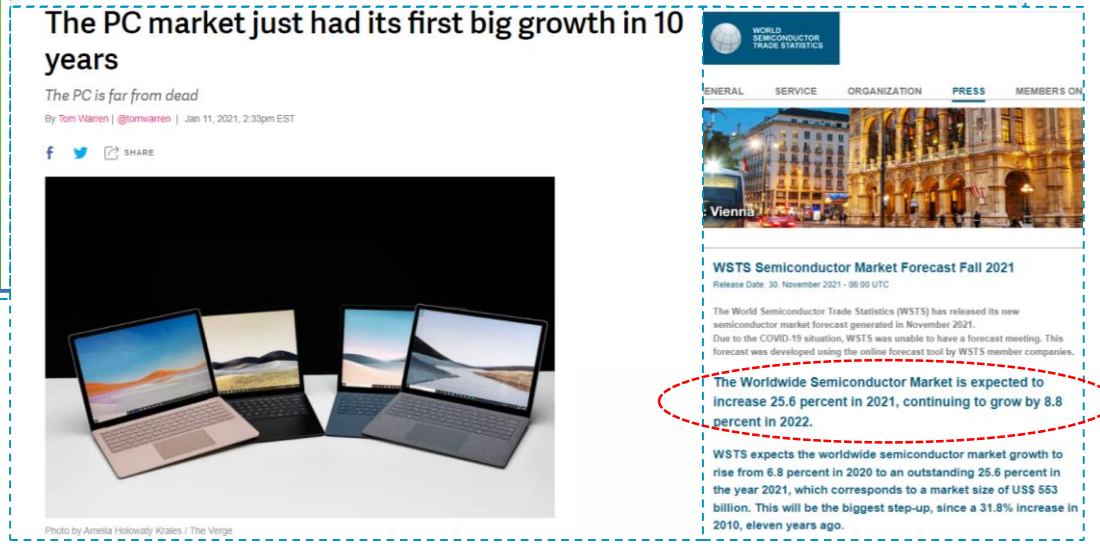
Nasdaq

Nasdaq Global Semiconductor Index™

Powering the Thematic Technologies of Tomorrow

Acceleration in Demand Due to Covid-19



Sources: MarketWatch, The Verge, ComputerWeekly, World Semiconductor Trade Statistics

1. https://www.marketwatch.com/story/videogames-are-a-bigger-industry-than-sports-and-movies-combined-thanks-to-the-pandemic-11608654990
2. https://www.theverge.com/2021/1/11/22225356/pc-sales-shipments-2020-growth-idc-canalys-remote-work
3. https://www.wsts.org/76/Recent-News-Release
4. https://www.computerweekly.com/news/252495507/Smartphone-industry-roars-back-in-Q4-2020-as-iPhone-propels-Apple-to-new-heights

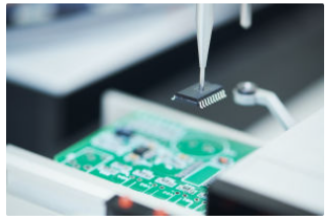
Global Supply Shortages Due to Covid-19

TECHNOLOGY | STREET NOTES

The Chip Shortage Could Be Spreading to iPhones

By Al Root Dec. 3, 2021 10:08 am ET

Text size



Dreamstime

The global semiconductor shortage has roiled automotive and appliance production all year long. Now a warning from Apple raises the possibility that the impact of the shortage is spreading and, more important, affecting consumer demand.

Apple (ticker: AAPL) reportedly told its suppliers this week to cut targeted production of the iPhone 13 to about 80 million units from 90 million units. Apple wasn't immediately available to comment on the reports.

Apple stock fell more than 3% shortly after the open of trading Thursday. Shares clawed back some of those losses, closing down 0.6%. The S&P 500 and Dow Jones Industrial Average gained 1.4% and 1.8%, respectively, on Thursday.

TECH

Hewlett Packard Enterprise CEO says navigating the chip shortage won't be easy — but end is in sight

PUBLISHED THU, DEC 2 2021·7:46 AM EST | UPDATED THU, DEC 2 2021·9:40 AM EST

Sam Shead
@SAM_L_SHEAD

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KEY POINTS

- Antonio Neri, president and CEO of Hewlett Packard Enterprise, said: "It's not going to be easy but I actually believe we're going to be in a much better shape after the summer of 2022."
- New chip fabrication plants, known as fabs, will come online and create more capacity, Neri said, adding that this should alleviate some of the supply chain issues.
- He added that HPE has suppliers across the globe and the company is constantly thinking about how it builds its products.

AUTOS

Commerce secretary says House needs to pass CHIPS Act immediately to ease semiconductor shortage

PUBLISHED MON, NOV 29 2021·1:41 PM EST | UPDATED MON, NOV 29 2021·6:47 PM EST

Michael Wayland
@MIKEWAYLAND

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KEY POINTS

- Commerce Secretary Gina Raimondo said the House needs to "immediately" pass legislation that supports U.S. production of semiconductor chips.
- She said the bill is critical to avoid future supply issues and lower the country's dependence on parts from China.
- The U.S. Innovation and Competition Act, which contains the CHIPS Act, passed the Senate with bipartisan support in June but has stalled in the House of Representatives.

TV
Shepard Smith
UP NEXT | Shark Tank 8:00

BUSINESS

New cars to remain scarce well into next year as semiconductor shortage wears on. 'We can't even backfill what people are wanting to buy today.'

By ROBERT CHANNICK
CHICAGO TRIBUNE | NOV 22, 2021 AT 5:00 AM

The semiconductor shortage has disrupted the auto industry throughout 2021, halting production, reducing inventory and raising prices, a formula that has left some frustrated buyers searching for any tires to kick.

ADVERTISEMENT

Deloitte: Chip shortage will extend into 2022

The consulting firm gave its predictions for the extent of the ongoing semiconductor shortage and the impact it will have on market innovation.

Written by **Stephanie Condon**, Staff Writer
Posted in Between the Lines on November 30, 2021 | Topic: Processors

