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

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Emerging Trends and Technologies

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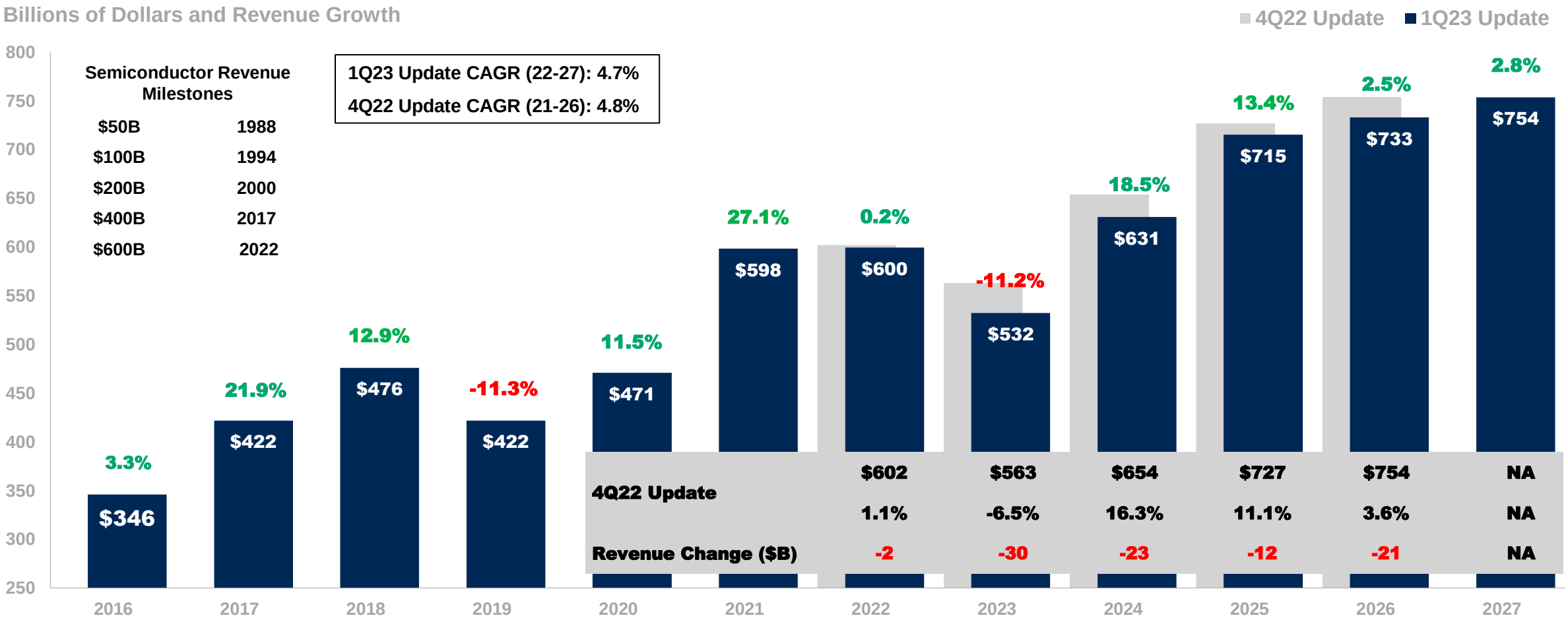
Key Questions

