

Leading companies in the semiconductor market around the world

IDM (design, manufacture and assembly & testing)

SAMSUNG, intel, Texas Instruments, infineon, ST life.augmented

Design

Qualcomm, ARM, MEDIATEK, AMD, Apple, NOVATEK, NVIDIA, XILINX, REALTEK, BROADCOM, MARVELL, dialog SEMICONDUCTOR A Renesas Company

Manufacturing (fabs)

tsmc, UMC, SMIC, GLOBALFOUNDRIES, SK hynix, Micron, KIOXIA

Assembly and testing

ASE GROUP, JCET, Amkor Technology

Software

cadence, SYNOPSYS, Mentor Graphics

Materials/chemicals

BASF, Linde, MERCK, DUPONT, AIR PRODUCTS, Air Liquide, FUJIFILM, JSR, Mitsui Chemicals, Shin-Etsu, SUMITOMO CHEMICAL, LG Chem

Equipment

ASML, APPLIED MATERIALS, Lam RESEARCH, KLA, TEL TOKYO ELECTRON, Nikon, Canon

Presence in Catalonia

Source: compiled by author, from Stiftung Neue Verantwortung (2020), "The global semiconductor value chain", and from the German Council on Foreign Relations (2021), "Europe's Capacity to Act in the Global Tech Race"

Major European semiconductor companies

Despite the presence of niche companies, it will take a great deal of effort for Europe to catch up on manufacturing state-of-the-art semiconductors on a large scale in the medium term.

Europe has companies (European as well as foreign) in some parts of the semiconductor value chain:

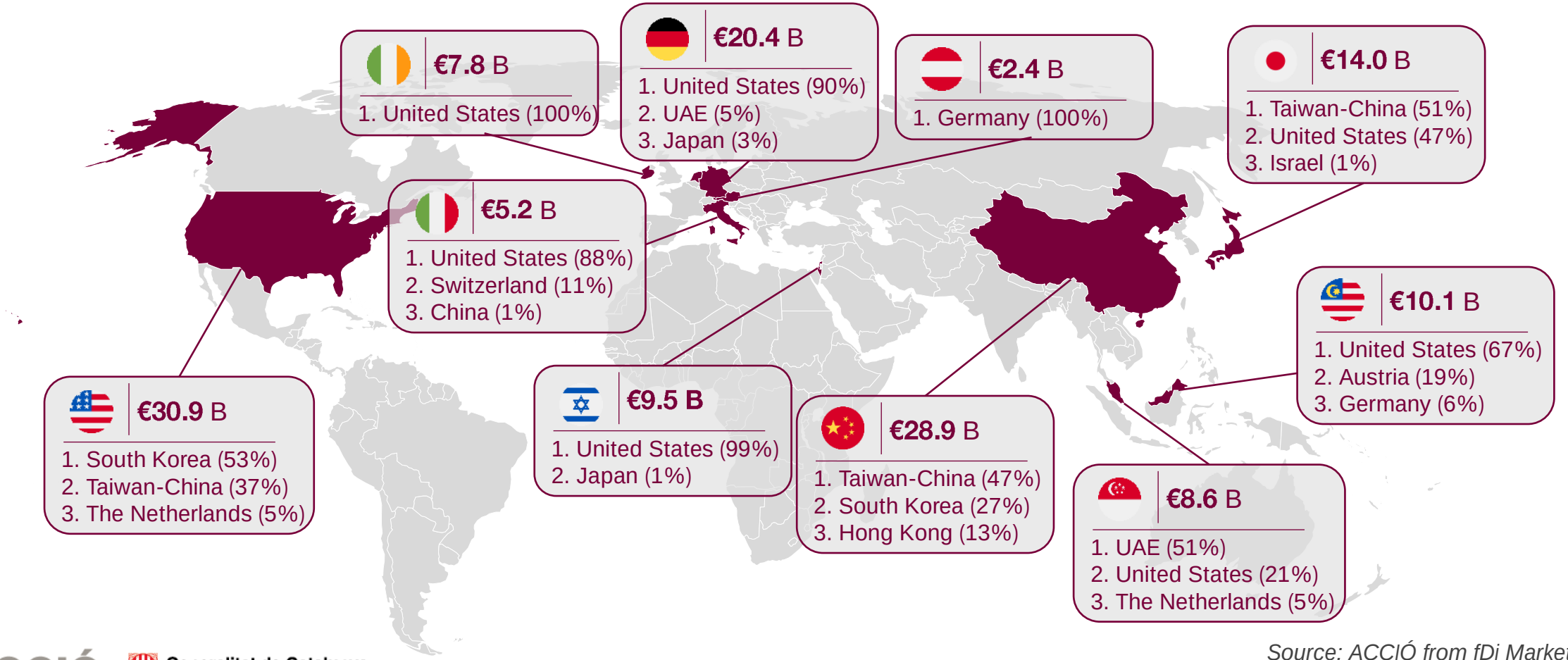
- Semiconductor manufacturers and IDM with application to automotive equipment, industrial automation and sensors. The main ones are the Franco-Italian ST Microelectronics (28 nm), the Dutch NXP (140 nm) and the German-based companies Global Foundries (22 nm), Bosch (65 nm), Infineon (90 nm), X-FAB (130 nm) and UMS (180 nm). Europe does not currently have state-of-the-art semiconductor companies, although Intel, which already has a 20 nm plant in Ireland, will install one in Germany.
- Fabless such as ARM, established in the UK. It has developed its own architectural standard, and its chips are used in almost every smartphone in the world.
- Key technology suppliers for the industry. The Dutch company ASML is a niche leader, as it has developed the most advanced chip structure miniaturisation method using its extreme ultraviolet lithography (EUV) system. Without this company's technology, the production of high-end chips around the world is not possible. Also worth mentioning is the French company SOITEC, as a producer of special wafers.