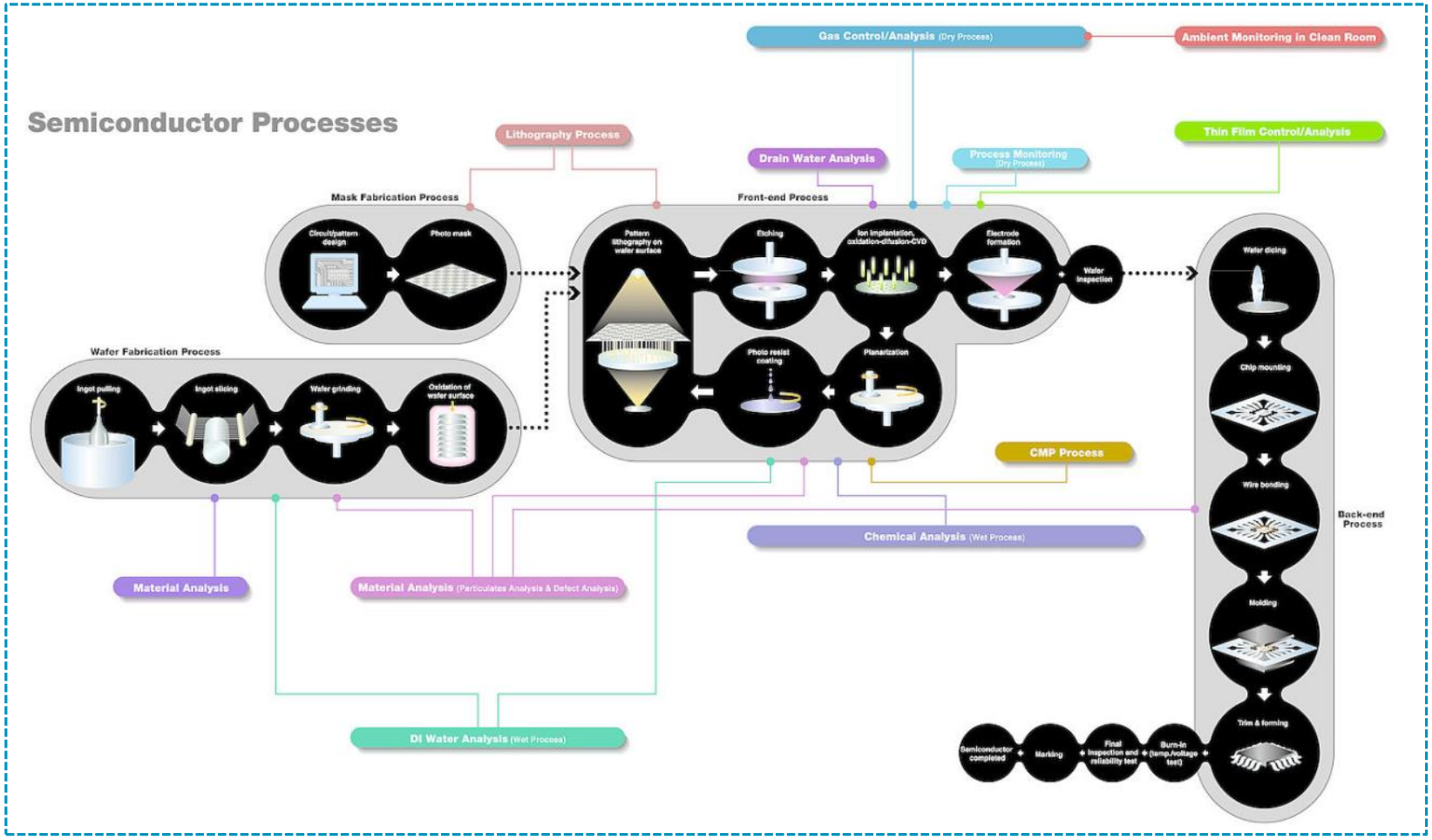
Connection
Rise to the challenge

Sources: Barron's, CNBC, Chicago Tribune, ZDNet.
1. https://www.barrons.com/articles/apple-stock-chip-shortage-iphones-51638543940
2.https://www.cnbc.com/2021/12/02/hpe-ceo-says-navigating-semiconductor-shortage-wont-be-easy.html
3.https://www.cnbc.com/2021/11/29/commerce-secretary-says-us-house-needs-to-pass-chips-act-immediately-to-ease-semiconductor-shortage.html
4. https://www.chicagotribune.com/business/ct-biz-chip-shortage-new-car-dealers-20211122-soyrq6qkyndprku6brqhszz5wq-story.html
5. https://www.zdnet.com/article/deloitte-chip-shortage-will-extend-into-2022/

Semiconductor Industry Overview

An Extremely Long, Capital-Intensive Process…

- Raw input – pure single crystal silicon – must be sourced and molded into 300mm ingots, then mechanically sliced into thin, polished wafers
- Electronic circuits with transistors and wiring must be formed on the surface of the wafer, which requires a thin film layer to first be deposited, then coated with "photoresist"
- The circuit pattern is then "projected" onto the photoresist using photolithography technology
- This forms just one of many layers of circuits that must be formed on top of one another

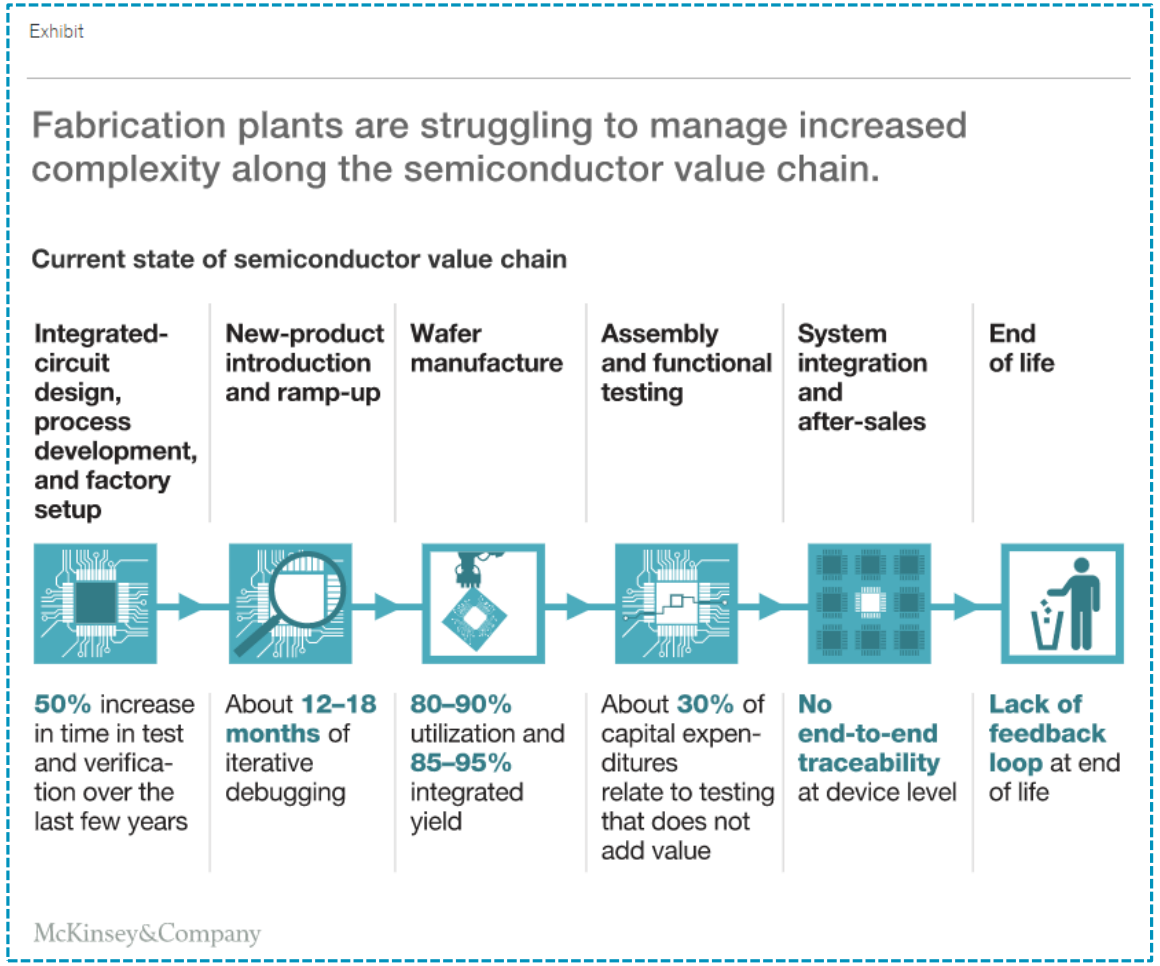


Sources: Hitachi, Horiba.
1. https://www.hitachi-hightech.com/global/products/device/semiconductor/process.html
2. https://www.horiba.com/aut/applications/information-technology/semiconductor-manufacturing-process/

Industry Overview

...That Affords Very Little Room for Error

- New product introduction and ramp-up generally involves 12-18 months of debugging
- Test and verification time during the design process has increased by 50%
- Each fab has thousands of process steps, which, in turn, have thousands of parameters that can be used in different combinations
- Manufacturing process typically takes 6-8 weeks; more advanced, up to 15 weeks
- Individual chip details can be thousands of times smaller than a grain of sand
- Single chip can contain billions of transistors
- Measurement/inspection/testing processes occur hundreds of times for a typical chip
- Despite all this complexity, more than 1 trillion chips were manufactured in 2020



Sources: McKinsey, ASML.
1.https://www.mckinsey.com/industries/semiconductors/our-insights/reimagining-fabs-advanced-analytics-in-semiconductor-manufacturing
2.https://www.asml.com/en/news/stories/2021/semiconductor-manufacturing-process-steps