- 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



Source: Semiconductor Forecast Database, Worldwide, 1Q23 Update

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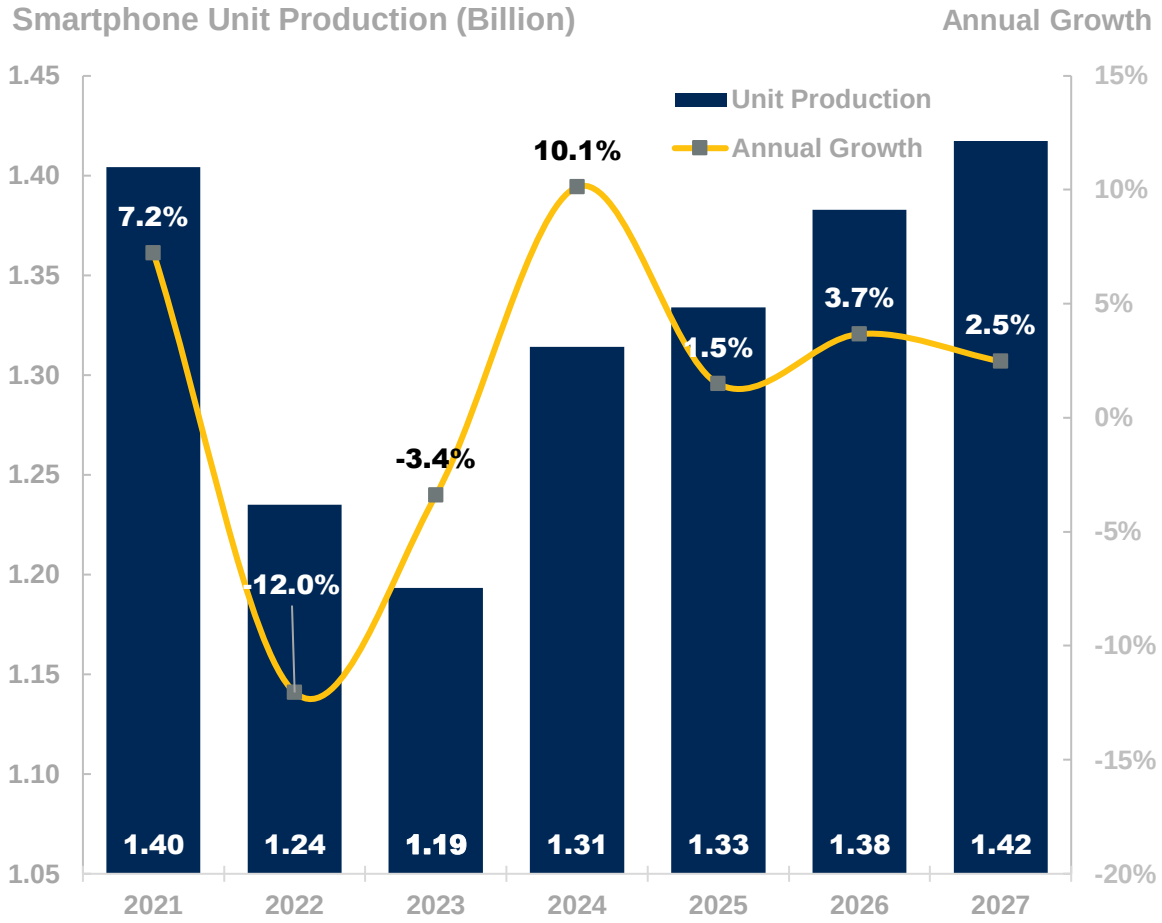
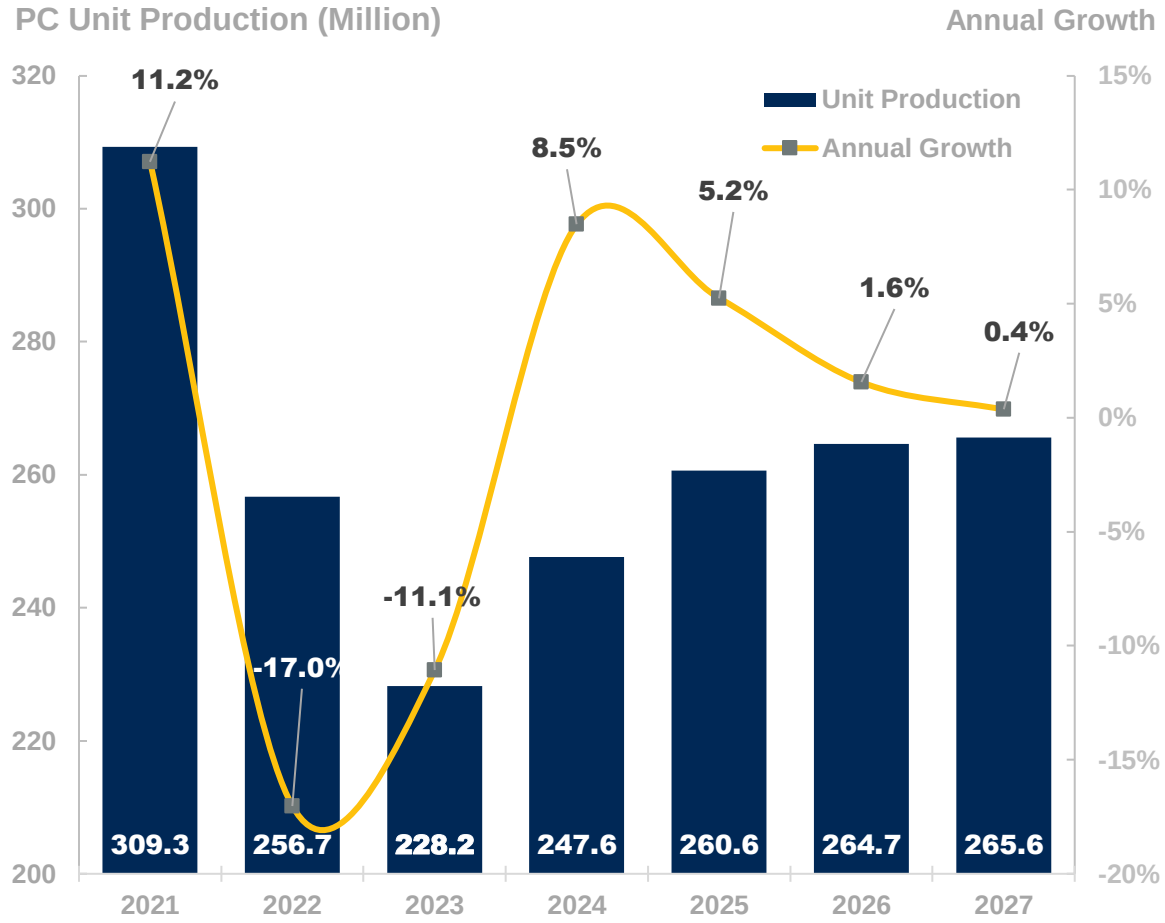
Smartphone & PC Decline Continues in 2023

