



Semiconductors in a Post-Covid World

Tracking the Thematic Technologies of
Tomorrow with Nasdaq Global Indexes

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Semiconductor Industry Overview

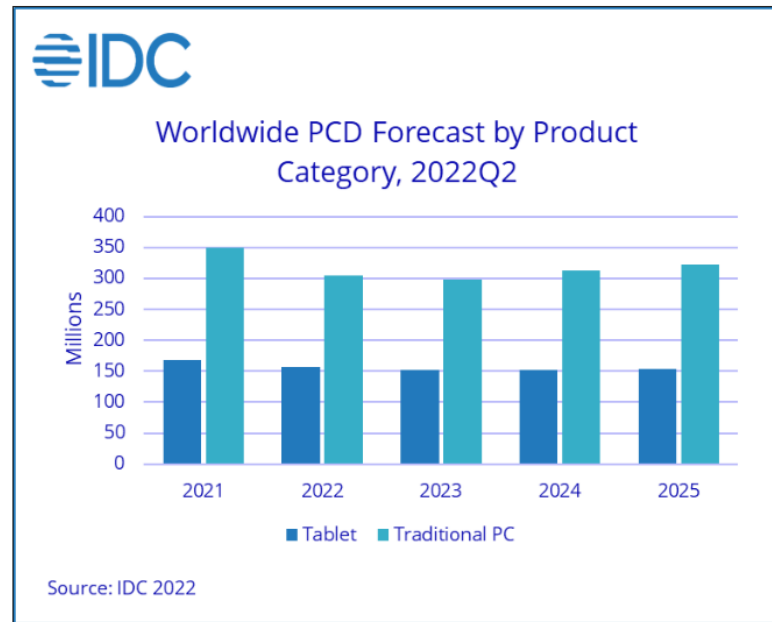


Some Deceleration in Demand Post Covid-19

PC Slowdown Will Drain Shipments Through 2023: IDC

BY SHANE SNIDER
SEPTEMBER 01, 2022, 03:53 PM EDT

Research firm shows drop in expected shipments for personal computers and tablets through at least 2023, but sales will stay stronger than pre-pandemic numbers – for now, at least. ‘Overall, this report is not a surprise, and we’re confident we can manage through it,’ one partner says.



27 Oct 2022

Smartphone Market Suffers Fifth Consecutive Decline in Global Shipments in Q3 2022, According to IDC Tracker

Contact: Michael Shirer, press@idc.com

NEEDHAM, Mass., October 27, 2022 – Worldwide smartphone shipments declined 9.7% year over year to 301.9 million units in the third quarter of 2022 (3Q22), according to preliminary data from the International Data Corporation (IDC) [Worldwide Quarterly Mobile Phone Tracker](#). The drop marks the largest-ever third quarter decline and the fifth consecutive quarter of decline for the smartphone market as shipments continue to struggle amidst weakened global demand and economic uncertainties.

Qualcomm warns of slowdown in smartphone chip sales and its stock slides

BY MIKE WHEATLEY

Smartphone chip company Qualcomm Inc. is trading lower today after it issued a forecast for its fiscal fourth quarter that fell short of Wall Street's expectations.



STAMFORD, Conn., October 10, 2022

Gartner Says Worldwide PC Shipments Declined 19.5% in Third Quarter of 2022

PC Market Experiences Steepest Decline in Over Two Decades

Worldwide PC shipments totaled 68 million units in the third quarter of 2022, a 19.5% decrease from the third quarter of 2021, according to preliminary results by Gartner, Inc. This is the steepest market decline since Gartner began tracking the PC market in the mid-1990s and the fourth consecutive quarter of year-over-year decline.



Sources: Gartner, IDC, TechCrunch, Canalys, Silicon Angle

- <https://www.gartner.com/en/newsroom/press-releases/2022-10-10-gartner-says-worldwide-pc-shipments-declined-19-percent-in-third-quarter-of-2022>
- <https://techcrunch.com/2022/07/28/smartphone-sales-drop-sharply-in-china/>
- <https://siliconangle.com/2022/07/27/qualcomm-warns-slowdown-smartphone-chip-sales-stock-slides/>
- https://www.gsmarena.com/canalys_global_smartphone_shipments_declined_by_9_in_q3_2022-news-56201.php
- <https://www.idc.com/getdoc.jsp?containerId=prUS49809922#:~:text=NEEDHAM%2C%20Mass.%2C%20October%2027,Worldwide%20Quarterly%20Mobile%20Phone%20Tracker.>



Global Supply Shortages Easing

07 Jun 2022



Worldwide Semiconductor Revenue to Grow 13.7%, but Supply Chain Remains Selectively Challenging amidst Global Economic Volatility, according to IDC

Technology Report

When Will the Chip Shortage End?

Even with recent investments and signs of improvement, the recovery will be uneven and depend on such wild cards as general economic activity, geopolitical tensions, and shortages of “bleeding-edge” chipmaking equipment.

By Anne Hoecker, Peter Hanbury, Hans Joachim Heider, and Sophia Zou
September 19, 2022 • 7 min read

Listen to this article 6 minutes

At a Glance

- ▶ The semiconductor shortage won't end on a single date. Some companies are starting to see relief this year, while others may have to wait until 2024 or later.
- ▶ Softening demand is the fastest route to relief, and it's conceivable given the slowdown in the global economy.
- ▶ Leading companies are designing their products to increase resilience, systematically assessing risks, investing in value chain innovations, and revamping their operating model.

Authors: Anne Hoecker, Partner, Silicon Valley; Peter Hanbury, Partner, San Francisco

The Chip Shortage Isn't Over Quite Yet

By **Ian King**
August 19, 2022 at 6:45 AM EDT

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For Chip Makers, the Flip From Shortage to Glut Intensifies

After sharp growth during Covid, semiconductor executives now are pausing hiring and cutting costs amid high costs.



Electronics manufacturers tend to stock up on chips ahead of the holiday selling season, but that hasn't played out this year for some.

By **Ann Flinch**
Nov. 4, 2022 7:07 am ET

Jaguar Land Rover cuts output at UK factories due to chip shortage

3 days ago



J.P.Morgan

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RESEARCH

Supply Chain Issues and Autos: When Will the Chip Shortage End?

How long will the semiconductor crisis last? Here's how the chip shortage will play out according to J.P. Morgan Research.

Updated August 11, 2022

Supply chain issues are widespread and prevalent, with the ongoing chip shortage causing reverberations across many sectors. Among those most affected is the auto industry, where chip shortages are holding up production and denting sales.

Semiconductors or chips are a crucial element in the manufacturing of consumer electronics such as smartphones, cameras and computers. In cars, they are needed for everything from entertainment systems to power steering. For the auto industry, the supply crunch and shortage of chips has forced car manufacturers to cut production and delivery targets and has led to a number of profit warnings.

In this supply chain spotlight, J.P. Morgan Research explores how the current chip shortage is impacting automakers, the “perfect storm” that is causing it and what the path forward might look like for the auto and auto parts industries.

When Will the Chip Shortage End?

More chips will become available in the second half of 2022 and the shortage is nearing the end according to J.P. Morgan Research. However, available chips may not be the right type to satisfy all demand. Volkswagen believes that semiconductor supply is unlikely to meet auto industry demand until 2024.

“We're going to get a lot more semiconductor capacity in the second half of 2022 - we're nearing the end of the supply crunch. However, capacity still needs to be qualified for use in the automotive industry. Can the right matching occur between available supply and correct qualification? This is the difficulty that remains.”

Sandeep Deshpande, Head of European Technology Research, J.P. Morgan

Sources: IDC, Bain & Company, JP Morgan, Wall Street Journal, BBC.

1. <https://www.bain.com/insights/chip-shortage-end-tech-report-2022/>
2. <https://www.idc.com/getdoc.jsp?containerId=prAP49266822>
3. <https://www.bbc.com/news/business-63756079>
4. <https://www.jpmorgan.com/insights/research/supply-chain-chip-shortage>
5. <https://www.wsj.com/articles/chip-makers-cut-costs-as-demand-slump-supplants-pandemics-chip-shortage-11667560050>
6. <https://www.bloomberg.com/news/newsletters/2022-08-19/the-chip-shortage-isn-t-over-quite-yet>

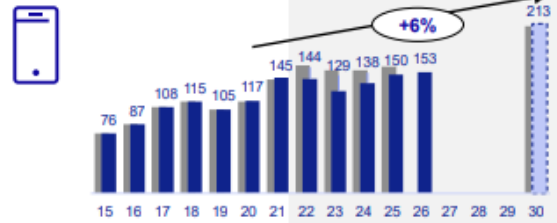


Sources of Future Demand Growth

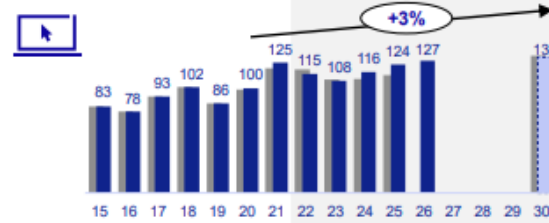
Semi end markets expected to grow 9% through 2030

All markets contributing; Datacenter, Automotive and Industrial expected to outperform

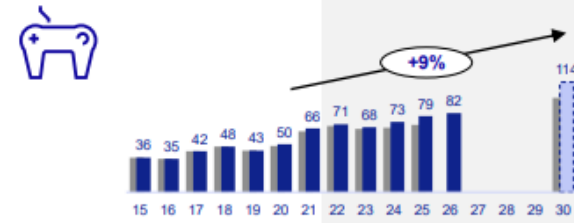
Smartphone (\$bn)



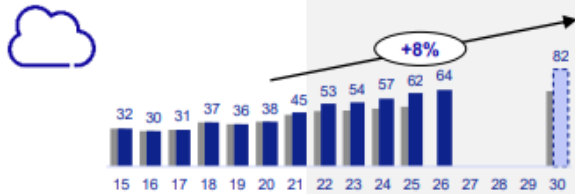
Personal Computing (\$bn)



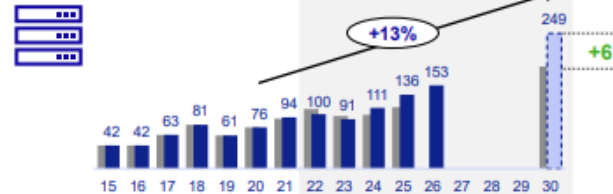
Consumer Electronics (\$bn)