Industry Overview

Semiconductors in 2022

7 Semiconductor Component Types:

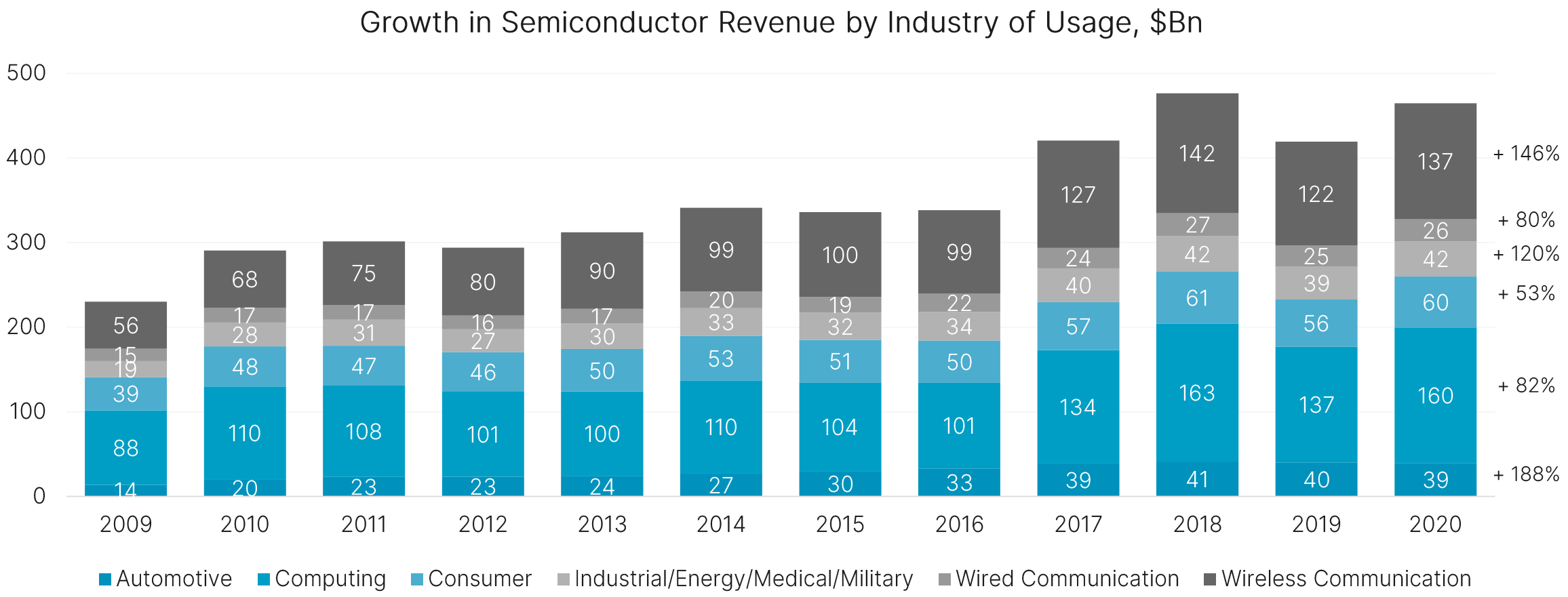
- Memory (largest share of industry, ~25%)
  - Cloud Computing/Virtual Reality
- Microcomponent (every electronic device)
- Logic
  - ASIC (application-specific integrated circuits) + ASSP (application-specific logic chips)
- Analog
  - Power Management/Signal Conversion/Autos
- Optoelectronic
  - Image Recognition/Internet of Things/Solid-State Lighting/Machine Vision/Smart-Grid Energy
- Sensor
  - Automated Controls / IoT Applications
- Discrete

Top Drivers / Sources of Growth:

- Automotive (Autonomous/EV/Hybrid): 11.9% CAGR
- Industrial (Security/Healthcare): 10.8% CAGR
- Communications (Smartphones, 5G, EM): 2.2% CAGR
- Consumer Electronics (TVs/Gaming/Handhelds): 6.0% CAGR
  - Wearables (21.0% CAGR)
- Data Processing (Servers/Storage Devices): 2.1%
- Internet of Things (IoT)
- Artificial Intelligence & Machine Learning: ~50%
- LEDs

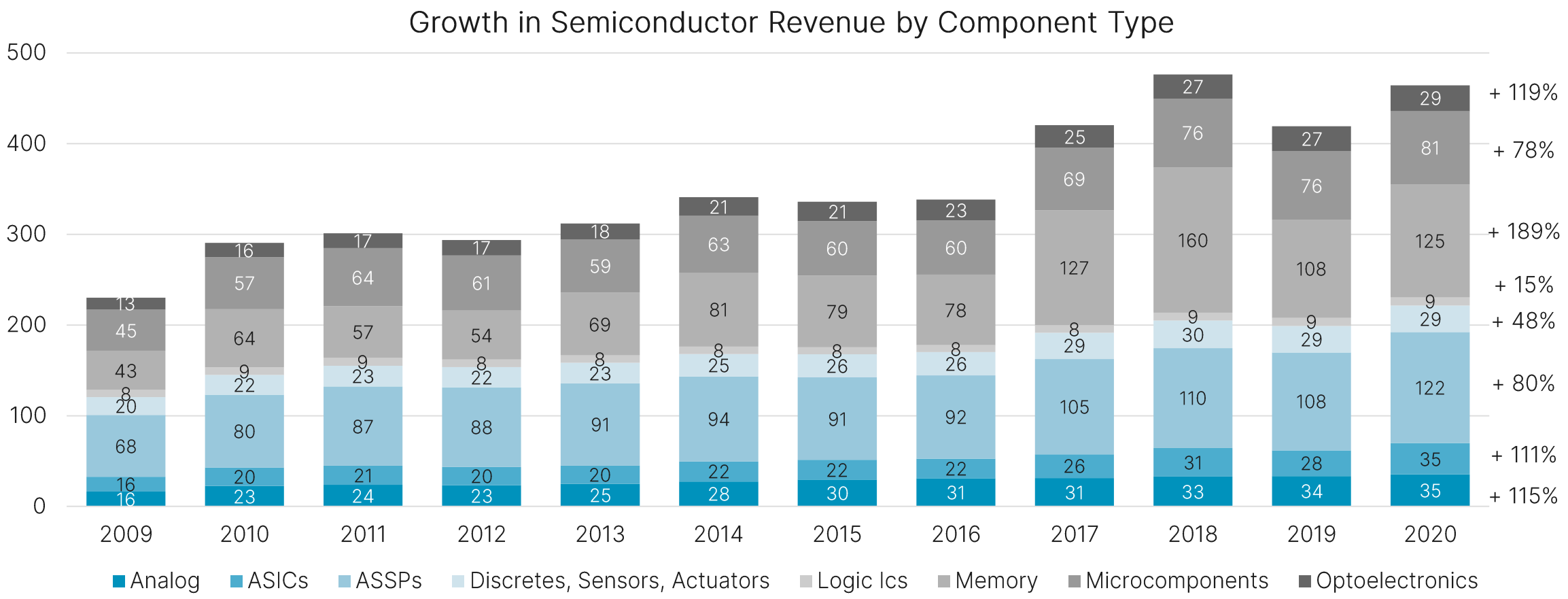
Source: Nasdaq Global Indexes, PricewaterhouseCoopers

Semiconductor Revenues up 100% Since 2009



Source: IDC Data via Bloomberg

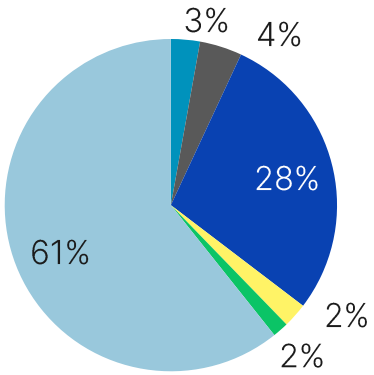
Semiconductor Revenues up 100% Since 2009