Sources: German Council on Foreign Relations (2021) "Europe's Capacity to Act in the Global Tech Race" and Stiftung Neue Verantwortung (2021) "The lack of semiconductor manufacturing in Europe"

Foreign Direct Investment (FDI) in semiconductors

FDI in Europe is capitalised by the American company Intel, which also concentrates investments in most countries around the world.

Main countries receiving FDI in semiconductors and origin of FDI (in %) (2017-2021)

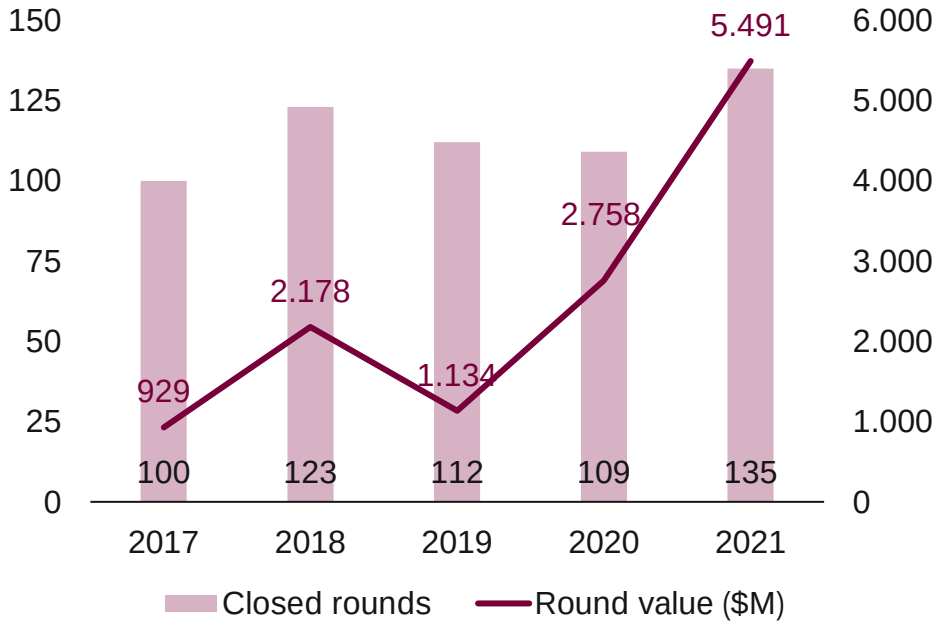


Source: ACCIÓ from fDi Markets

Venture capital in semiconductor startups

2021 was a record year in venture capital for semiconductor startups in the world, with $5.5 billion, almost double the 2020 figure, which was also a record year at the time. Chinese and American startups lead the ranking.