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





Source: Semiconductor Forecast Database, Worldwide, 1Q23 Update

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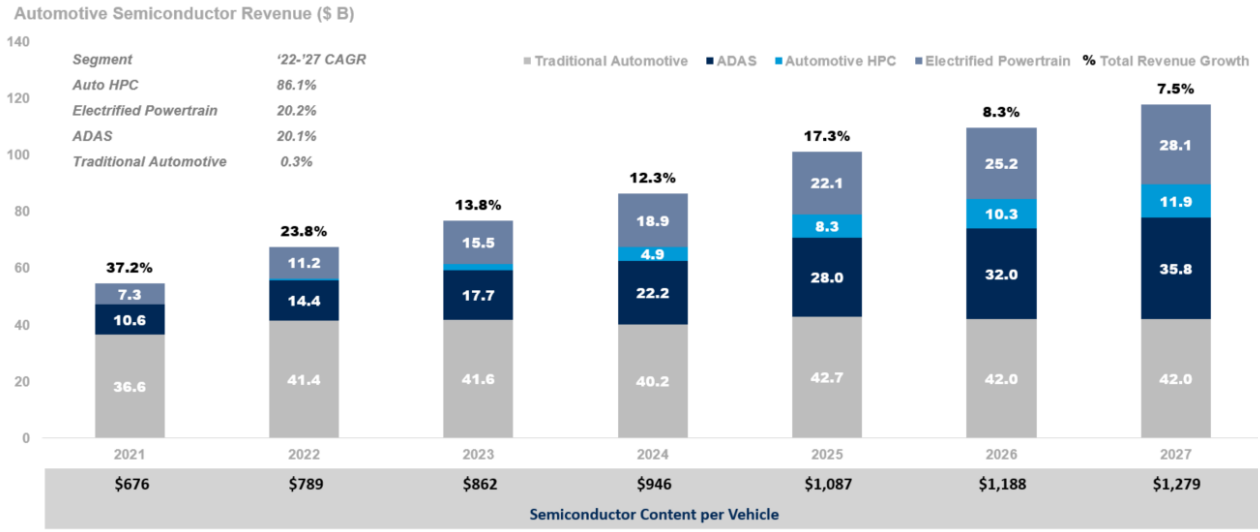
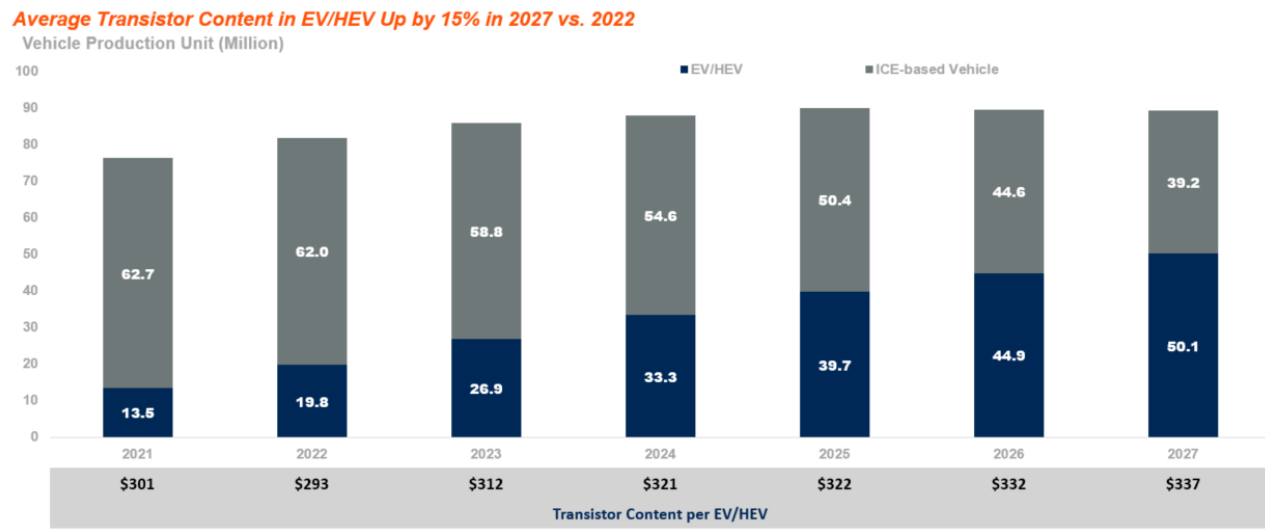
Automotive will be the strongest growth driver