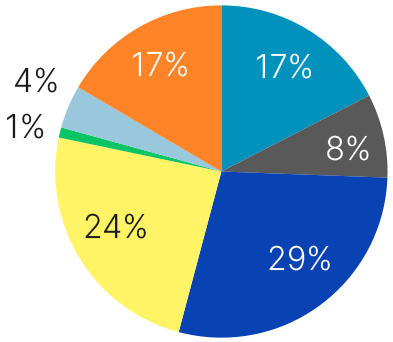
Source: IDC Data via Bloomberg

Revenue by Industry & Semiconductor Type

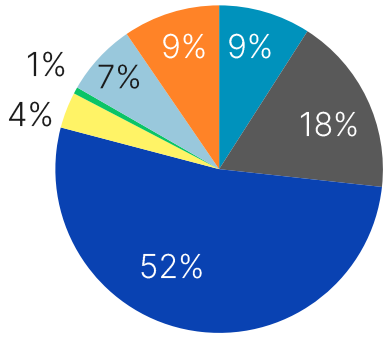
Computing



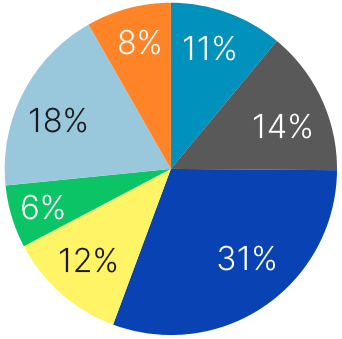
Automotive



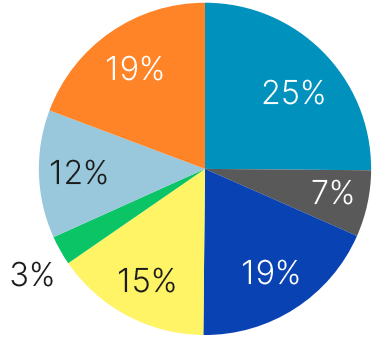
Wired Communication



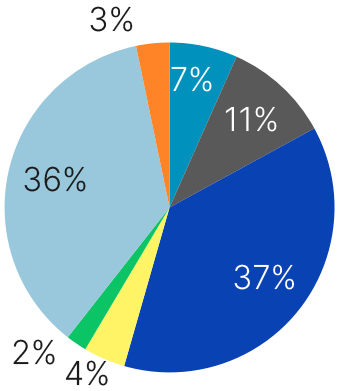
Consumer



Industrial



Wireless Communication



Source: IDC Data via Bloomberg

Analog ASICs ASSPs Discretes / Sensors / Actuators Logic Memory Microcomponents

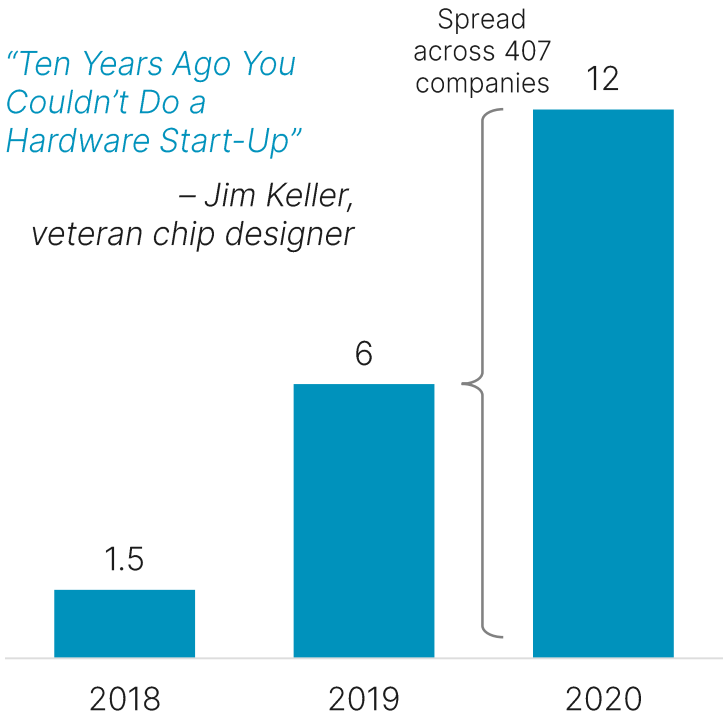
Industry Overview

A New Era of Semiconductor Investment

Estimated US Venture Capital Investments into Semiconductor Startups, $Bn

"Ten Years Ago You Couldn't Do a Hardware Start-Up"

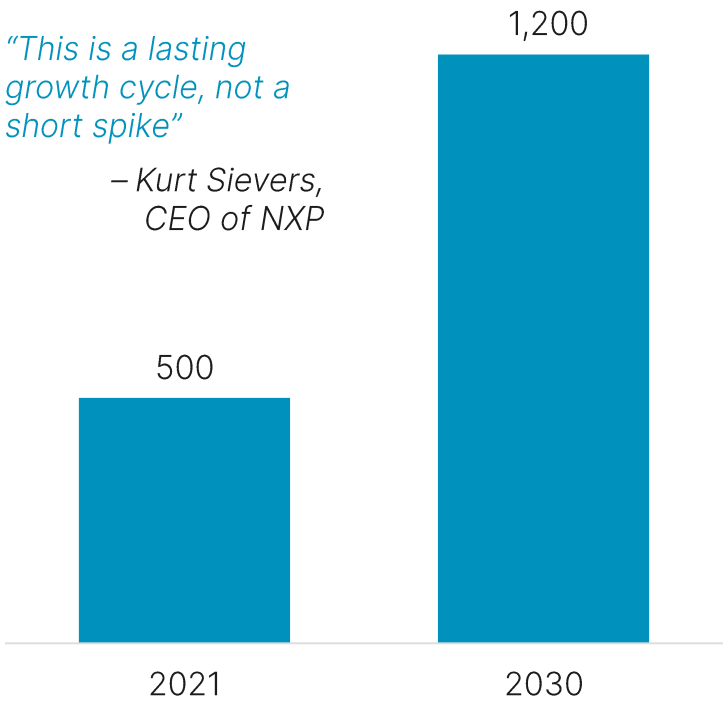
– Jim Keller, veteran chip designer



Forecasted Growth of Global Chip Revenues, $Bn

"This is a lasting growth cycle, not a short spike"

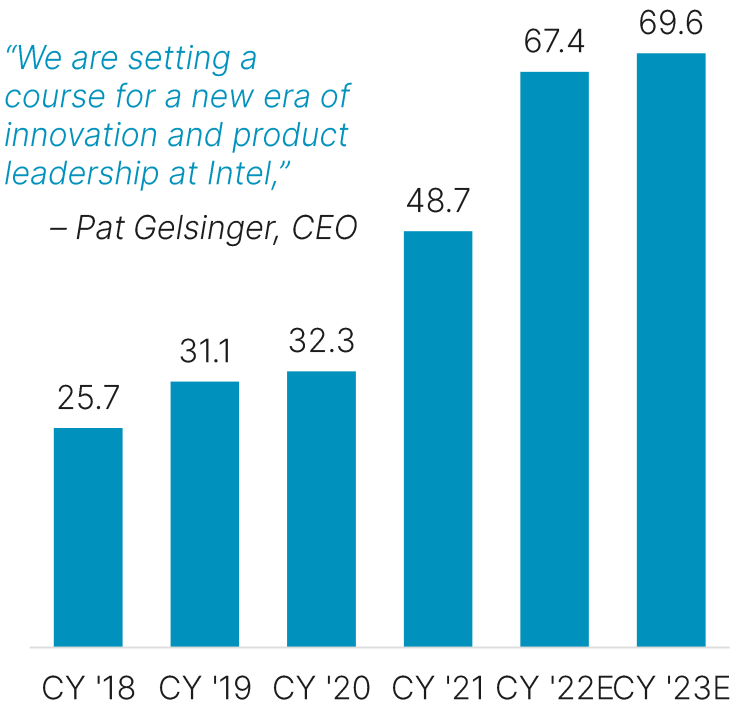
– Kurt Sievers, CEO of NXP



Intel + Taiwan Semiconductor Annual CapEx, $Bn

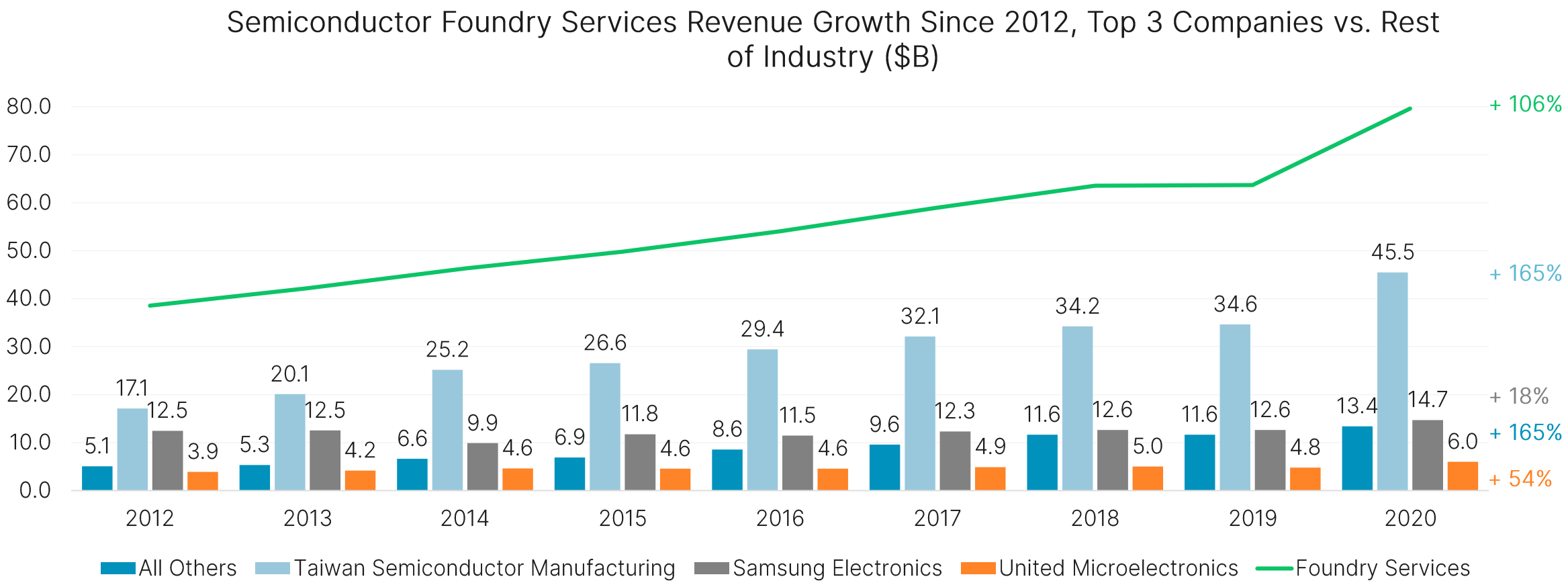
"We are setting a course for a new era of innovation and product leadership at Intel,"