Semiconductor investment rounds



Note: Pre-seed, seed and A-J series investment rounds are included. The data refers to 2017-2021

Value and number of closed rounds in major countries*

$5.3 B	$3.8 B	$1.7 B	$871 M	$256 M
137 rounds	199 rounds	61 rounds	32 rounds	30 rounds

** There are only 11 EU-27 countries, totalling $445 million and 77 rounds in total. Spain is not included.*

Major startups by closed round value

SambaNova	ESWIN	BITMAIN	GRAPHCORE	Enflame 燧原科技
$1.1 B	$1.1 B	$765 M	$652 M	$472 M

Leading investors in venture capital

intel capital · SEQUOIA CAPITAL 红杉资本 | CHINA · Celesta · SAMSUNG VENTURE INVESTMENT · DELL Technologies CAPITAL

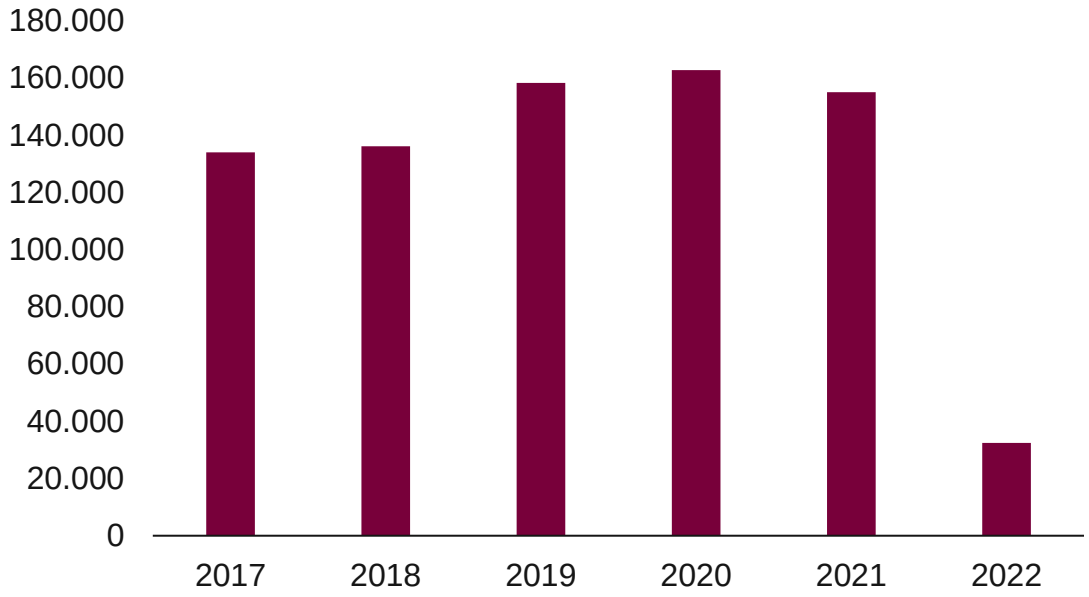
Source: ACCIÓ from Crunchbase

Semiconductor patents

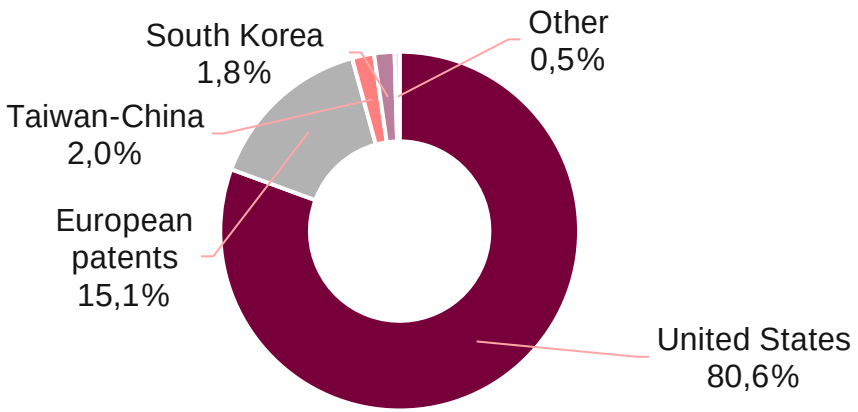
The analysis of semiconductor-related patent publications, with a total of 779,004 in the last five years, shows a constant interest in this field, especially in the United States.

Evolution of the number of patents

2017 to first quarter of 2022



Patent distribution by geographical jurisdiction



Top patent applicant companies

IBM, Samsung Electronics, intel, tsmc, Qualcomm, Microsoft, SONY, Apple

Source: Lens.org

5. International initiatives

Leading countries

Taiwan-China is the world leader in semiconductor manufacturing, with a large manufacturing capacity and a complete industrial supply chain. The world market is dominated by TSMC and UMC, which have received significant public subsidies. Government efforts are focused on training the next generation of semiconductor engineers, given the shortage of talent, and to consolidate their global dominance.

South Korea's semiconductor industry has benefited from government subsidies and financial support from the country's industrial conglomerates (*chaebol*). In May 2021, the government announced the K-Semiconductor Strategy to increase investment, tax credits and incentives for domestic chip manufacturers. A public-private investment of $452 billion is expected by 2030 to make South Korea a world leader in semiconductors and ensure technological independence. Samsung is the main national company.

Although Japan's global share has declined considerably, it continues to lead in the supply of raw materials, equipment and components, such as transistors, resistors and transformers. Kyushu Island is home to major companies and accounts for 5% of global semiconductor production alone. It also concentrates the production of high-strength chemicals and high-purity hydrogen fluoride that are used as etching gas.