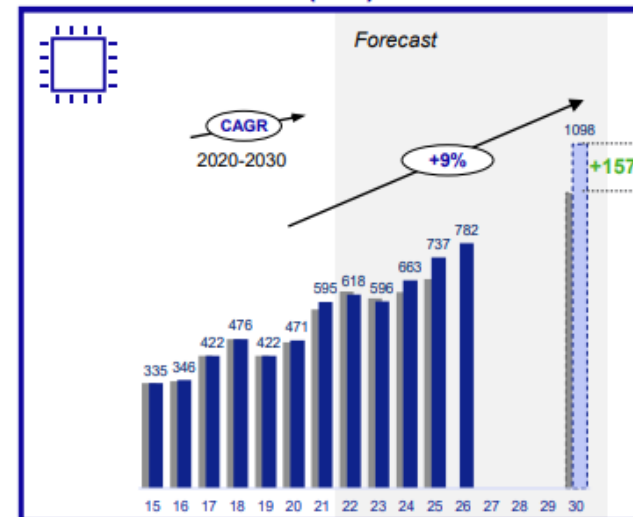
Wired & wireless Infrastructure (\$bn)



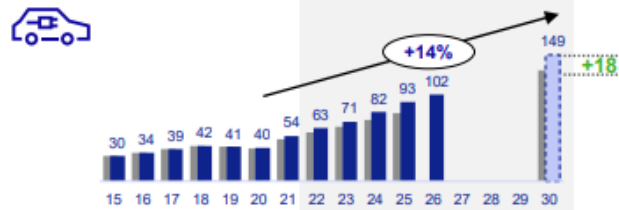
Servers, Datacenters & Storage (\$bn)



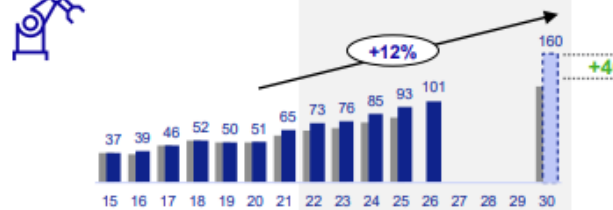
Total Semiconductor (\$bn)



Automotive (\$bn)



Industrial Electronics (\$bn)



Source: Historical data: Gartner. Outlook: Gartner 3Q22 Forecast (Sep22, 2022) for years '22-'26; Outlook 2030: ASML estimate; segment revenue extrapolated using '20-'26 Compound Annual Growth Rate (CAGR). Some deviations from this methodology due to expected growth profile differences across the decade

■ CMD 2021 ■ CMD 2022
 ■ CMD 2022 - extrapolation



Sources of Future Growth: Green Energy

Energy transition will be one of the market drivers over the coming decades

Semiconductors are crucial in generation, storage, distribution, consumption of electrical energy

Generation

Accelerated migration to different energy mix due to environmental, scarcity and geopolitical factors¹

Green energy generators have **high-power semiconductor content**²:

- Wind: ~3,000 €/MW
- Solar: ~4,000 €/MW

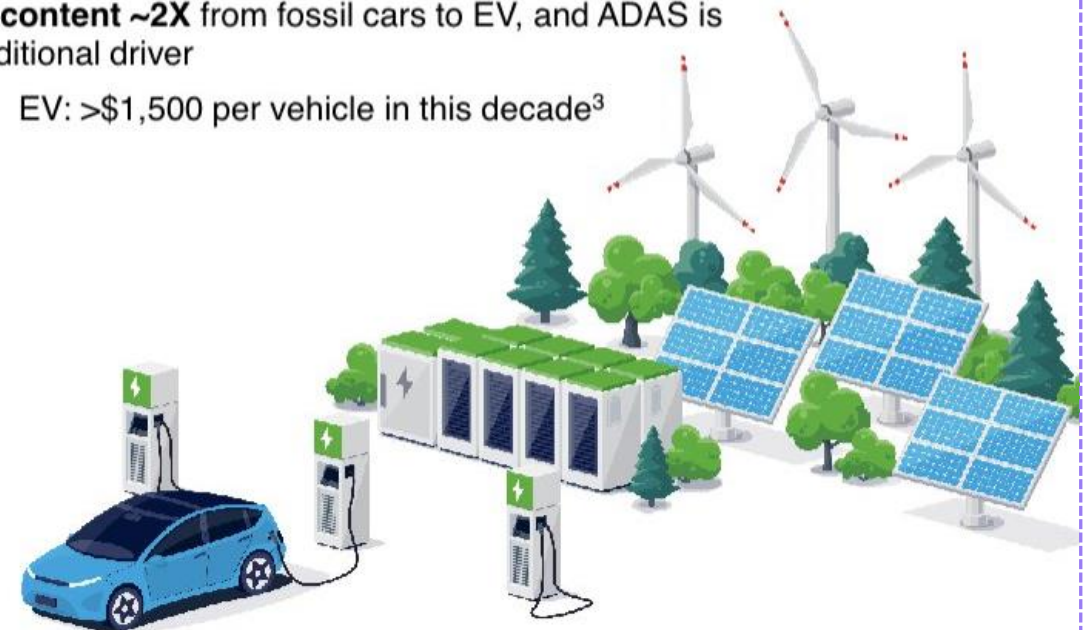
Consumption

Accelerated conversion from fossil to electrical in mobility

- ~70% of car sales in 2030 will be xEV (up from ~15% in 2021)³

Semi content ~2X from fossil cars to EV, and ADAS is an additional driver

- EV: >\$1,500 per vehicle in this decade³



Sources

1: Shell-2021 The energy transition scenarios

2: Infineon-August 2022: Third quarter FY2022- quarterly update

3: Infineon-October 2022: Automotive Division Call

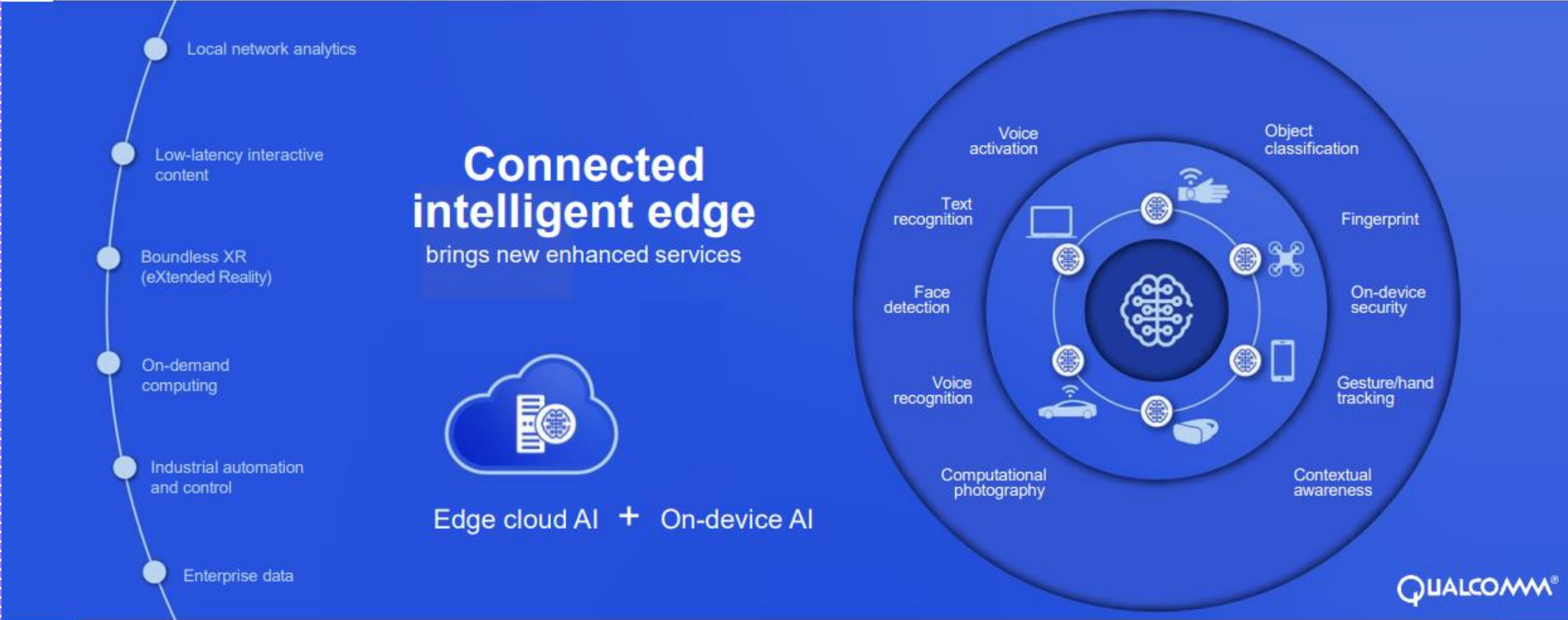
xEV: all types of electric vehicles, including mild hybrid electric vehicles



Sources of Future Growth: Artificial Intelligence

The connected intelligent edge delivers new and enhanced services

Artificial intelligence of things



Source: Qualcomm, What's the role of artificial intelligence in the future of 5G and beyond?, September 21, 2021

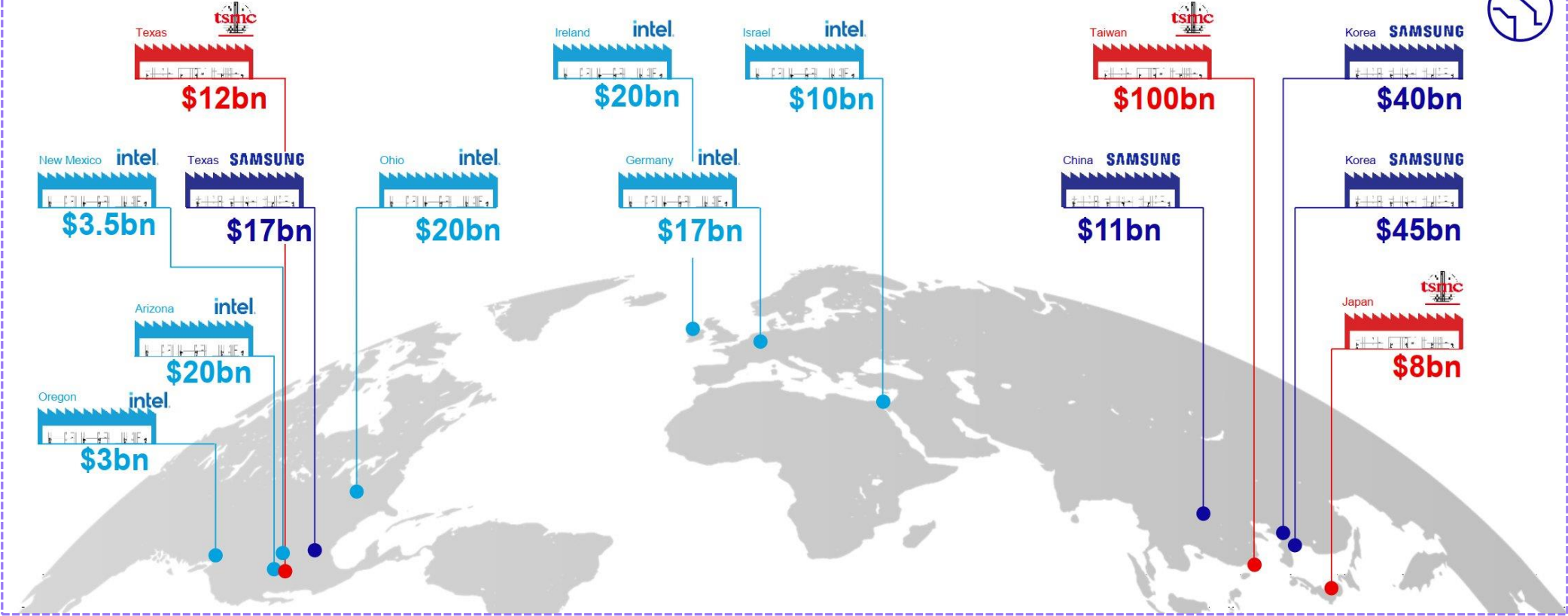


Source: ASML 2022 Investor Day Presentation. As of 11/11/2022.

