Semiconductor Industry-
Navigating Cyclicality While
Planning For Long-term
Opportunities and Challenges

Gaurav Gupta, VP Analyst
Emerging Trends and Technologies
Key Questions

▪ What is the latest outlook for semiconductor market?
  ○ Trend for major applications
  ○ Foundry/Capex/Inventory forecasts

▪ What are major challenges and opportunities in the decade?
Chip Revenue Falls in 2023

Billions of Dollars and Revenue Growth

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>$50B</td>
<td>1988</td>
</tr>
<tr>
<td>$100B</td>
<td>1994</td>
</tr>
<tr>
<td>$200B</td>
<td>2000</td>
</tr>
<tr>
<td>$400B</td>
<td>2017</td>
</tr>
<tr>
<td>$600B</td>
<td>2022</td>
</tr>
</tbody>
</table>

1Q23 Update CAGR (22-27): 4.7%
4Q22 Update CAGR (21-26): 4.8%

Source: Semiconductor Forecast Database, Worldwide, 1Q23 Update

Revenue Change ($B)

<table>
<thead>
<tr>
<th>Year</th>
<th>4Q22 Update</th>
<th>1Q23 Update</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>$346</td>
<td>$422</td>
</tr>
<tr>
<td>2017</td>
<td>$422</td>
<td>$476</td>
</tr>
<tr>
<td>2018</td>
<td>$476</td>
<td>$422</td>
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<tr>
<td>2019</td>
<td>$422</td>
<td>$422</td>
</tr>
<tr>
<td>2020</td>
<td>$471</td>
<td>$598</td>
</tr>
<tr>
<td>2021</td>
<td>$600</td>
<td>$600</td>
</tr>
<tr>
<td>2022</td>
<td>$532</td>
<td>$502</td>
</tr>
<tr>
<td>2023</td>
<td>$631</td>
<td>$600</td>
</tr>
<tr>
<td>2024</td>
<td>$654</td>
<td>$715</td>
</tr>
<tr>
<td>2025</td>
<td>$727</td>
<td>$733</td>
</tr>
<tr>
<td>2026</td>
<td>$754</td>
<td>NA</td>
</tr>
<tr>
<td>2027</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Revenue Change Percentages

<table>
<thead>
<tr>
<th>Year</th>
<th>4Q22 Update</th>
<th>1Q23 Update</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>3.3%</td>
<td>21.9%</td>
</tr>
<tr>
<td>2017</td>
<td>21.9%</td>
<td>12.9%</td>
</tr>
<tr>
<td>2018</td>
<td>12.9%</td>
<td>-11.3%</td>
</tr>
<tr>
<td>2019</td>
<td>-11.3%</td>
<td>-11.5%</td>
</tr>
<tr>
<td>2020</td>
<td>11.5%</td>
<td>27.1%</td>
</tr>
<tr>
<td>2021</td>
<td>27.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>2022</td>
<td>0.2%</td>
<td>-11.2%</td>
</tr>
<tr>
<td>2023</td>
<td>-11.2%</td>
<td>12.9%</td>
</tr>
<tr>
<td>2024</td>
<td>12.9%</td>
<td>18.5%</td>
</tr>
<tr>
<td>2025</td>
<td>18.5%</td>
<td>13.4%</td>
</tr>
<tr>
<td>2026</td>
<td>13.4%</td>
<td>2.5%</td>
</tr>
<tr>
<td>2027</td>
<td>2.5%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>
Smartphone & PC Decline Continues in 2023

Smartphone unit production lowest since 2013 amid inventory correction/reduction on the supply side

Source: Semiconductor Forecast Database, Worldwide, 1Q23 Update
Automotive will be the strongest growth driver
Semiconductor Supply Chain Swings

Rebunding Demand Will Lead to a Sharp Reduction of Index in 4Q23

Directional Projection of Inventory Index Movement, 2Q23-1Q24

<table>
<thead>
<tr>
<th>Inventory Index Status and Trend</th>
<th>Inventory Index Trend, 4Q22 Vs. 3Q22</th>
<th>Inventory Index Status, 4Q22</th>
<th>Inventory Index Trend, 1Q23* Vs. 4Q22</th>
<th>Inventory Index Status, 1Q23*</th>
</tr>
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<tbody>
<tr>
<td>Supply Chain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi Vendor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distributor</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>EMS/CEM</td>
<td></td>
<td></td>
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<tr>
<td>OEM</td>
<td></td>
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Note: 1Q23 is a modelled estimate and is subject to change based on actual financials to be reported by vendors in 2Q23. The index bar for 2Q23 to 1Q24 is only a directional projection.

Inventory Index Trend: Direction of the arrow indicates if the inventory index went up, came down, or stayed stable during the quarter.

Inventory Index Zones: ■ Severe Shortage (<0.9) ■ Moderate Shortage (0.9 to <1.0); □ Normal (1.0 to <1.1) ■ Moderate Surplus (1.1 to <1.2); ■ Severe Surplus (>1.2)

Source: Semiconductor Inventory Analysis Worldwide, 1Q23 Update

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Foundry Wafer Shipment will Decline

Source: Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 1Q23 Update
CAPEX Will Drop in the Near Term

CAPEX correction started, led by decline in 2022 memory spending; Large spenders have revised their capex down for 2023

Growth, 4Q22 Update

Growth, 1Q23 Update

Source: Forecast: Semiconductor Capital Spending, Wafer Fab Equipment and Capacity, Worldwide, 1Q23 Update
Key Takeaway:

Near-term outlook is negative

But long-term forecast stays positive
# Industry Challenges & Opportunities, 2023 – 2030