China's current capabilities focus on assembly, testing and packaging (ATP), and it has historically lagged behind in manufacturing state-of-the-art semiconductors. China coordinates its semiconductor strategy through the National Integrated Circuit Plan (2014), the 2025 Made in China programme (2015) and the five-year plans. So far, more than $150 billion in government funding has been channelled into China's domestic semiconductor industry.

Semiconductors have become a critical area in the United States, which in recent years has lost the innovative advantage it enjoyed to the detriment of Asian countries. Therefore, the CHIPS Act have been passed recently, which will provide $52.7 billion for semiconductor manufacturing. There are currently more than 700 companies involved in the semiconductor manufacturing process, primarily located in California, Texas, Oregon and New York.

Source: Acces Partnership (2021) "Semiconductors Global Policy Review"

European Chips Act

The European Chips Act will reassert Europe's competitiveness and resilience in semiconductor chip technologies and applications and will help to achieve the twin digital and green transition.

The European Chips Act, introduced in February 2022, proposes the following:

- Make investments in next-generation technologies.
- Provide access to design tools and pilot lines to create prototypes, perform tests and experiment with state-of-the-art chips.
- Apply reliable and efficient chip certification procedures.
- Support innovative startups, expanding companies and SMEs to access capital funding.
- Foster skills, talent and innovation in the field of microelectronics.
- Use tools to anticipate and respond to crises and semiconductor shortages, in order to ensure supply.
- Create international semiconductor partnerships with related countries.
- Establish a more favourable framework for attracting investors and establishing manufacturing facilities in Europe.

Intel, taking advantage of the European Chips Act, has announced an investment of **€17** billion into a state-of-the-art semiconductor mega factory in Germany, the creation of a new R&D and design centre in France and investment into R&D, foundry manufacturing and services in Ireland, Italy, Poland and Spain (mostly in Barcelona).

With the target of the EU accounting for 20% of the global market by 2030, **more than €43** billion will be invested.