Explosion in Announced Semiconductor CapEx

Customers are investing to support these demand drivers

Top three semiconductor manufacturers announced plans to invest >\$300 billion in global capacity



Source: ASML 2022 Investor Day Presentation. As of 11/11/2022.

CapEx Growth Boosted by New Industrial Policy

Countries push for 'technological sovereignty', fueling capex spend



CHIPS Act, FABS Act

- \$52bn
- Investment tax credits



European CHIPS Act

- \$46bn



Integrated Circuit Industry Investment Fund ("Big Fund")

- \$20.7bn Phase 1
- \$30.5bn Phase 2
- Tax breaks



Invest Taiwan Initiative

- Tax credits
- Help securing land, water and electricity



K-Semiconductor Belt

- Tax credits
- Aim to attract \$450bn in private investment by 2030



Specified ICT Utilization

- \$4.42bn
- Subsidies for setup costs

Source: "The resilience myth: Fatal flaws in the push to secure chip supply chains," Nikkei Asia, July 26, 2022

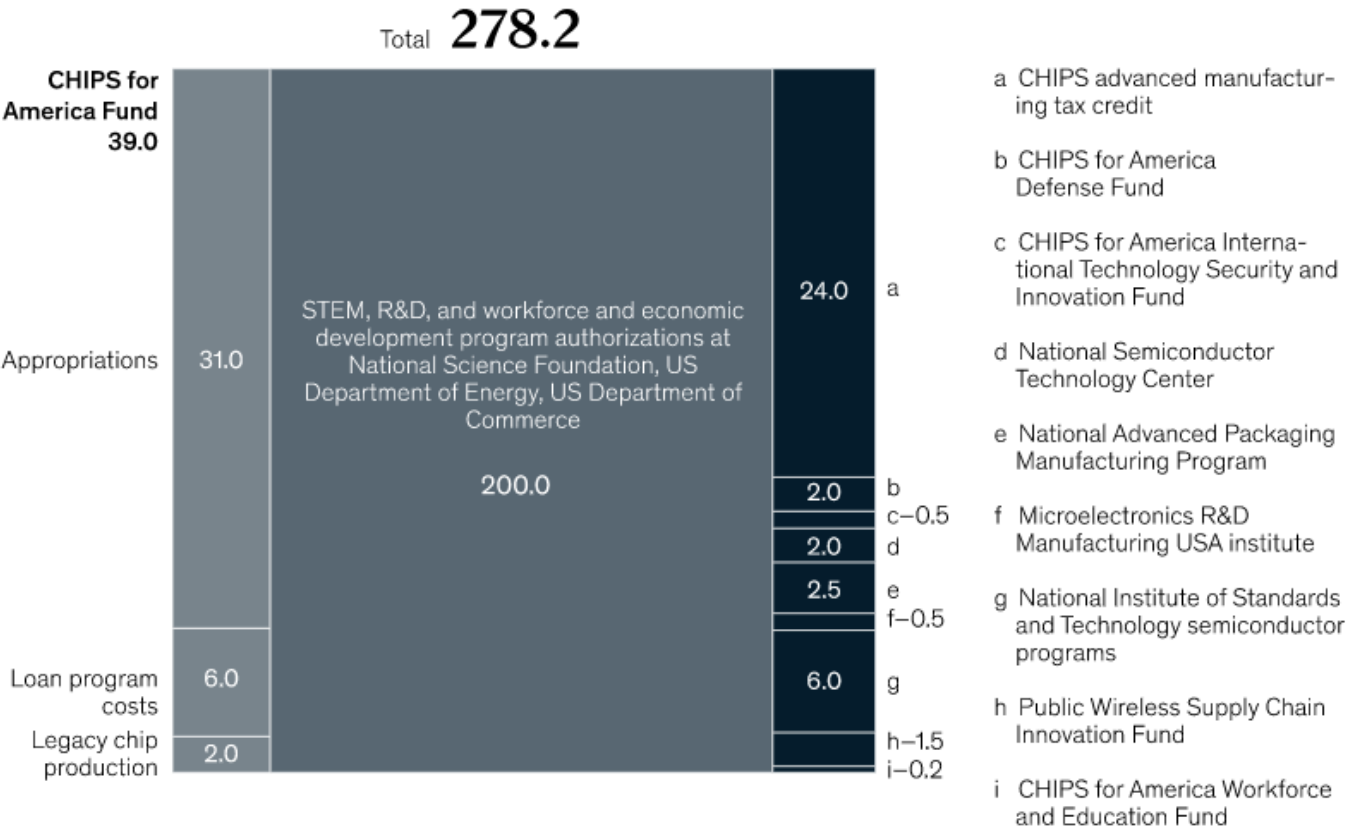
Source: ASML 2022 Investor Day Presentation. As of 11/11/2022.



US CHIPS and Science Act of 2022

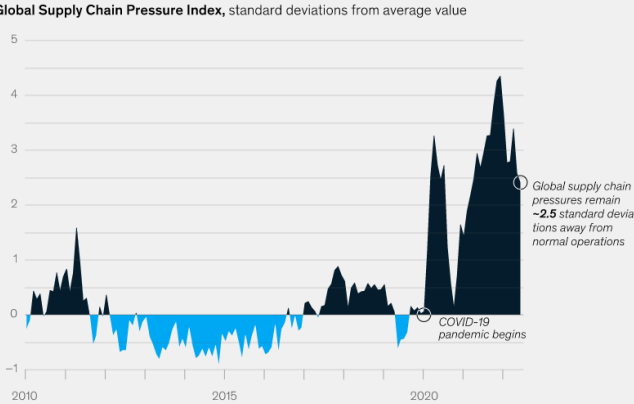
The CHIPS and Science Act of 2022 directs \$280 billion in spending over the next ten years, with the bulk for scientific R&D.

CHIPS and Science Act funding for 2022–26, \$ billion



The chips are down: The United States makes 12 percent of the world's semiconductors, compared with 37 percent in the 1990s, according to US government statistics.^[1] Many US firms are dependent on chips made abroad, and the fragility of those supply chains has been laid bare over the past 18 months. Moreover, McKinsey research estimates that worldwide demand will become a \$1 trillion industry by the end of the decade.

Semiconductor shortages have been a key aspect of global supply chain pressures over the past 18 months.



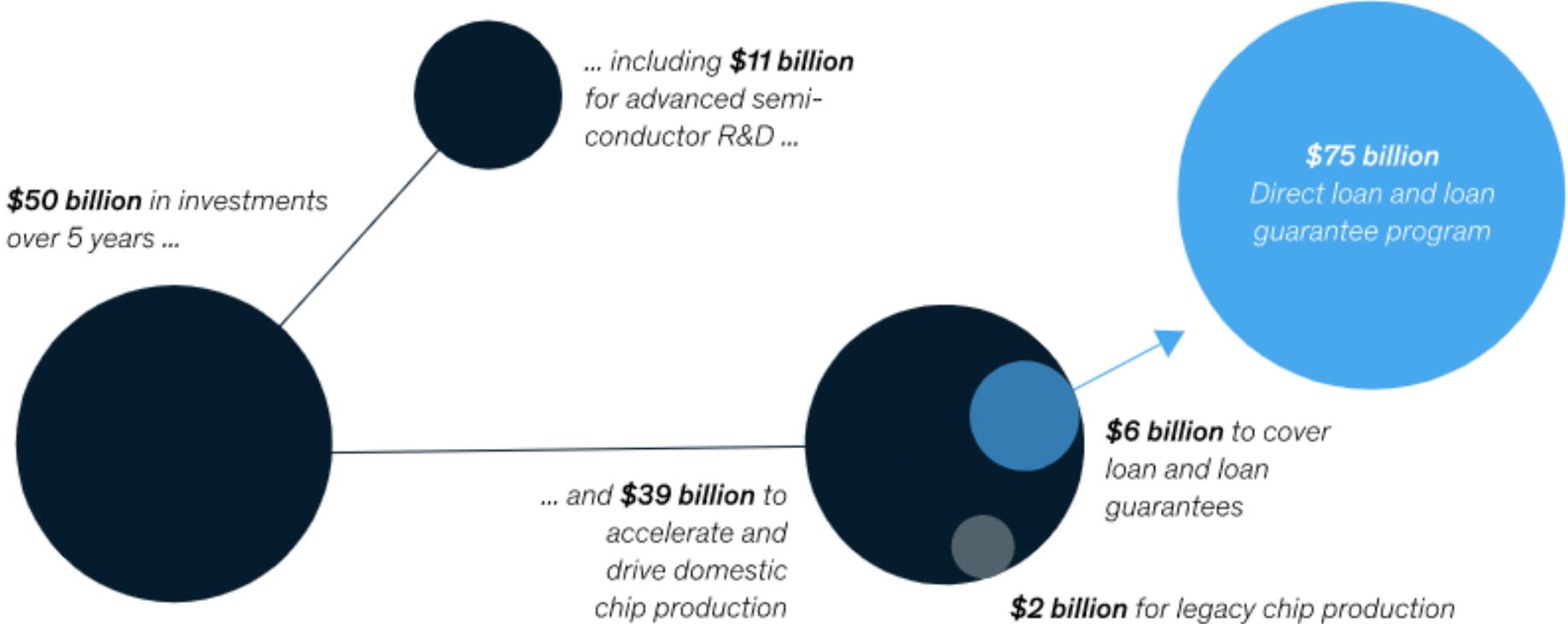
Source: Federal Reserve Bank of New York, S&P Global PMI Commodity Price and Supply Indicators

Source: Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022, H.R. 4346, 117th Cong. (2022)

US CHIPS and Science Act of 2022

The US Department of Commerce will oversee \$50 billion in investments to expand domestic manufacturing of mature and advanced semiconductors.