– Pat Gelsinger, CEO



Sources: NYTimes, CB Insights, Factset, Intel.
1.https://www.nytimes.com/2021/05/07/technology/semiconductor-chip-innovation-boom.html?auth=link-dismiss-google1tap

TSMC Capturing Most Foundry Revenue Growth



Source: IDC Data via Bloomberg as of May 14, 2021

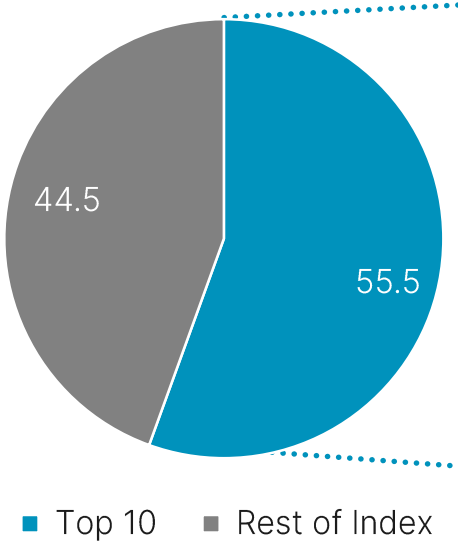
Nasdaq Global Semiconductor Index™

Nasdaq's Industry-Leading Benchmark

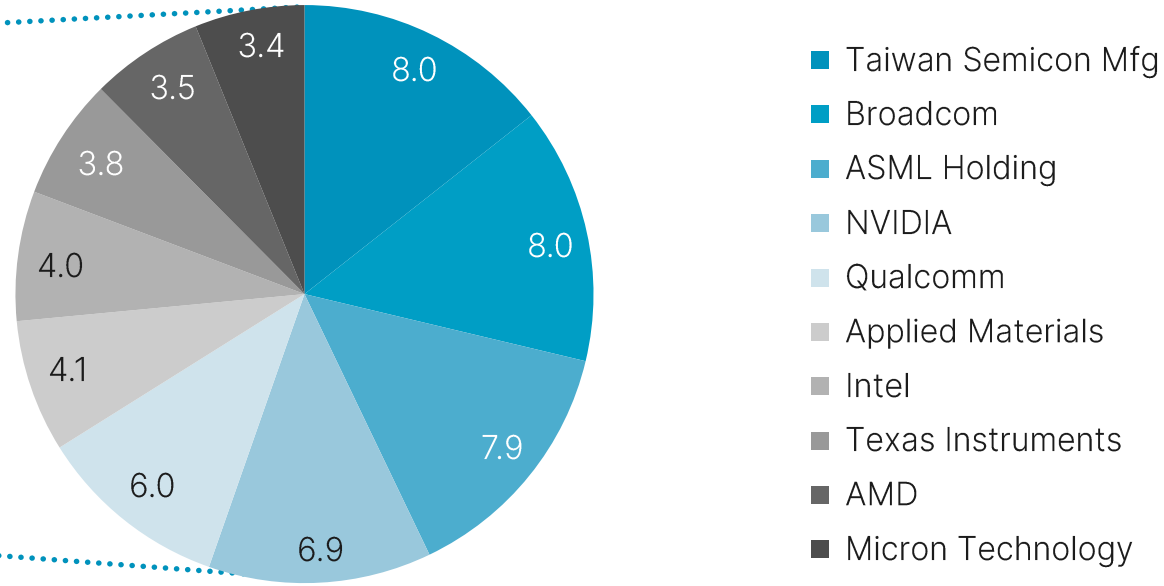
GSOX™ Index Composition

The Nasdaq Global Semiconductor Index is designed to track the performance of the 80 largest semiconductor companies globally. In order to qualify for inclusion, companies must be classified under the Semiconductors Subsector or Production Technology Equipment Subsector according to the Industry Classification Benchmark (ICB). Each constituent must have a market capitalization of at least $150 million and a three-month average daily traded value of at least $1 million. ESG screening criteria – as determined by Sustainalytics – are also applied.