Sources: European Commission and Intel

PERTE (Strategic Project for Economic Recovery and Transformation) regarding semiconductors

Develop the design and production capabilities of the microelectronics and semiconductor industry in Spain.

€12.25 B
Public investment

Until 2027

Four cornerstones

Scientific capacity
€1.165 B
Strengthen R&D&I on cutting-edge microprocessors

Design strategy
€1.33 B
Promote microprocessor design

Manufacturing plants
€9.35 B
Provide semiconductor production capacity

Industry ICT
€400 M
Create a capital fund focused on chips

7 principles

1. Long-term vocation
2. Prioritisation
3. Progress by stages
4. Technical leadership
5. Public/private partnership
6. Integrated nature
7. Alignment of the European Chips Act

6. Semiconductors in Catalonia

Mapping of the semiconductor ecosystem in Catalonia

86 companies

€158.3 M€

701 jobs

81.4% of the companies are SMEs.

66.3% have a turnover of more than €1 M and 37.2% of more than €10 M.

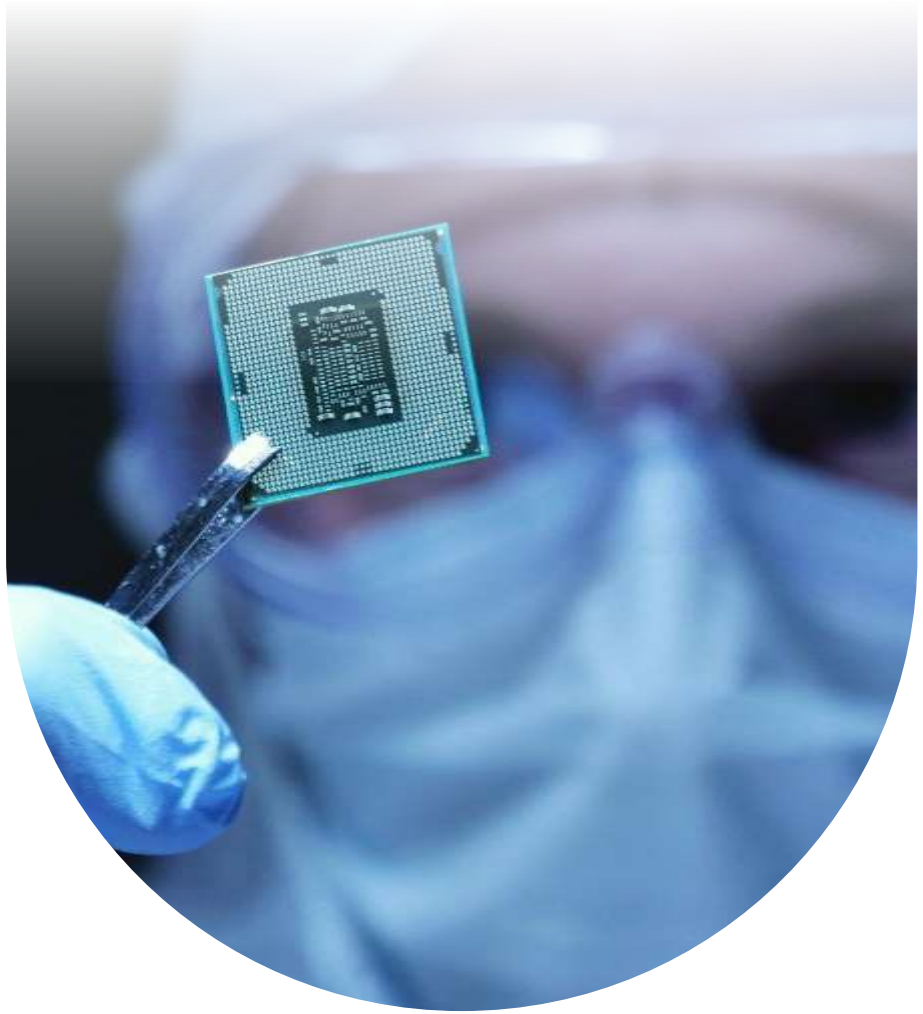
53.5% are exporters.