Budget to expand domestic manufacturing of mature and advanced semiconductors



Source: US Department of Commerce



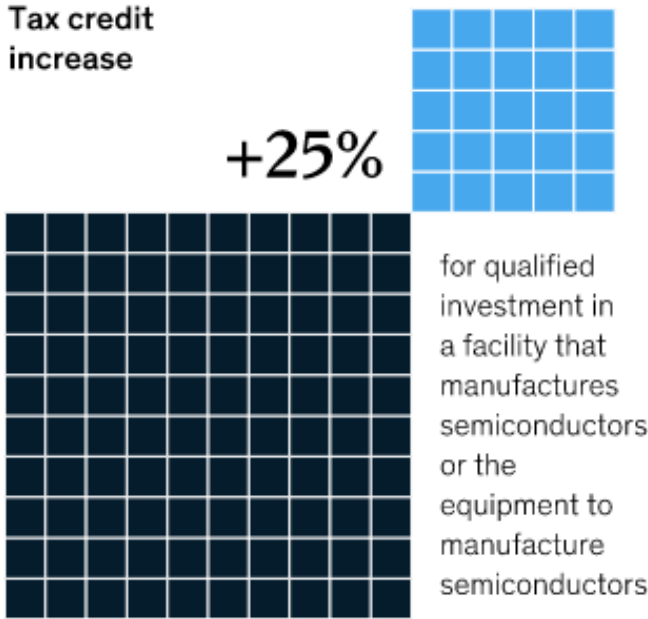
Source: McKinsey & Company.

1. <https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-chips-and-science-act-heres-whats-in-it>

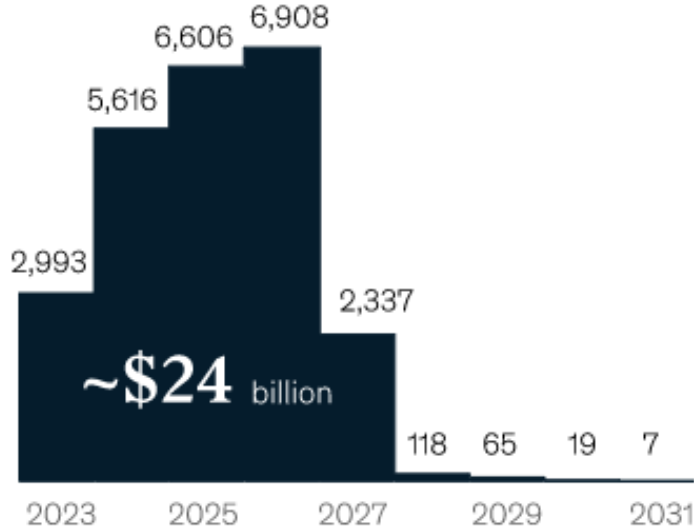
US CHIPS and Science Act of 2022

The CHIPS and Science Act establishes a semiconductor investment tax credit of approximately \$24 billion to spur private investment until January 1, 2027.

Advanced manufacturing investment tax credit



Estimated outlays of advanced manufacturing investment tax credits by US Treasury, \$ million



Boosting national security and 5G supply chains: The CHIPS Act allocates \$2 billion to the US Department of Defense to fund microelectronics research, fabrication, and workforce training. An additional \$500 million goes to the US Department of State^[1] to coordinate with foreign-government partners on semiconductor supply chain security. And \$1.5 billion funds the USA Telecommunications Act of 2020, which aims to enhance competitiveness of software and hardware supply chains of open RAN (radio access network) 5G networks.

The CHIPS and Science Act will fund a national network of semiconductor technologies for the defense industrial base and investments in supply chain resilience.



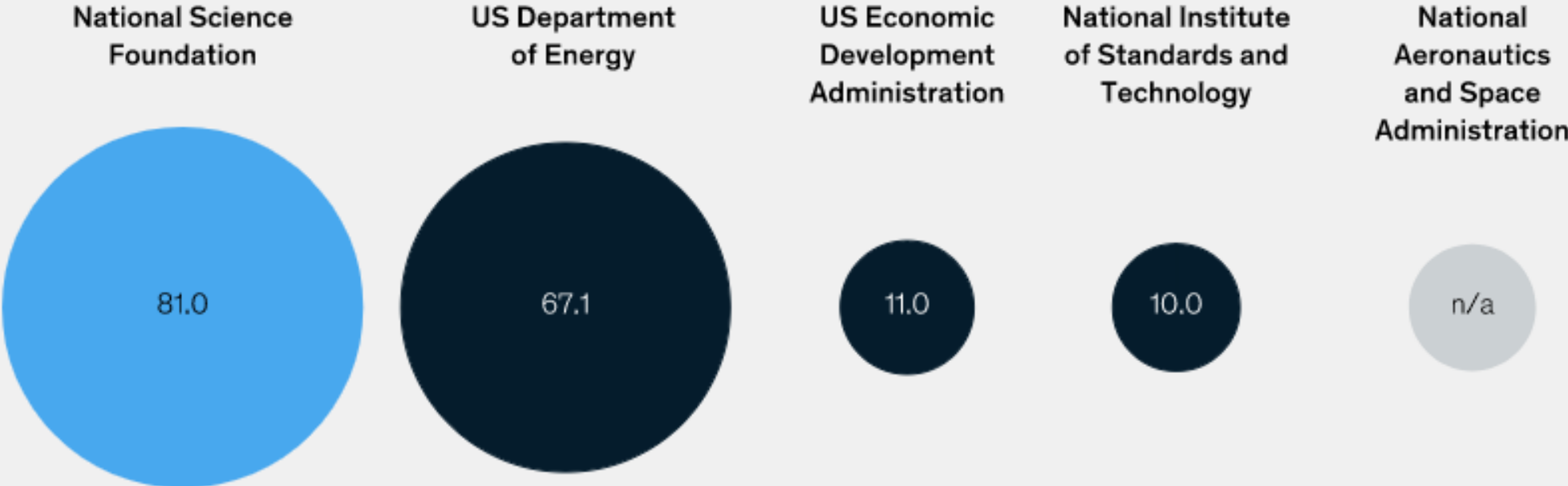
Radio access network. Source: US Department of Commerce

Source: Congress.gov; Congressional Research Service; Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022, H.R. 4346, 117th Cong. (2022); "Estimated budgetary effects of H.R. 4346, Divisions A and B," Congressional Budget Office; William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Public Law 116-283

US CHIPS and Science Act of 2022

The CHIPS and Science Act authorizes \$174 billion for investment in science, technology, engineering, and math programs, workforce development, and R&D.

CHIPS and Science Act funding 2022–27,¹ \$ billion



¹Final funding levels subject to future budget appropriations by US Congress.
Source: Congress.gov; Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022, H.R. 4346, 117th Cong. (2022)



US Semiconductor Policy Towards China

Biden's hugely consequential high-tech export ban on China, explained by an expert

The ban on semiconductor exports to China is one of the most important policy moves of the year — and could set off a geopolitical quake.

By Michael Bluhm | Nov 5, 2022, 8:00am EDT

f t SHARE



An employee works on the production line of semiconductors at a factory in Huai'an, China, on September 27. | VCG/VCG via Getty Images



US Ban on Americans Aiding China Chip Firms Narrower Than Feared

- Rules will only restrict people performing certain functions
- China relies on US personnel and firms for tech development

By Debby Wu and Jenny Leonard
October 31, 2022 at 10:06 PM EDT

Washington's restrictions on US citizens assisting China's chip industry will be more narrowly enforced than feared, suggesting a smaller-than-expected impact on semiconductor companies doing business in the world's second largest economy.

US semiconductor ban targets highest of Chinese high tech

By Ann Scott Tyson
November 4, 2022 | BEING

ANALYSIS

Biden Short-Circuits China

The latest U.S. moves undermine China's ability to import, manufacture, and export the semiconductors that run the world.

By [Rishi Iyengar](#), a reporter at Foreign Policy.



U.S. President Joe Biden speaks during an event on Micron's plan to invest in chips manufacturing at the SRC Arena in Syracuse, New York, on Oct. 27. MANDEL NGAN/AFP VIA GETTY IMAGES

OCTOBER 28, 2022, 11:43 AM

After four years of watching Donald Trump inflict flesh wounds on China with his ineffectual trade war, U.S. President Joe Biden appears to have found the jugular. The goal is the same, but this knife is sharper—and could set back China's tech ambitions by as much as a decade.

Sources: Gartner, IDC, TechCrunch, Canalsy, Silicon Angle

- <https://www.vox.com/world/2022/11/5/23440525/biden-administration-semiconductor-export-ban-china>
- <https://foreignpolicy.com/2022/10/28/biden-china-semiconductors-chips/>
- <https://www.csmonitor.com/World/Asia-Pacific/2022/1108/US-semiconductor-ban-targets-highest-of-Chinese-high-tech>
- <https://www.bloomberg.com/news/articles/2022-11-01/us-ban-on-americans-aiding-china-chip-firms-narrower-than-feared>
- <https://carnegieendowment.org/2022/10/27/biden-s-unprecedented-semiconductor-bet-pub-88270>



