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

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

Global Supply Shortages Easing

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

Sources: IDC, Bain & Company, JP Morgan, Wall Street Journal, BBC.
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 3022 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.

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 factors*¹

Green energy generators have *high-power semiconductor* content²:
- 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 decade⁴

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**Sources**

1: Shell-2021 The energy transition scenarios
2: Infineon-August 2022: Third quarter FY2022- quarterly update
3: Infineon-October 2022: Automotive Division Call
4: 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
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

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.*

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

<table>
<thead>
<tr>
<th>CHIPS for America Fund</th>
<th>Appropriations</th>
<th>Loan program costs</th>
<th>Legacy chip production</th>
</tr>
</thead>
<tbody>
<tr>
<td>39.0</td>
<td>31.0</td>
<td>6.0</td>
<td>2.0</td>
</tr>
<tr>
<td>200.0</td>
<td>24.0</td>
<td>6.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Total 278.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. CHIPS advanced manufacturing tax credit
b. CHIPS for America Defense Fund
c. CHIPS for America International Technology Security and Innovation Fund
d. National Semiconductor Technology Center
e. National Advanced Packaging Manufacturing Program
f. Microelectronics R&D Manufacturing USA institute
g. National Institute of Standards and Technology semiconductor programs
h. Public Wireless Supply Chain Innovation Fund
i. CHIPS for America Workforce and Education Fund

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.[12] 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 keep growing, with semiconductors poised to 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. Global Supply Chain Pressure Index, standard deviations from average value

Source: Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022, H.R. 4546, 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

- $50 billion in investments over 5 years...
- ...including $11 billion for advanced semiconductor R&D...
- ...and $39 billion to accelerate and drive domestic chip production
- $2 billion for legacy chip production
- $6 billion to cover loan and loan guarantees
- $75 billion Direct loan and loan guarantee program

Source: US Department of Commerce

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


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, $ billion

<table>
<thead>
<tr>
<th>Agency</th>
<th>2022–27 Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Science Foundation</td>
<td>81.0</td>
</tr>
<tr>
<td>US Department of Energy</td>
<td>67.1</td>
</tr>
<tr>
<td>US Economic Development Administration</td>
<td>11.0</td>
</tr>
<tr>
<td>National Institute of Standards and Technology</td>
<td>10.0</td>
</tr>
<tr>
<td>National Aeronautics and Space Administration</td>
<td>n/a</td>
</tr>
</tbody>
</table>

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 Buhler | Nov 5, 2022, 8:00am EDT

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


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 Rich Joshen, a reporter at Foreign Policy

After four years of watching Donald Trump inflict flash 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.
Nasdaq’s Semiconductor Indexes

Industry-Leading Benchmarks Since 1993
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.
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

- $100B+: 20.6%
- $50-100B: 34.4%
- $10-50B: 17.7%
- <$10B: 27.2%

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

Index Weight (%) by ICB Subsector

- Production Technology Equipment: 65.8%
- Semiconductors: 34.2%

# of Semiconductors: 20
# of Production Technology Equipment: 10

Index Weight (%) by Country

- US: 86.3%
- Taiwan: 3.3%
- Netherlands: 7.3%
- Bermuda: 3.1%

# of US-Domiciled: 26
# of International: 4

Source: Nasdaq Global Indexes, FactSet, Bloomberg as of November 30, 2022
GSOX™ Market Cap/Subsector/Globality Profile

Source: Nasdaq Global Indexes, FactSet, Bloomberg as of November 25, 2022
Performance Since 2008 vs. Market Benchmarks

YTD’22 Semis Performance vs. Market Benchmarks

Nasdaq Semiconductor Indexes YTD 2022 Performance

4Q’2022 Performance

GSOX Top 20 Constituents Performance YoY

Top 20 Index Weights: YTD’22, FY’21 and FY’20 Returns (%)

Semiconductor Fundamentals

Semiconductor Revenue by Industry of Usage ($B)

Semiconductor Fundamentals

GSOX Index Valuations: Current vs. Year-End 2021

<table>
<thead>
<tr>
<th>Metric</th>
<th>12/31/2021</th>
<th>11/28/2022</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price/Earnings</td>
<td>25.4</td>
<td>15.8</td>
<td>-38%</td>
</tr>
<tr>
<td>EV/EBIT</td>
<td>23.1</td>
<td>14.8</td>
<td>-36%</td>
</tr>
<tr>
<td>EV/EBITDA</td>
<td>15.7</td>
<td>10.1</td>
<td>-36%</td>
</tr>
<tr>
<td>Price/Cash Flow</td>
<td>17.5</td>
<td>12.2</td>
<td>-30%</td>
</tr>
<tr>
<td>Price/Book Value</td>
<td>5.8</td>
<td>3.8</td>
<td>-35%</td>
</tr>
<tr>
<td>Price/Sales</td>
<td>3.8</td>
<td>3.5</td>
<td>-34%</td>
</tr>
<tr>
<td>EV/Sales</td>
<td>5.4</td>
<td>3.7</td>
<td>-32%</td>
</tr>
</tbody>
</table>


GSOX Margins: Current vs. YE'21

<table>
<thead>
<tr>
<th>Margin</th>
<th>12/31/2021</th>
<th>11/28/2022</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Margin</td>
<td>43.8</td>
<td>45.1</td>
<td>+3%</td>
</tr>
<tr>
<td>Operating Margin</td>
<td>23.5</td>
<td>24.7</td>
<td>+5%</td>
</tr>
<tr>
<td>Profit Margin</td>
<td>20.8</td>
<td>21.4</td>
<td>+3%</td>
</tr>
</tbody>
</table>

Semi Fundamentals: SOX Index Valuation History

Valuations at or near long-run historical averages

Semi Fundamentals: SOX Index Valuation History

Margins remain at or near record highs

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