25.6% are under 10 years old.

8.1% are startups.

17.9% have women in management positions.

By segment*, 37.2% of companies are dedicated to design, 19.8% to electronic circuits, 18.6% are auxiliary companies within the value chain, 14.1% are dedicated to distribution and 12.8% to materials. Other less relevant segments are EMS (5.8%), equipment (3.5%) and fabs (3.5%).



*Companies can be classified into more than one segment within the semiconductor value chain.

Source: ACCIÓ (last available data)

Semiconductor value chain segmentation in Catalonia

Design*

wallbox, EBV Elektronik, SEMIKRON, TD SYNNEX, BROADCOM, gtd, MPS, Johnson Controls, esperanto.ai, imasenic, Avant Studio, Mobile Knowledge, SIEMENS, LEAR, FAE, Semidynamics, MARVELL, openchip, qorvo, nanusens, IDEADED, AST SpaceMobile, intel, cisco, SIPEARL

---Quantics---

KILIMANJARO, QUSIDE, LUXQUANTA

---Comercial---

HITACHI Inspire the Next, infineon, ST life.augmented, NXP, wiyo

Manufacturing (fabs)*

IDEADED, DT Microelectrónica, A.I.E.

Electronic circuit manufacturers

CIBERTRONIK, qurv, IDEADED, nmi electronics embedded systems, ChatuTech, PRO CIRCUITS, EDEP, aci, WE WÜRTH ELEKTRONIK, DigiProces, PROMAX INNOVATION, CIPSA CIRCUITS, Farnell, LAB CIRCUITS, SEMIKRON, EBV Elektronik

EMS

ISEE, GUASCH, DigiProces, elausa, TEF, QPLOX

Distribution

CS, tti, AVNET, MOUSER ELECTRONICS, GUASCH, FUTURE ELECTRONICS, RUTRONIK, Farnell, ARROW

End user

Materials/chemicals*

BASF, DUPONT, AIR PRODUCTS, MERCK, Linde, Air Liquide, BS

Equipment*

ZEISS, SENSOFAR, FESTO

Auxiliary industry/engineering

Quimipol, ALIBAVA, KISTLER, NUFESA, SGS, Telstar, SENSOFAR, LAUDA, IS, Minstec Salas Blancas, S.L., labsom, dmalgua, HidroQuimia, NORDICWATER

*Main segments in the semiconductor value chain

ACCIÓ Catalonia Trade & Investment

Generalitat de Catalunya Government of Catalonia

Source: ACCIÓ

CataloniaConnects

Impact of semiconductors on the Catalan manufacturing industry

42.3% of the Catalan manufacturing industry uses semiconductors in processes or products.

The sectors that use more semiconductors are:

HIGH EXPOSURE

- Computer and electronic products
- Transport equipment
- Electrical materials and equipment

MEDIUM EXPOSURE

- Food and beverage
- Pharmaceuticals
- Chemicals
- Textiles, clothing, leather and footwear
- Machinery

Semiconductors are key to developing the mobility of the future and Industry 4.0 in Catalonia.

Note: estimate made from 2019 Catalonia GVA data from IDESCAT

Source: ACCIÓ

Related industrial systems

Demand

Mobility
352 companies | €19,404 millions | 38,845 jobs

ITC
19,148 companies | €129,520 millions | 175,949 jobs

IoT
251 companies | €520 millions | 3,188 jobs

Robotics
147 companies | €461 millions | 1,910 jobs

New Space
53 companies | €143 millions | 379 jobs

Support

Quantics

Photonics
174 compnies | €1,860 millions | 9,434 jobs

Water
505 companies | €5,010 millions | 26,257 jobs

Nano Materials
107 companies | €430 millions | 779 jobs

Chemistry
1,053 companies | €18,543 millions | 37,824 jobs

Semiconductor ecosystem agents in Catalonia

Technology centres and research institutes

CNM, CSIC, ICN2, MCIA, MIND, ICMAB, IFAE, UPC BARCELONATECH, ICFO, BSC, eurecat, LEITAT managing technologies, CITCEA, SIC Sistemes d'Instrumentació i Comunicacions, Microsystems nanotechnologies for Chemical Analysis Research Group, CD6