Nasdaq's Semiconductor Indexes

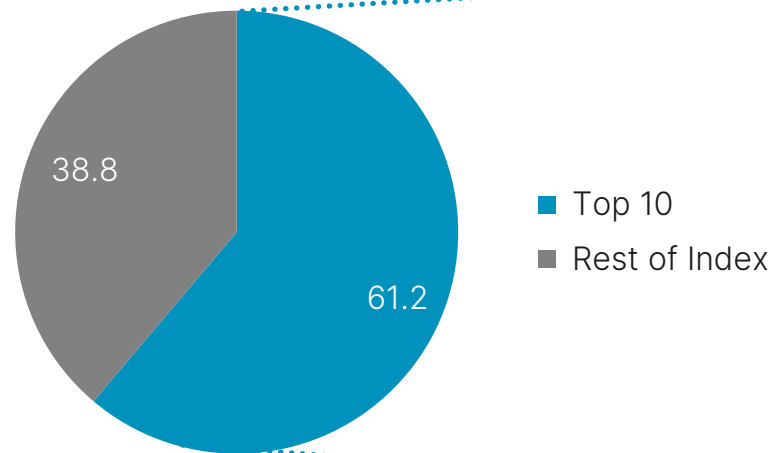
Industry-Leading Benchmarks Since 1993



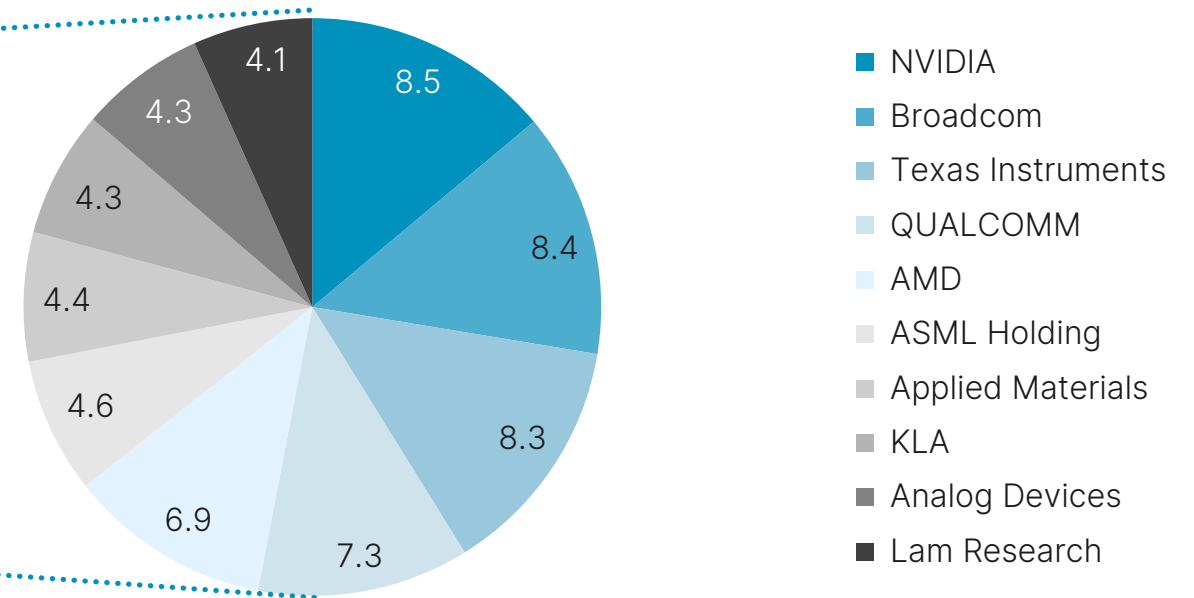
SOX™ Index Composition

The PHLX Semiconductor Sector Index™ is designed to track the performance of the 30 largest US-listed semiconductor companies. 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 \$100 million and a six-month average daily traded volume of at least 1.5 million shares. The index is modified market capitalization-weighted, and was launched on December 1, 1993.

Top 10 vs. Rest of Index

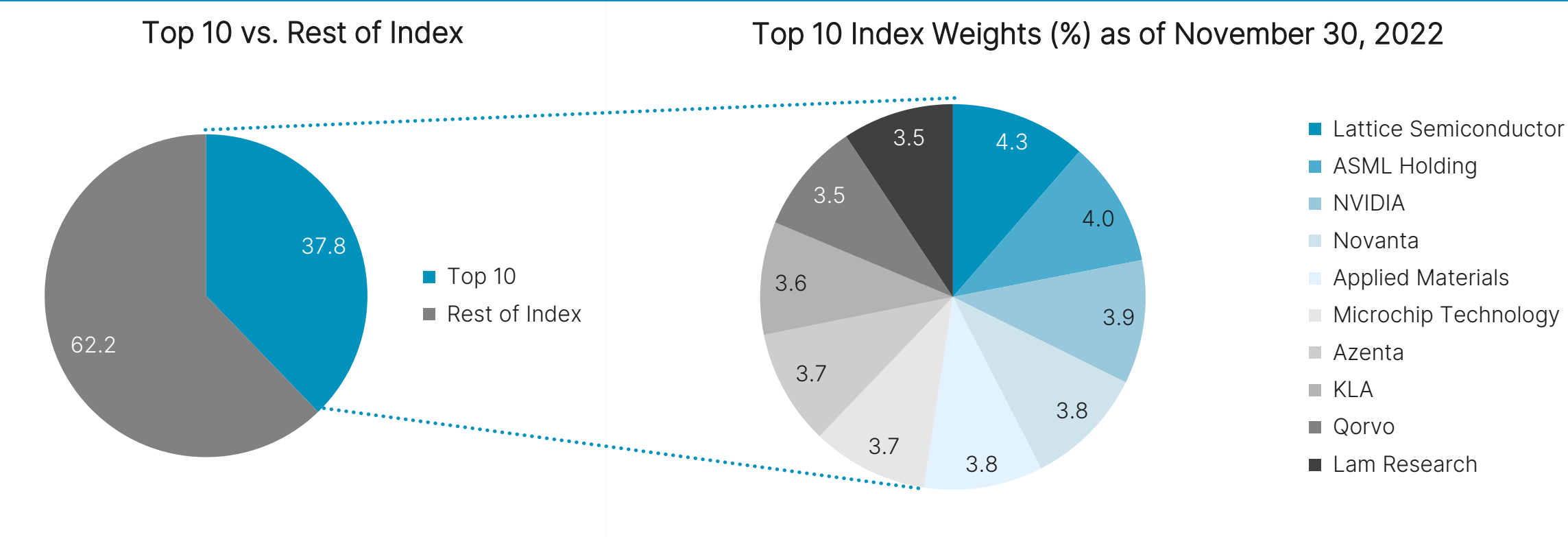


Top 10 Index Weights (%) as of November 30, 2022



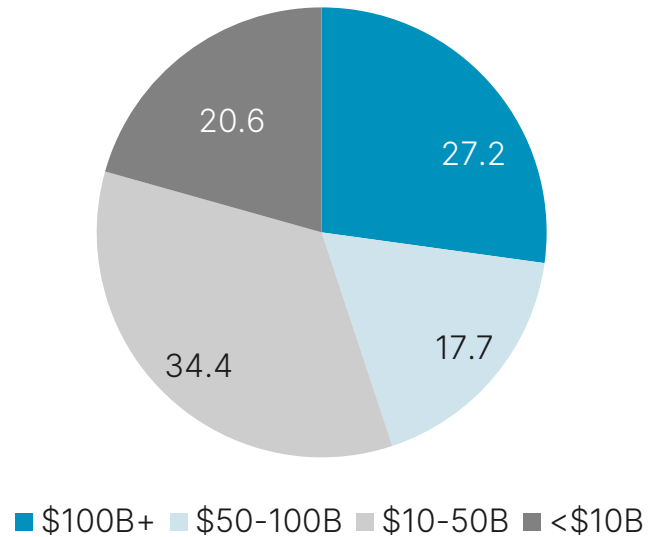
ESOX™ Index Composition

The PHLX Semiconductor Equal Weighted Index™ is designed to track the performance of the 30 largest US-listed semiconductor companies. 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 \$100 million and a six-month average daily traded volume of at least 1.5 million shares. The index is equal-weighted, and was launched on November 9, 2021.



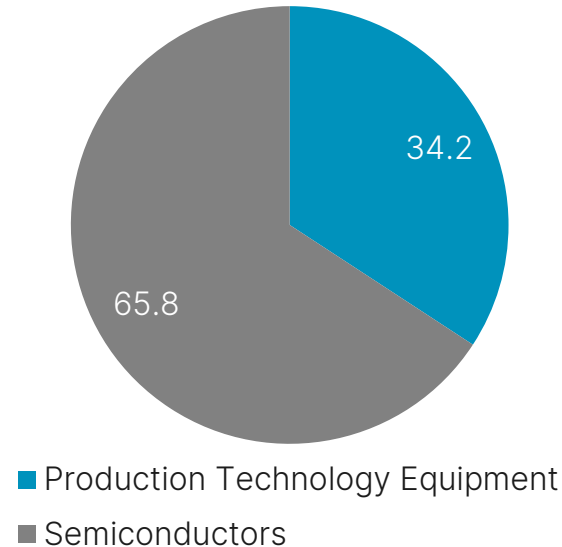
ESOX™ Market Cap/Subsector/Globality Profile

Index Weight (%) by Market Cap



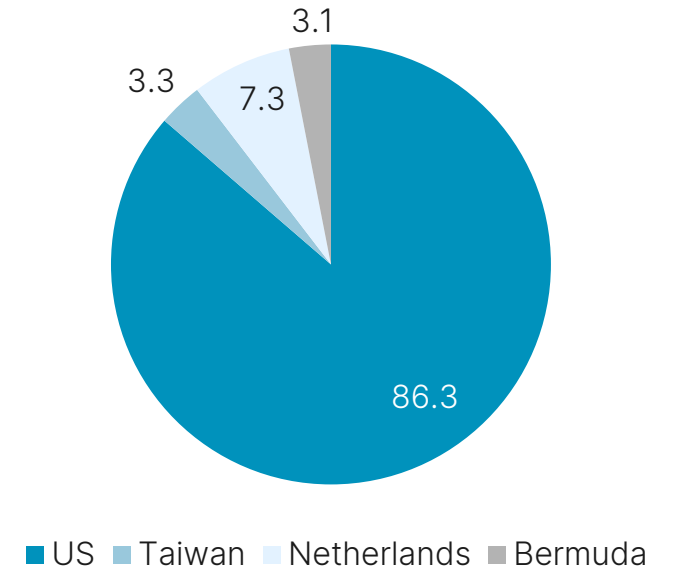
of \$50B+ Companies: 13
 # of \$10-50B Companies: 11
 # of <\$10B Companies: 6

Index Weight (%) by ICB Subsector



of Semiconductors: 20
 # of Production Technology Equipment: 10

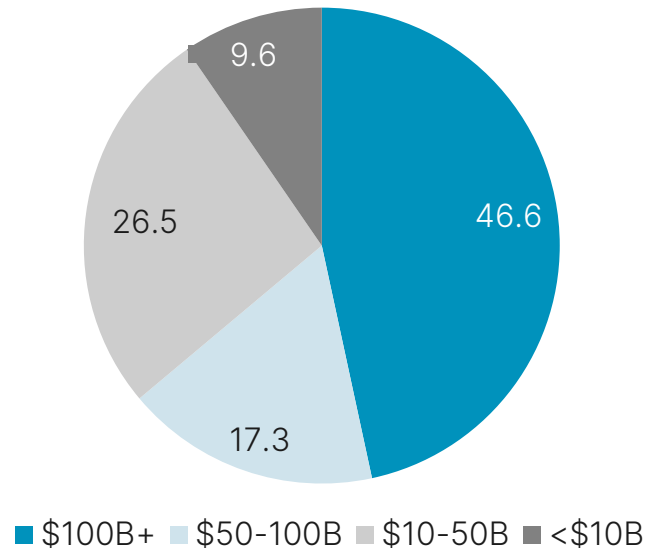
Index Weight (%) by Country



of US-Domiciled: 26
 # of International: 4

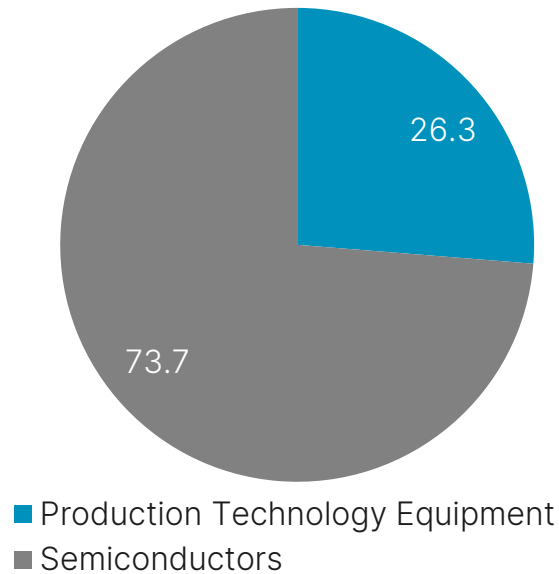
GSOX™ Market Cap/Subsector/Globality Profile