Auto HPC, ADAS and EV Will Drive Semiconductor Growth



EV/HEVs More Than Half of Total Vehicle Unit Production by 2026



Source: Semiconductor Forecast Database, Worldwide, 1Q23 Update

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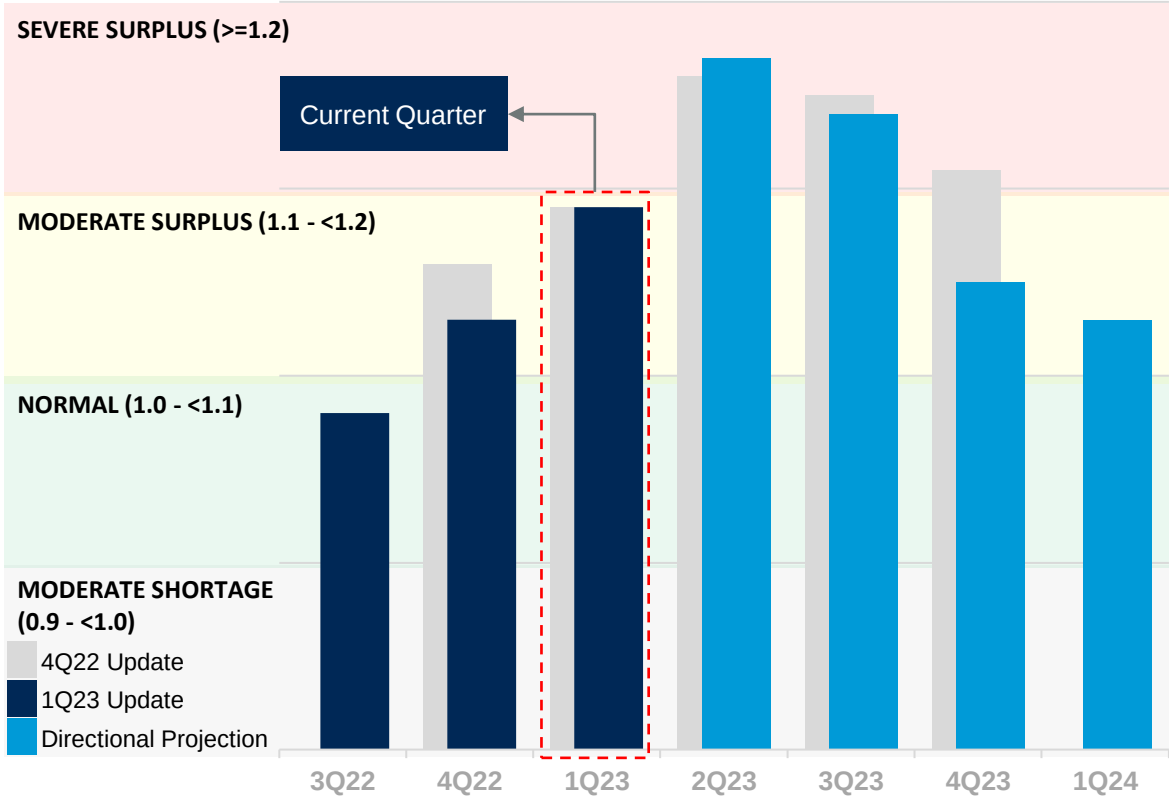
Semiconductor Supply Chain Swings