Top 10 vs. Rest of Index

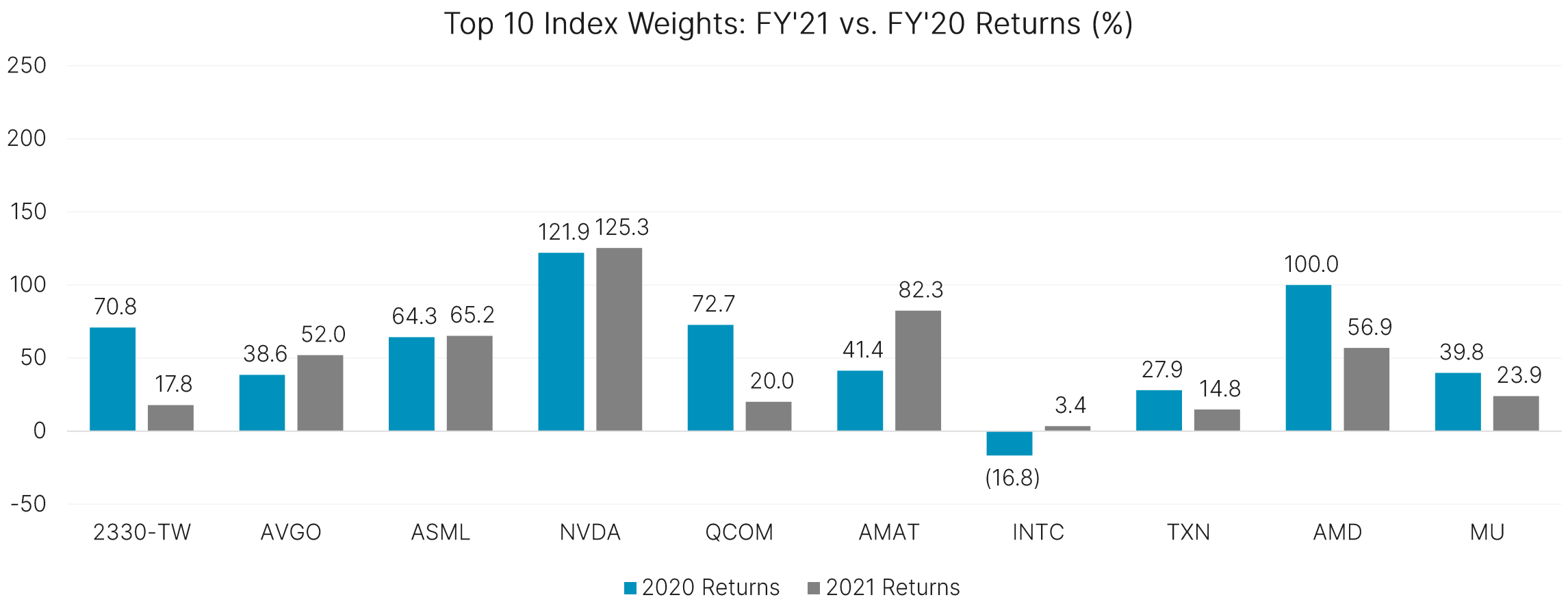


Top 10 Index % Weights as of December 31, 2021



Source: Nasdaq Global Indexes as of December 31, 2021

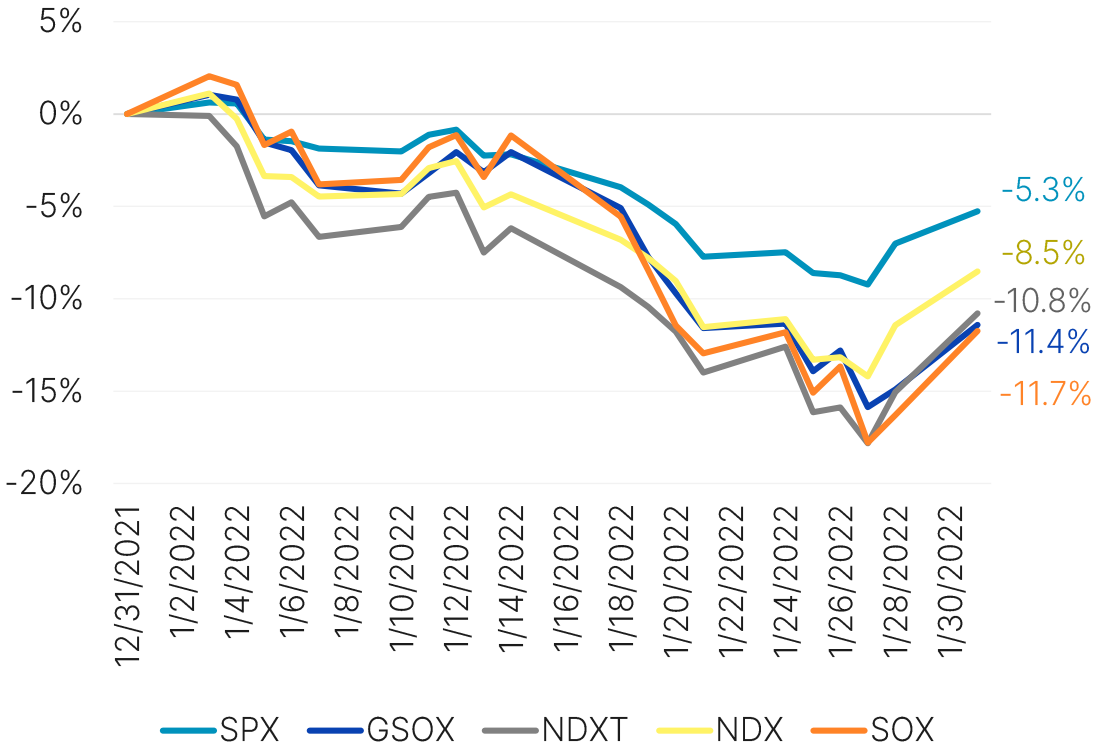
Top 10 Constituents: YoY Price Performance



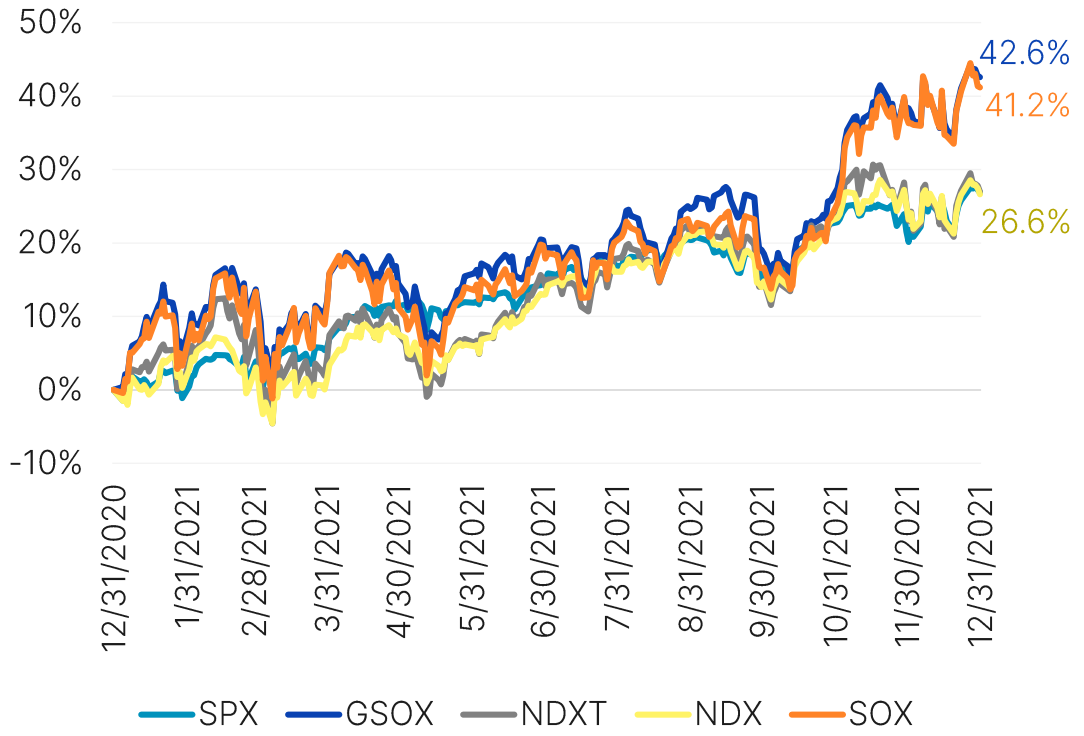
Source: Nasdaq Global Indexes, FactSet, Bloomberg as of December 31, 2021