Index Weight (%) by Market Cap



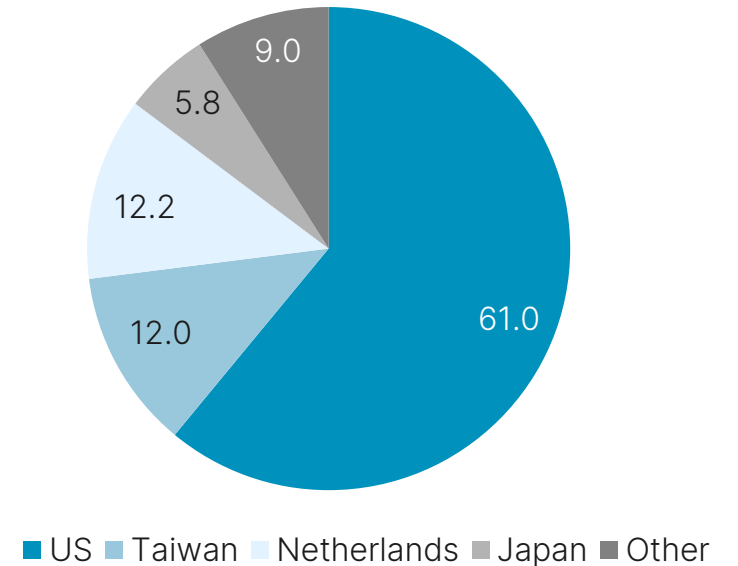
of \$50B+ Companies: 12
 # of \$10-50B Companies: 20
 # of <\$10B Companies: 48

Index Weight (%) by ICB Subsector



of Semiconductors: 60
 # of Production Technology Equipment: 20

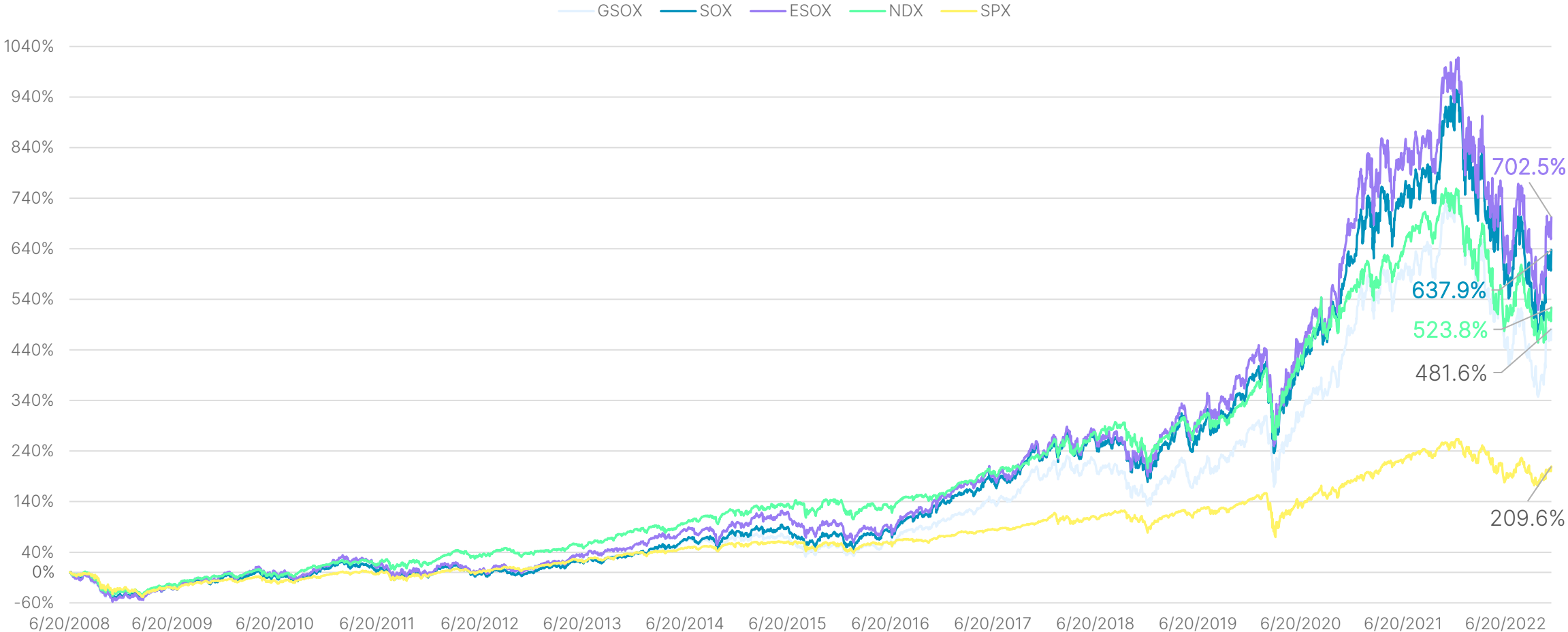
Index Weight (%) by Country



of US-Domiciled: 42
 # of International: 38

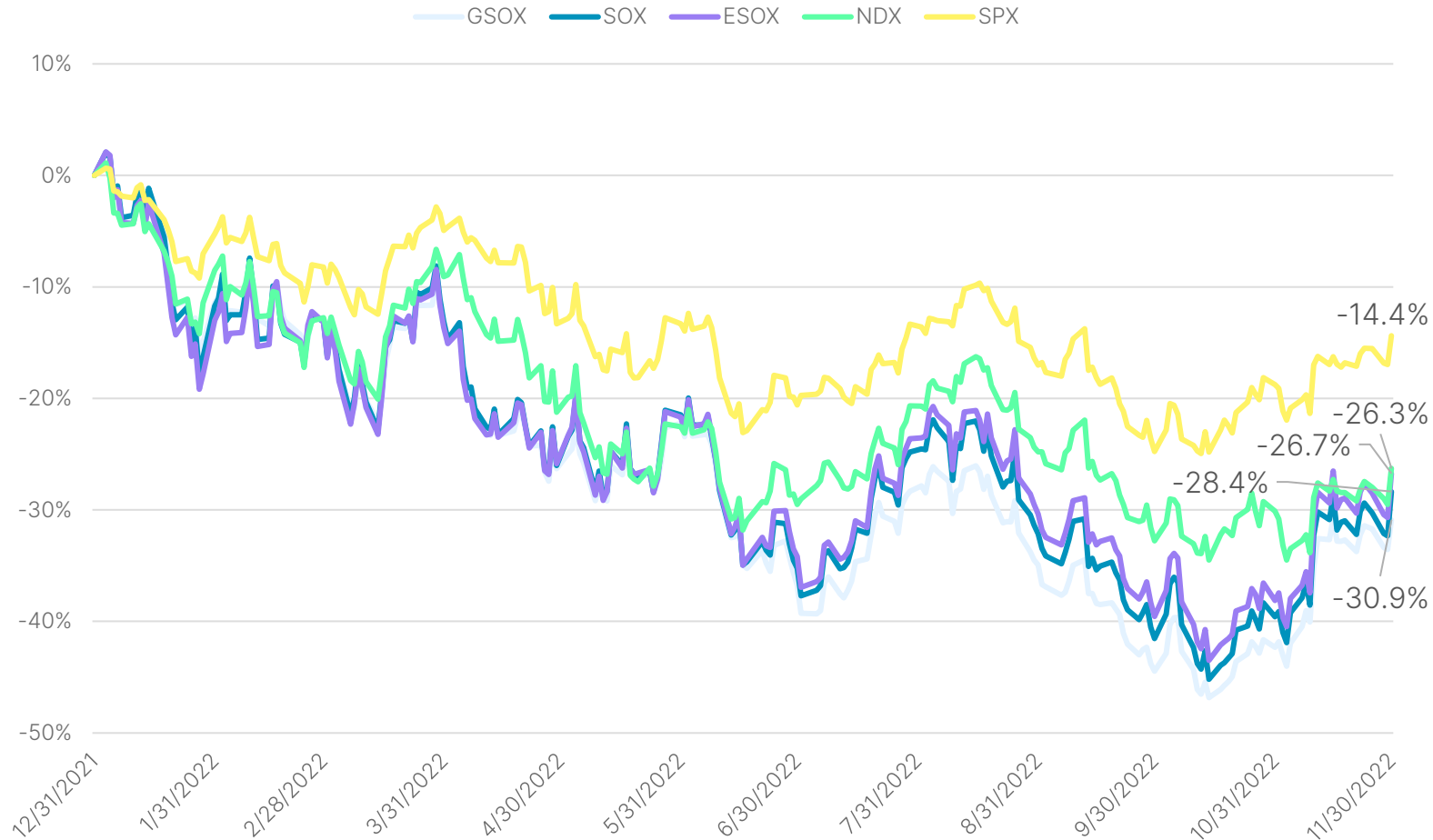
Performance Since 2008 vs. Market Benchmarks