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

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



Inventory Index Status and Trend	Inventory Index Trend, 4Q22 Vs. 3Q22	Inventory Index Status, 4Q22	Inventory Index Trend, 1Q23* Vs. 4Q22	Inventory Index Status, 1Q23*
Supply Chain	↑	■	↑	■
Foundry	↓	■	↑	■
Semi Vendor	↑	■	↑	■
Distributor	↑	■	↑	■
EMS/CEM	↓	■	↑	■
OEM	↓	■	↑	■

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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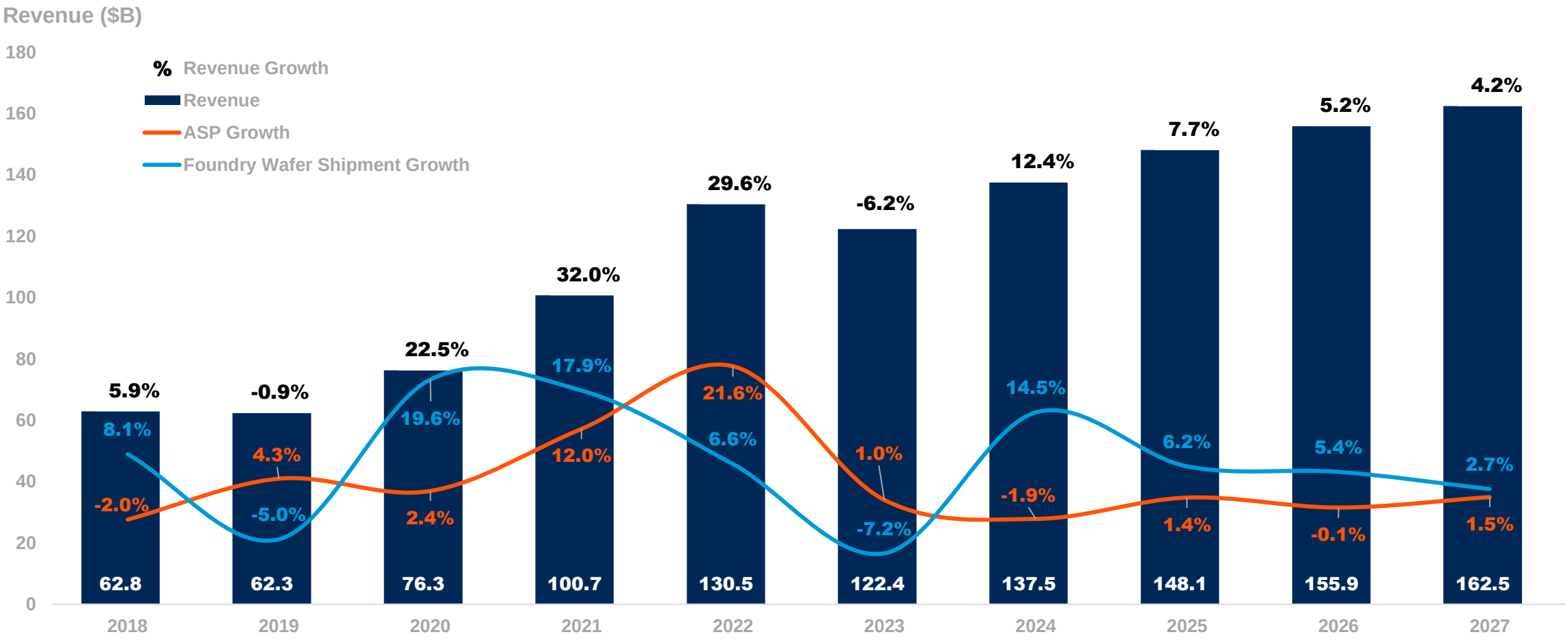
Foundry Wafer Shipment will Decline