YTD 2022 vs. Full-Year 2021 Performance

January 2022 Price Performance vs. Market Benchmarks

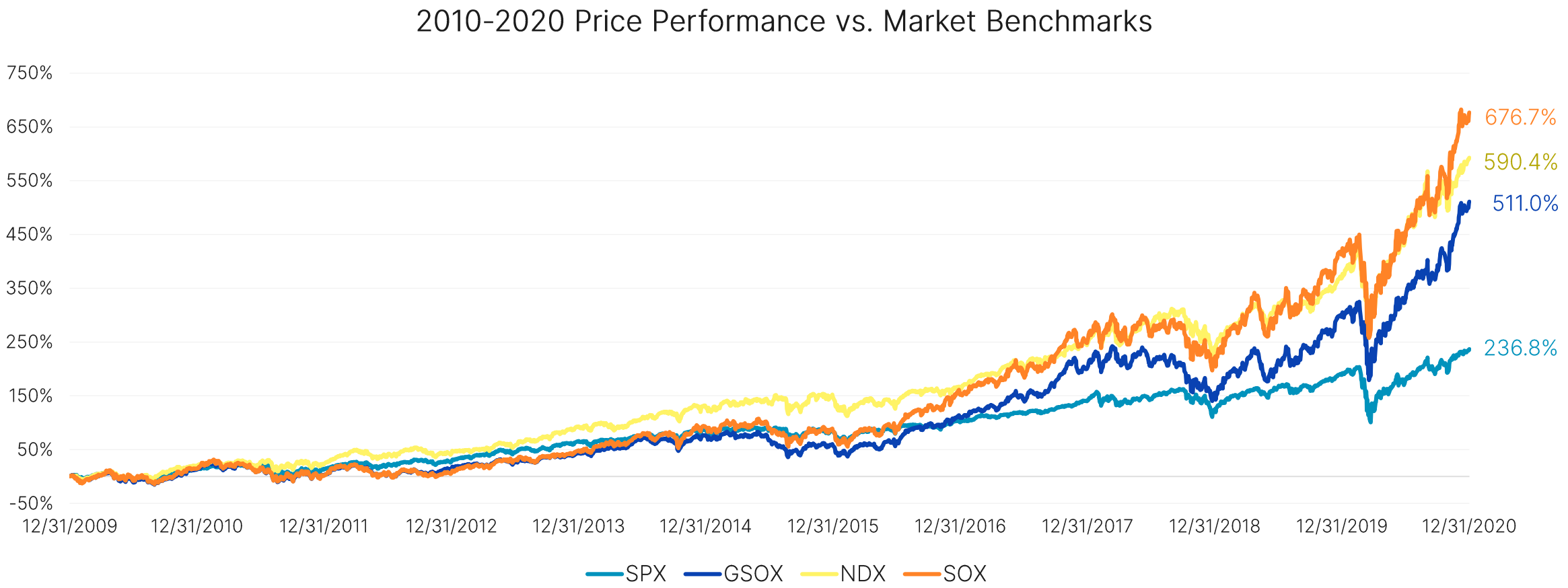


FY'21 Price Performance vs. Market Benchmarks



Source: Nasdaq Global Indexes, FactSet, Bloomberg as of January 31, 2022

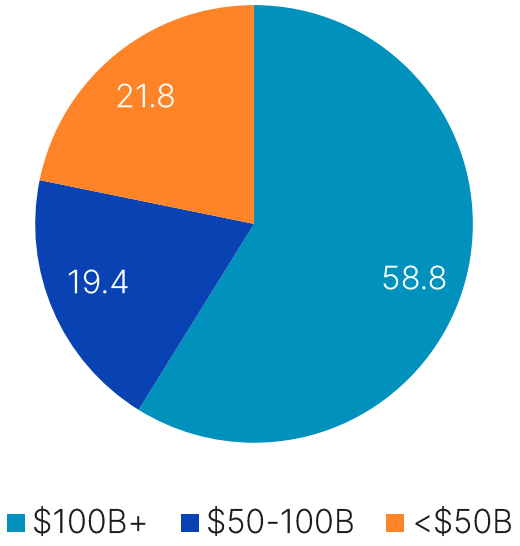
Prior Decade of Outperformance



Source: Nasdaq Global Indexes, FactSet, Bloomberg as of December 31, 2021

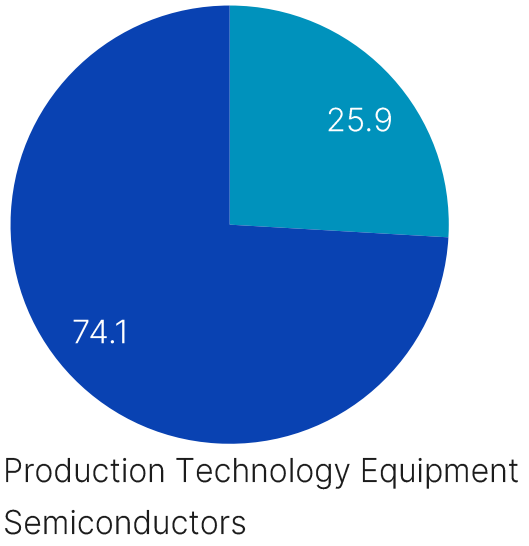
Market Cap/Subsector/Globality Profile

Index % Weight by Market Cap



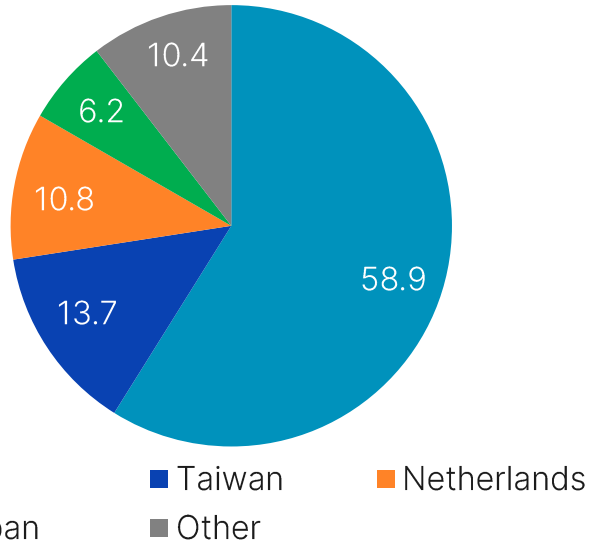
of $100B+ Companies: 11
of $50-100B Companies: 8
of <$50B Companies: 60

Index % Weight by ICB Industry



# of Semiconductors: 59
# of Production Technology Equipment: 20

Index % Weight by Domicile Country



# of US-Domiciled: 39
# of International: 40

Source: Nasdaq Global Indexes, FactSet, Bloomberg as of December 31, 2021

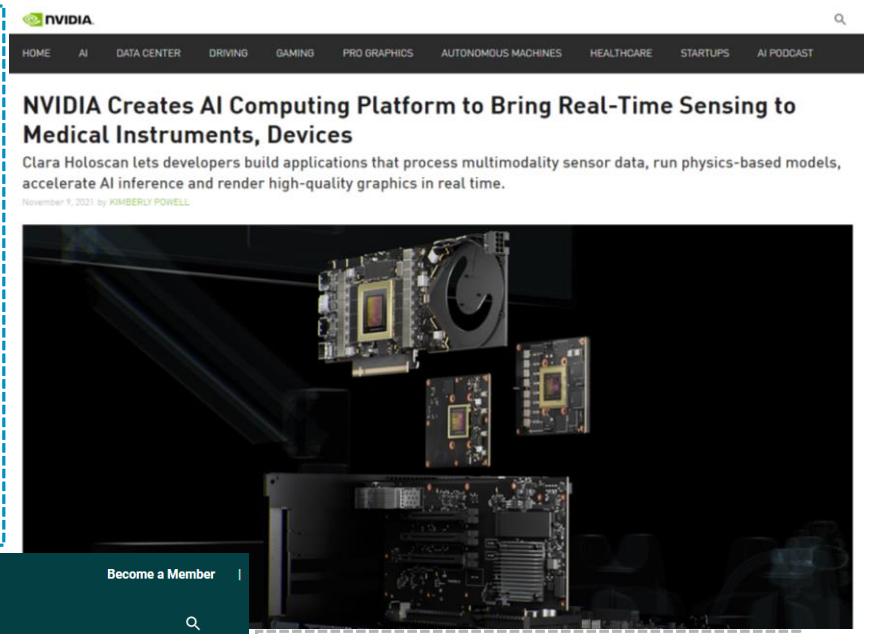
GSOX Company Case Studies

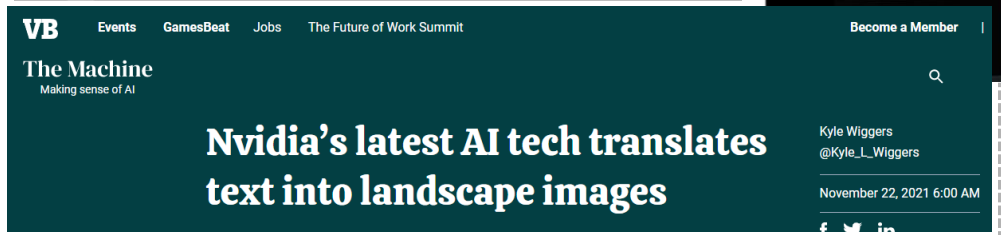
Case Studies

NVIDIA Corporation GSOX Weight: 6.93%

NVIDIA is a leading semiconductor designer and manufacturer. It is best known for its computer graphics processors (GPUs) that have established it as a leader in the markets for gamers, designers, AI data scientists, big data researchers, and cloud-based visual computing users. It has also pioneered the development of "system on a chip" to drive supercomputing for autonomous robots, drones, and cars, as well as for consoles, mobile gaming, and other entertainment devices. NVIDIA also builds its own supercomputers for internal and external research.

- Founded in 1993 and headquartered in Santa Clara, California
- Current Market Cap: $735B
- 5-Year Price Return: 1,002%
- FY'21 Revenue (est.): $26.6B, up 284% vs. $6.9B in FY'16 (31% CAGR)
- Q3'21 R&D Expense: $1.4B (20% of Revenue)
- Q3'21 Gross Margin: 65.2%
- Q3'21 Free Cash Flow: $1.3B
- Q3'21 Net Income: $2.5B
- # of Employees: ~19,000
- Key Customers: Microsoft, Google, Amazon, Oracle, Cisco





Source: Nasdaq, Bloomberg, FactSet, NVIDIA, VentureBeat, Engadget. Data as of 12/31/2021.