Nasdaq Semiconductor Indexes Performance Since 2008

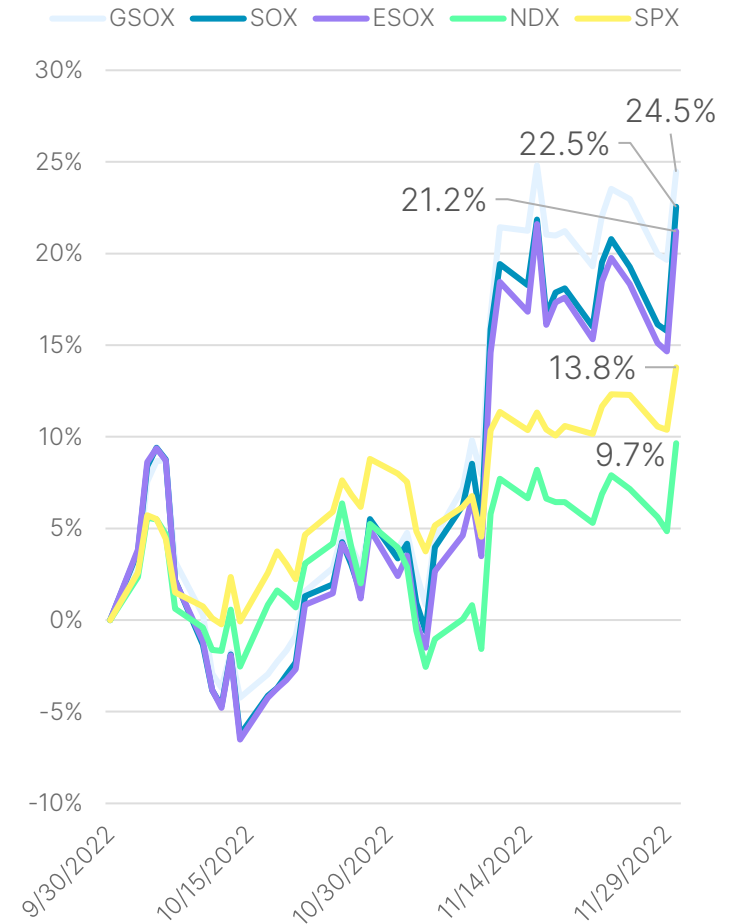


YTD'22 Semis Performance vs. Market Benchmarks

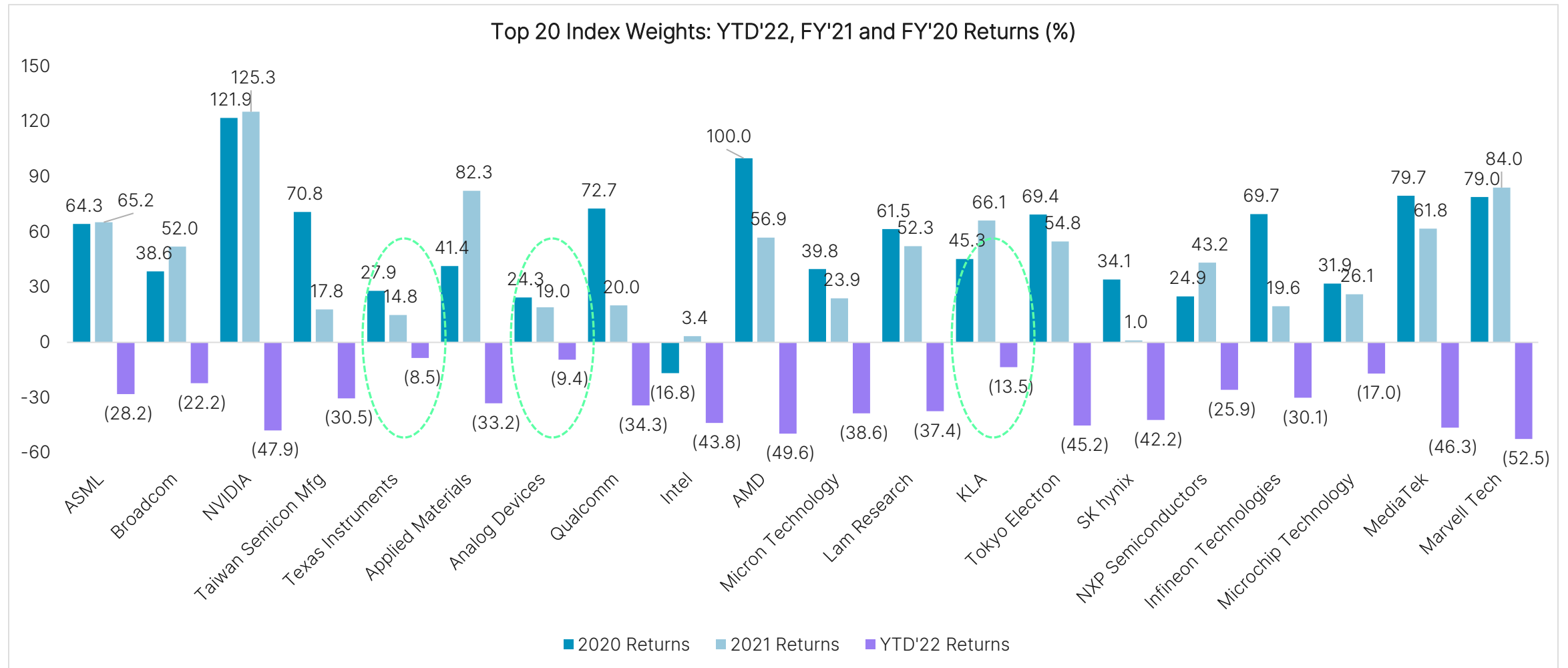
Nasdaq Semiconductor Indexes YTD 2022 Performance