Source: Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 1Q23 Update

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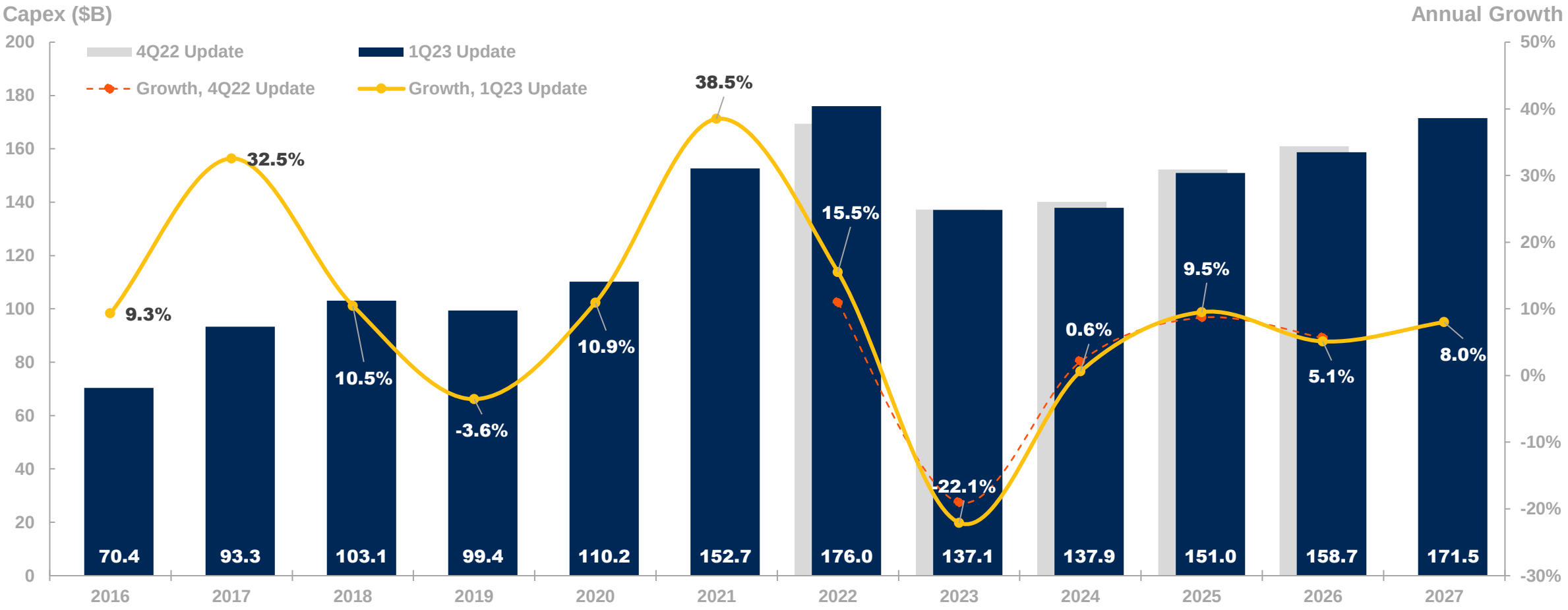
CAPEX Will Drop in the Near Term

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



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

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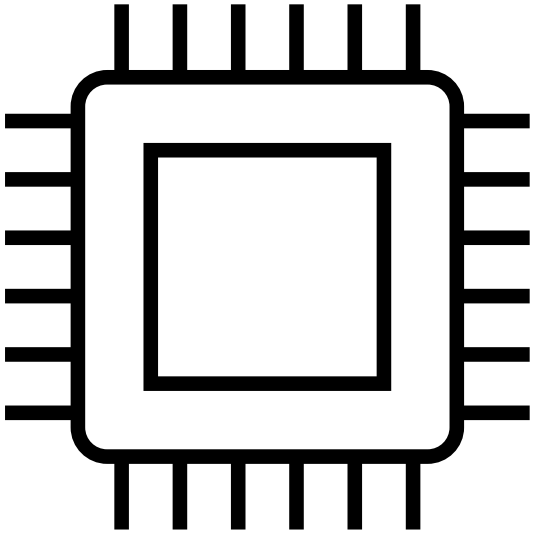
Key Takeaway:

Near-term outlook is negative



But long-term forecast stays positive

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

Advanced Nodes Getting More Expensive while Scaling Lags

Equipment Costs and Foundry Wafer Prices

Source: Gartner (September 2022)
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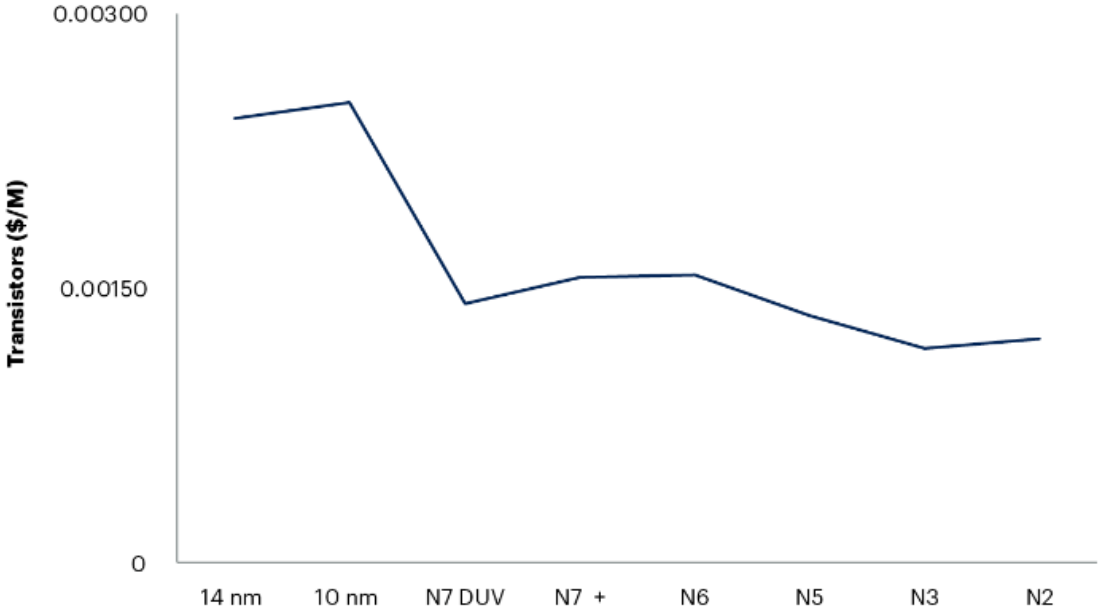
Wafer Price per Million Transistors



Source: Gartner (September 2022)
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Source: Forecast: Semiconductor Capital Spending, Wafer Fab Equipment and Capacity, Worldwide, 3Q22 Update

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Advanced Packaging will Drive Innovation

TRENDS
➢ Chiplets will be the future
➢ Hybrid bonding will enable further scaling
➢ Foundries will play a bigger role

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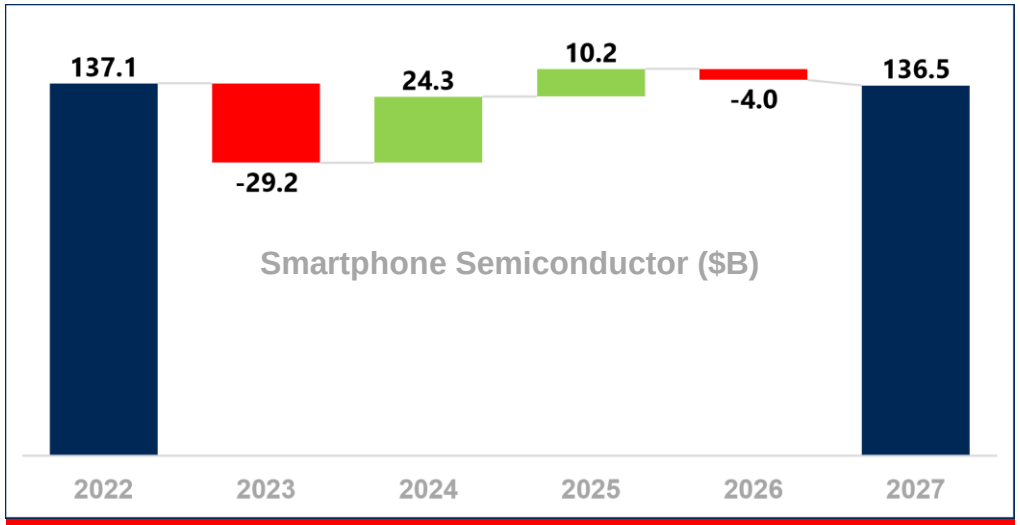
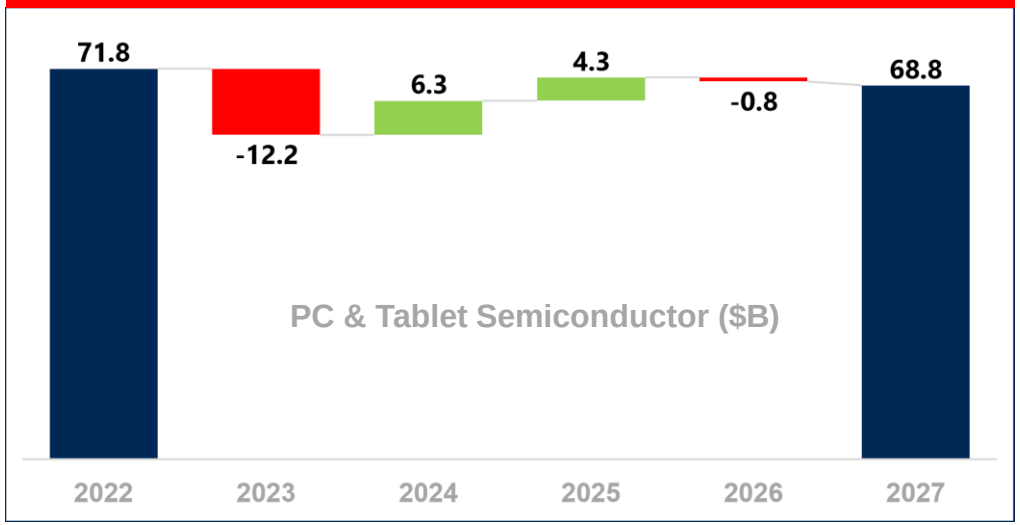
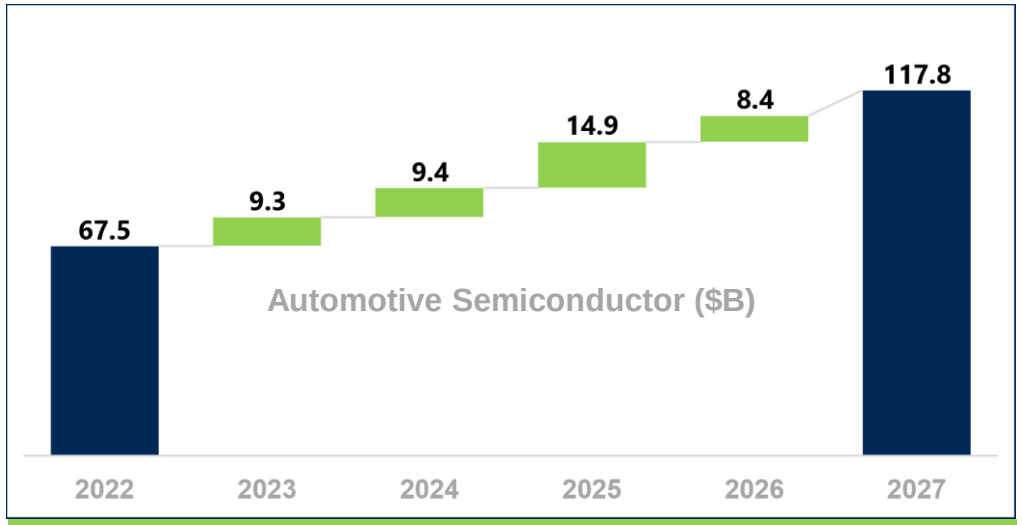
Semiconductor Demand Will Shift