Universities and training centres

UPC, Universitat de Barcelona, UAB Universitat Autònoma de Barcelona, Universitat Rovira i Virgili, Universitat de Girona, Universitat Pompeu Fabra Barcelona, UOC Universitat Oberta de Catalunya, Universitat Ramon Llull, Universitat de Lleida, UVIC Universitat de Vic Universitat Central de Catalunya

Associations and clusters

FABCAT, AESEMI, secpho, Clúster Digital, CEEC Clúster d'Eficiència Energètica de Catalunya, Mav, Smartech Cluster, Ametic, AENTEG Associació d'Empreses de Noves Tecnologies de Girona, ciac Clúster de la Indústria d'Automoció de Catalunya, BIST Barcelona Institute of Science and Technology

Institutions and public administration

Generalitat de Catalunya, Cambra de Comerç de Barcelona, Cambra de Comerç de Girona, pimec, Foment del Treball Nacional 250

Source: ACCIÓ

Researchers in Catalonia

More than 3,600 researchers in the field of nanotechnology, photonics and microelectronics in Catalonia.

Talent in Catalonia

Catalan universities and vocational training centres offer semiconductor training in a transversal manner, and work is underway to offer a specific inter-university master's degree in semiconductors.

Degrees

- Electronic, Industrial and Automation Engineering
- Engineering in Industrial Technologies
- Electronic Telecommunications Engineering
- Telecommunications Systems Engineering
- Telecommunications Technology and Services Engineering
- Physics
- Chemistry

Master's

- Electronic Engineering
- Physical Engineering
- Advanced Materials Engineering
- Automotive Engineering
- Power Electronics
- Nanoscience and Nanotechnology
- Materials Chemistry

Vocational training

- Electricity and Electronics
- Electronic Product Development
- Electronic Maintenance
- Laboratory Operations
- Analysis and Quality Control Laboratory

Catalan universities that provide semiconductor training

UPC
UAB Universitat Autònoma de Barcelona
Universitat de Barcelona
upf. Universitat Pompeu Fabra Barcelona
Universitat Ramon Llull
Universitat Rovira i Virgili
Universitat de Lleida
Universitat de Girona
UVIC Universitat de Vic Universitat Central de Catalunya
UOC Universitat Oberta de Catalunya

Source: compiled by author

Opportunities and challenges

The current shortage of semiconductors has alerted nations worldwide to the strategic and economic importance of chips and semiconductors, which has opened up unprecedented opportunities, although not without challenges.

Opportunities

- Stimulation of the economy
- Reinforcement of other industrial ecosystems
- European Chips Act
- European Fund, NGEU
- Research & technology

Challenges

- Value chain complexity
- Geographic concentration of supply
- Time and capital
- Constant innovation
- Talent
- Waste and water consumption

Source: compiled by author, based on interviews and personal communications

Case studies in Catalonia

TEF is a manufacturer of electronic boards (EMS) that has made a paradigm shift in the advent of semiconductor shortages.

MPS specialises in semiconductor devices for power and energy management and will create 150 jobs to turn the Catalan headquarters into the company's largest R&D centre in Europe.

TTI is a leading distributor of passive components, connectors and electromechanics worldwide.

IMB-CNM develops materials and researches semiconductor applications in fields such as health and aerospace.

IMASENIC specialises in developing image sensors and has extensive knowledge of applications and technologies related to this field.

The BSC is the national supercomputing centre in Spain. A collaboration agreement has been reached with INTEL to create a pioneering microchip design lab.

Interviews conducted

Interviews with institutions

We would like to thank the following entities for providing the data and information used to draft this semiconductor chip technology report:

Thanks!

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@catalonia_ti

See the report here:
https://www.accio.gencat.cat/ca/serveis/banc-coneixement/cercador/BancConeixement/eic-semiconductors-catalunya