4Q'2022 Performance

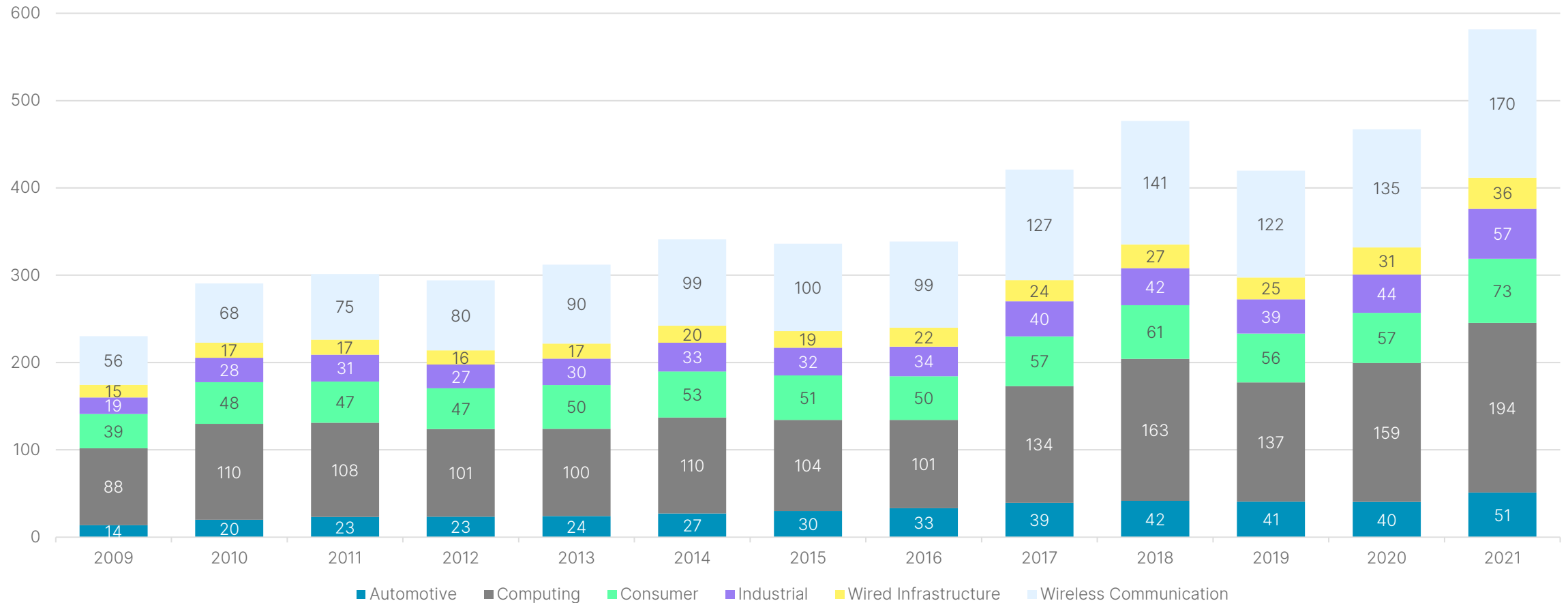


GSOX Top 20 Constituents Performance YoY

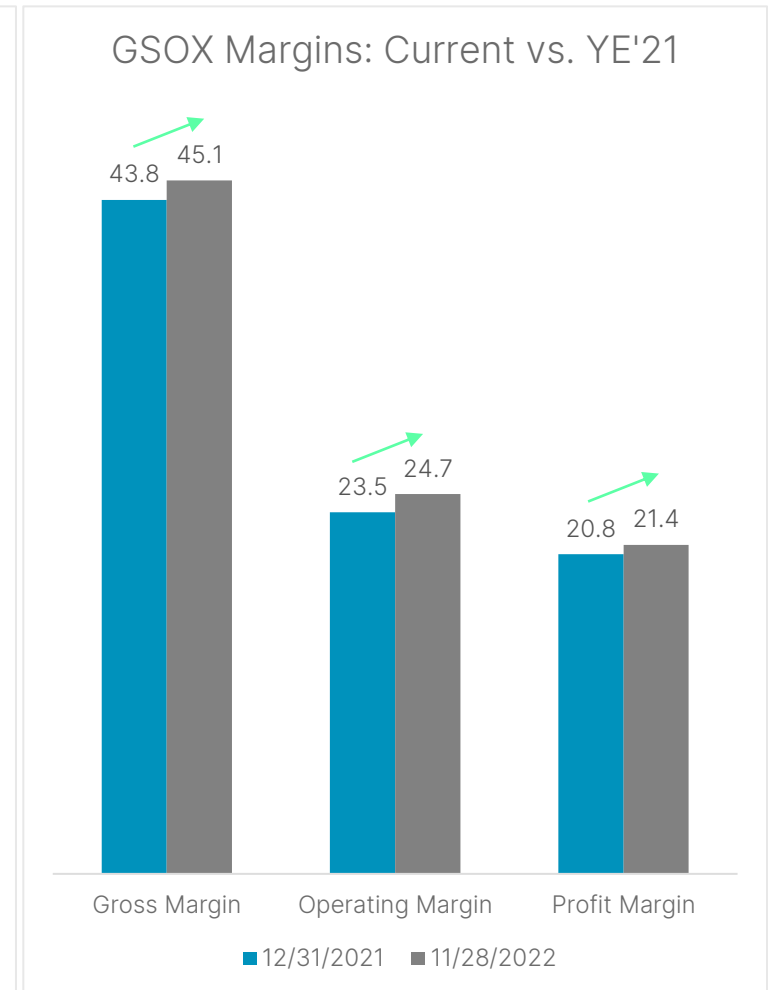
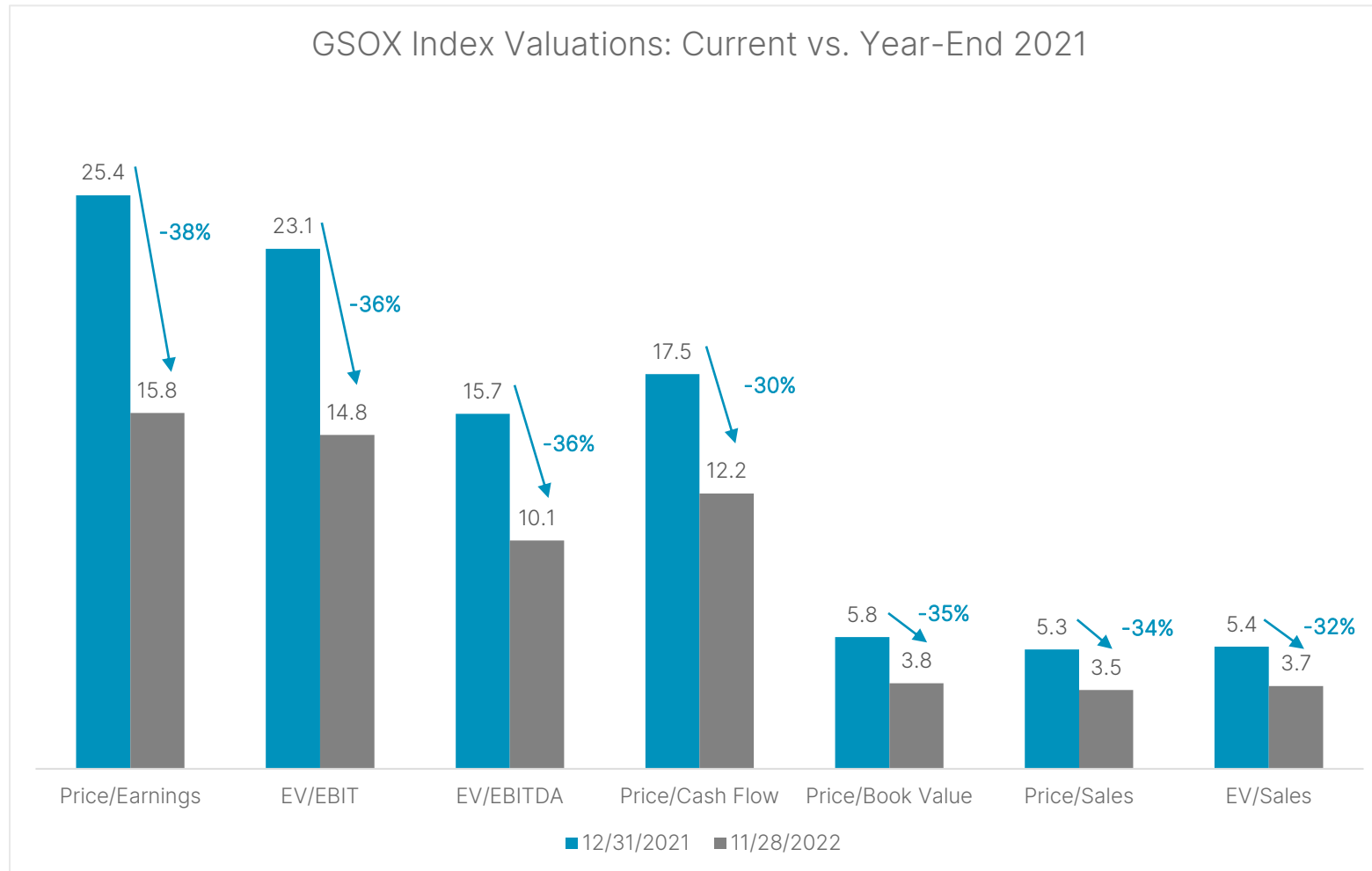


Semiconductor Fundamentals

Semiconductor Revenue by Industry of Usage (\$B)

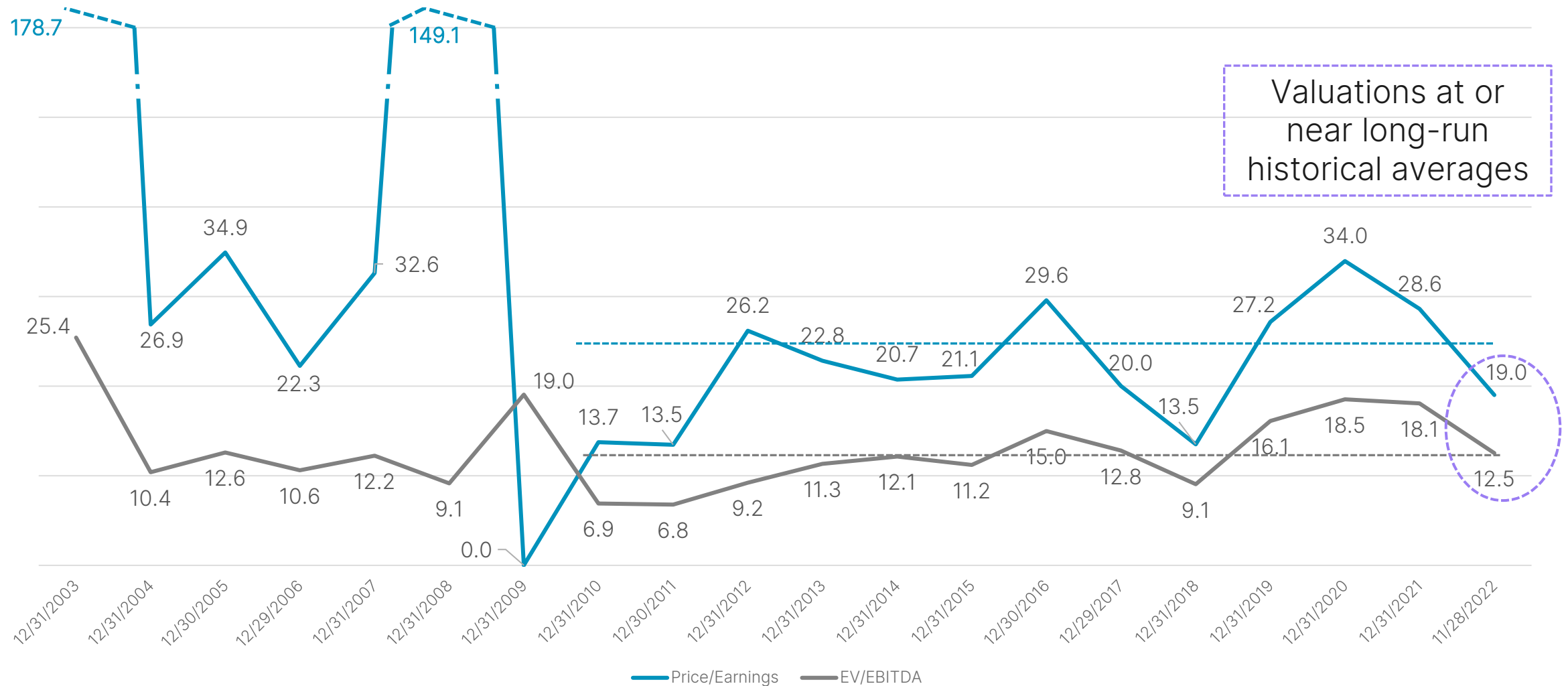


Semiconductor Fundamentals



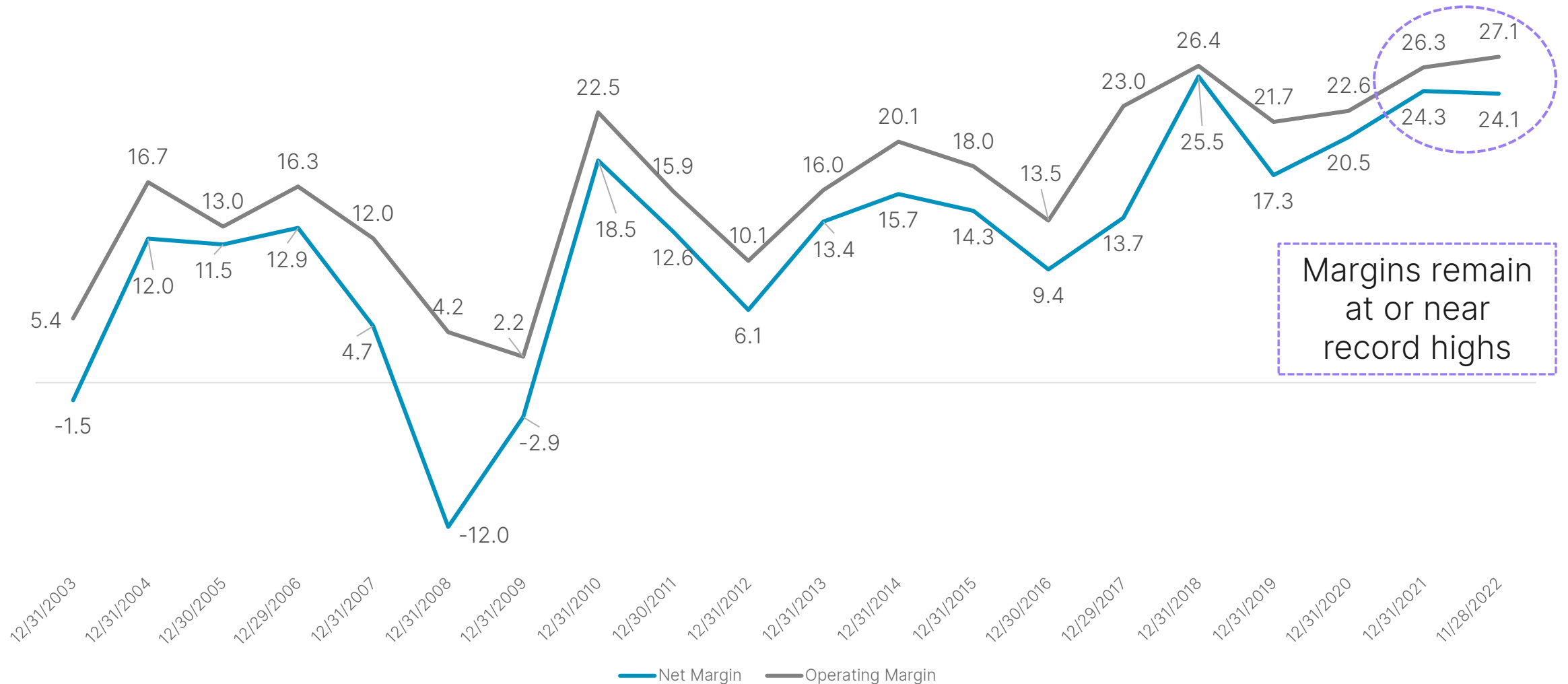
Source: Nasdaq Global Indexes, Bloomberg. Data as of 11/28/2022.

Semi Fundamentals: SOX Index Valuation History



Source: Nasdaq Global Indexes, Bloomberg. Data as of 11/28/2022.

Semi Fundamentals: SOX Index Valuation History



Source: Nasdaq Global Indexes, Bloomberg. Data as of 11/28/2022.

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