## Changing Moore’s Law Economics

<table>
<thead>
<tr>
<th>Fragmentation of Semiconductor Demand</th>
<th>Semiconductor Technology Roadmap is Changing</th>
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<tbody>
<tr>
<td>Techno-nationalism / Re-globalization</td>
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<td>Semiconductors as a National Security issue</td>
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<tr>
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<td>Increased Demand &gt;&gt; Constrained Supply</td>
</tr>
<tr>
<td></td>
<td>Innovation continues at rapid pace</td>
</tr>
</tbody>
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Advanced Nodes Getting More Expensive while Scaling Lags

Source: Forecast: Semiconductor Capital Spending, Wafer Fab Equipment and Capacity, Worldwide, 3Q22 Update
Advanced Packaging will Drive Innovation

TRENDS

➢ Chiplets will be the future
➢ Hybrid bonding will enable further scaling
➢ Foundries will play a bigger role
Industry Challenges & Opportunities, 2023 – 2030

- **Changing Moore’s Law Economics**: Semiconductor Technology Roadmap is Changing
- **Fragmentation of Semiconductor Demand**: Shift Away From High Volume / High Content Market Drivers
  - Techno-nationalism / Re-globalization
    - Semiconductors as a National Security issue
  - Energy Demand and Supply
    - Increased Demand >> Constrained Supply
  - Emerging Technologies & Business Models
    - Innovation continues at rapid pace
Semiconductor Demand Will Shift

**Smartphone & PC Markets are Stagnating**

- Smartphone Semiconductor ($B)
  - 2022: 137.1
  - 2023: -29.2
  - 2024: 24.3
  - 2025: 10.2
  - 2026: -4.0
  - 2027: 136.5

- PC & Tablet Semiconductor ($B)
  - 2022: 71.8
  - 2023: -12.2
  - 2024: 6.3
  - 2025: 4.3
  - 2026: -0.8
  - 2027: 68.8

**Automotive & Industrial are The New Growth Drivers**

- Automotive Semiconductor ($B)
  - 2022: 67.5
  - 2023: 9.3
  - 2024: 9.4
  - 2025: 14.9
  - 2026: 8.4
  - 2027: 117.8

- Industrial, Mil/Aero Semiconductor ($B)
  - 2022: 73.7
  - 2023: 0.2
  - 2024: 10.2
  - 2025: 8.9
  - 2026: 8.3
  - 2027: 109.1

**Shift Away From High Volume / High Content Market Drivers**

Smartphone & PC Markets are stagnating, while automotive and industrial markets are experiencing growth.
Vendors Focused on Auto/Indus Outgrew Market

Billions of Dollars and Year-on-Year Change

Note: where M&A activity takes place Gartner applies revenue to the whole calendar quarter in which the deal was closed.

Industry Challenges & Opportunities, 2023 – 2030

- **Changing Moore’s Law Economics**
  - Semiconductor Technology Roadmap is Changing

- **Fragmentation of Semiconductor Demand**
  - Shift Away From High Volume / High Content Market Drivers

- **Techno-nationalism / Re-globalization**
  - Semiconductors as a National Security issue

- **Energy Demand and Supply**
  - Increased Demand >> Constrained Supply

- **Emerging Technologies & Business Models**
  - Innovation continues at rapid pace
The Ugly Face of Geopolitics - Who Bears the cost?

Is the high-level goal to deal better with shortages or a national security question?

The US CHIPS Act - $52.7 B incentives, including $39 in manufacturing and an additional 25% tax credit.

EU CHIPS Act (43 B Euro) - increase EU chip production share to 20% share - reasonable?

Japan’s Rapidus – 2 nm, India with its schemes, and China pursuing IC self-sufficiency.

Export controls:
• WFE/EDA
• Advanced node chips
• Dutch/Japan support

SK Hynix CEO says CHIPS Act red tape may be too sticky to bother

NXP CEO said, “What I think for our industry is sometimes hard to deal with is there doesn't seem to be a clear roadmap on what to expect going forward”.


China Capex

Billions of Dollars

## Industry Challenges & Opportunities, 2023 – 2030

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IC power requirements will outstrip WW supply

Generative AI

- At the Peak of Inflated Expectation
- What We Know
  1. Training/Development
     - 10’s Ku GPUs per system, 1000’s of servers
     - >10^{23} FLOPS to train a model
  2. Inference/Deployment
     - 50-100 GPUs per instance

Source: Semiconductor Research Corporation Decadal Plan Update - https://www.src.org/about/sustainability/
Energy efficient Compute Is the Next big Oppty.

➢ Dynamic frequency scaling
➢ CPU to dedicated processor for specific tasks
➢ New memory materials ferroelectrics
➢ Energy-efficient storage- analog inference accelerator
➢ Conservative computing or reversible chips
➢ SRAM at the output of each filter stage
➢ In-memory computing
➢ Photons instead of electrons

Image Source: https://www.stonegroup.co.uk/blog/green-computing/improving-the-energy-efficiency-of-your-it/
Industry Challenges & Opportunities, 2023 – 2030

- Changing Moore’s Law Economics
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- Fragmentation of Semiconductor Demand
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- Emerging Technologies & Business Models
  - Innovation continues at rapid pace
By 2030, RISC-V will mature to become a mainstream processor architecture

By 2027, RISC-V Devices Will Account for 25% of All MCU/Processor Shipment

Note: This is only a qualitative measurement based on the number of active players and products in each ecosystem component. This does not include any exhaustive assessment of either supplier capabilities or product functionality.
Emerging technologies for growth applications

Impact Radar for 2023

Impact Radar for Semiconductor Manufacturing Technology

Impact Radar for Semiconductor and Electronics Technologies

Source: Gartner 767391
Key Takeaway:

But converting opportunities will determine winners

Plenty of Challenges