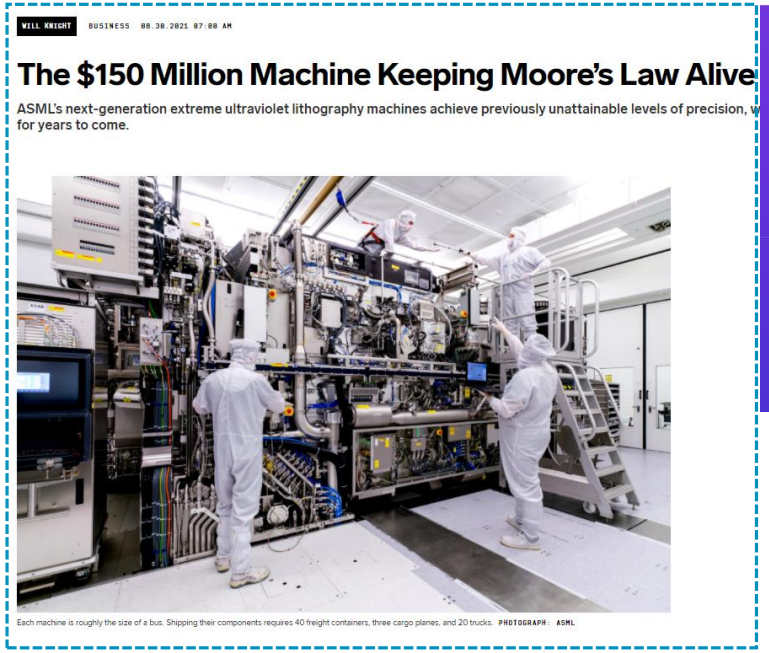
Case Studies

ASML Holding NV

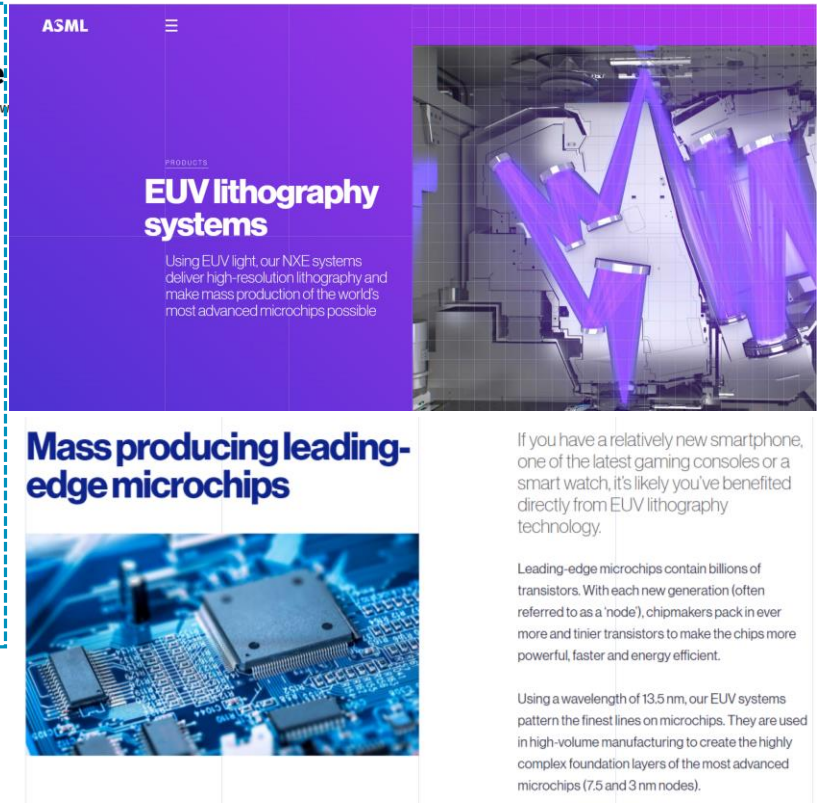
GSOX Weight: 7.86%

ASML is the world's leading photolithography equipment manufacturer and servicer. It pioneered the development of extreme ultraviolet lithography (EUV) in the 1990s, which enables the fabrication of the world's smallest and most powerful silicon wafers used in microprocessors. Along with Nikon and Canon, it is also a major supplier of older-generation, deep ultraviolet lithography (DUV) systems to the semiconductor foundry industry. Its machines can cost up to $150MM each, and require over 4,000 different suppliers to assemble.

- Founded in 1984 and headquartered in Veldhoven, Netherlands
- Current Market Cap: $327B
- 5-Year Price Return: 610%
- FY'21 Revenue (est.): $21.8B, up 190% vs. $7.5B in FY'16 (18% CAGR)
- Q3'21 R&D Expense: $718MM (12% of Revenue)
- Q3'21 Gross Margin: 51.7%
- Q3'21 Free Cash Flow: $1.9B
- Q3'21 Net Income: $2.1B
- # of Employees: ~28,000
- Key Customers: Intel, Samsung, Taiwan Semiconductor



Using a wavelength of just 13.5 nm (almost x-ray range), ASML's extreme ultraviolet (EUV) lithography technology can do big things on a tiny scale. EUV drives Moore's Law forward and supports novel transistor designs and chip architectures.



Source: Nasdaq, Bloomberg, FactSet, ASML, Wired.com. Data as of 12/31/2021.

Case Studies

STMicroelectronics NV GSOX Weight: 1.47%

STMicroelectronics (STM) is a leading semiconductor manufacturer. In the 1990s, STM pioneered the development of silicon carbide (SiC), a wide band-gap (WBG) semiconductor material with superior energy conversion properties vs. regular silicon. SiC is forecast to penetrate 70% of the electric vehicle market by 2030, and will more broadly transform the markets for energy storage. STM operates through 3 main business segments: Automotive & Discrete (32% of revenue), Analog, MEMS & Sensors (38%), and Microcontrollers & Digital Integrated Circuits (30%).

- Founded in 1987 and headquartered in Geneva, Switzerland
- Current Market Cap: $45B
- 5-Year Price Return: 331%
- FY'21 Revenue (est.): $12.6B, up 47% vs. $7.0B in FY'16 (8.2% CAGR)
- Q3'21 R&D Expense: $433MM (14% of Revenue)
- Q3'21 Gross Margin: 41.6%
- Q3'21 Free Cash Flow: $420MM
- Q3'21 Net Income: $474MM
- # of Employees: ~46,000
- Key Customers: Apple, Tesla, Huawei, Samsung, HP

Source: Nasdaq, Bloomberg, FactSet, STMicroelectronics. Data as of 12/31/2021.

Case Studies

Infineon Technologies AG GSOX Weight: 1.98%

Infineon (IFX) is a leading German semiconductor manufacturer, spun off from former parent company Siemens AG. Infineon operates through 4 main business segments: Automotive (41% of revenue), Power Management & Multimarket (31%), Industrial Power Control (16%), and Connected Secure Systems (11%). Following the largest acquisition in its history (Cypress, April 2020), Infineon is now the eighth largest semiconductor company in the world. With its core competence of power semiconductors, Infineon is also a major player in SiC technology.

- Founded in 1999 and headquartered in Neuberg, Germany
- Current Market Cap: $60B
- 5-Year Price Return: 166%
- FY'21 Revenue (est.): $13.2B, up 77% vs. $7.2B in FY'16 (8% CAGR)
- Q3'21 R&D Expense: $399MM (13% of Revenue)
- Q3'21 Gross Margin: 39.1%
- Q3'21 Free Cash Flow: $642MM
- Q3'21 Net Income: $295MM
- # of Employees: ~47,000

Automotive

p. 55

Key customers[1]
Aptiv / Bosch / BYD / Continental / Delphi / Denso / Hella / Hitachi / Hyundai / Keihin / Lear / Mando / Mitsubishi Electric / Preh / Valeo / Veoneer / Vitesco / ZF

Market position[2]
#1 with a market share of 13.4% for automotive semiconductors (including contribution from Cypress)
Source: Strategy Analytics, April 2020

#3 with a market share of 19.5% for NOR Flash memory ICs
Source: Omdia, March 2020

Industrial Power Control

p. 60

Key customers[1]
ABB / Alstom / Bombardier / CRRC / Danfoss / Eaton / Emerson / Goldwind / Inovance / Midea / Nidec / Rockwell / Schneider Electric / Semikron / Siemens / Sungrow / Toshiba / Vestas / Yaskawa

Market position[2]
#1 with a market share of 35.6% for IGBT modules
Source: Omdia: *Power Semiconductor Market Share Database 2020.* September 2020

#3 with a market share of 11.5% for IPMs
Source: Omdia: *Power Semiconductor Market Share Database 2020.* September 2020

Power & Sensor Systems

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Key customers[1]
Airbus / Alibaba / Amazon / Artesyn / Baidu / Boeing / Cisco / Dell / Delta / Ericsson / Google / Hewlett Packard Enterprise / HP / Lenovo / LG Electronics / Lite-On / Makita / Nokia / Osram / Panasonic / Quanta / Samsung / ZTE

Market position[2]
#1 with a market share of 24.6% for power MOSFETs
Source: Omdia: *Power Semiconductor Market Share Database 2020.* September 2020

#1 with a market share of 43.5% for MEMS microphones
Source: Omdia, October 2020

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Key customers[1]
Bang & Olufsen / Brother / Fitbit / Giesecke & Devrient / Google / HP / Idemia / Lenovo / Microsoft / Nintendo / Raspberry Pi / Thales / US Government Publishing Office / Watchdata

Market position[2]
#1 with a market share of 26.3% for secure ICs (excluding NFC controller and NFC embedded Secure Element)
Source: ABI Research, October 2020

#5 with a market share of 9.8% for Wi-Fi ICs (standalone ICs only)
Source: ABI Research, July 2020

Major distributions customers[1]
Arrow / Avnet / Intron / Jingchuan / Macnica / Nexty / Rutronik / Weikeng / WPG Holding (SAC)

Please find a detailed presentation of the segments' target applications and product range in the chapter "Applications and product range", p. 236 ff.

1 In alphabetical order.
2 All figures for 2019 calendar year. The market share of the five largest competitors is shown in the "Market position" section of the relevant segment. The figures provided in those sections with respect to changes in market share relate to the 2019 and 2018 market share figures as calculated in 2020. Due to changes in the way the market is analyzed, these figures may differ from the 2018 market share figures reported in 2019.

From their 2020 Annual Report:

- "Infineon supplies all major manufacturers of wind power turbines and [photovoltaic] inverters."
- "Infineon provides the essential power components and subsystems for efficient energy storage."
- "In the long term, green hydrogen has the potential to become a key growth driver for Infineon."
- "Our semiconductor solutions drive the [Internet of Things]."

Source: Nasdaq, Bloomberg, FactSet, Infineon. Data as of 12/31/2021.

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