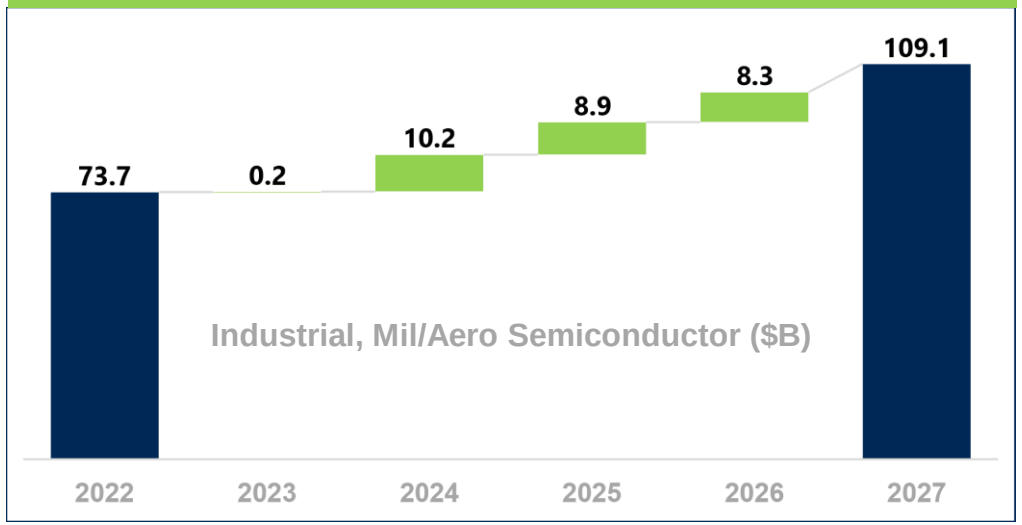
Smartphone & PC Markets are Stagnating



Shift Away From High Volume / High Content Market Drivers

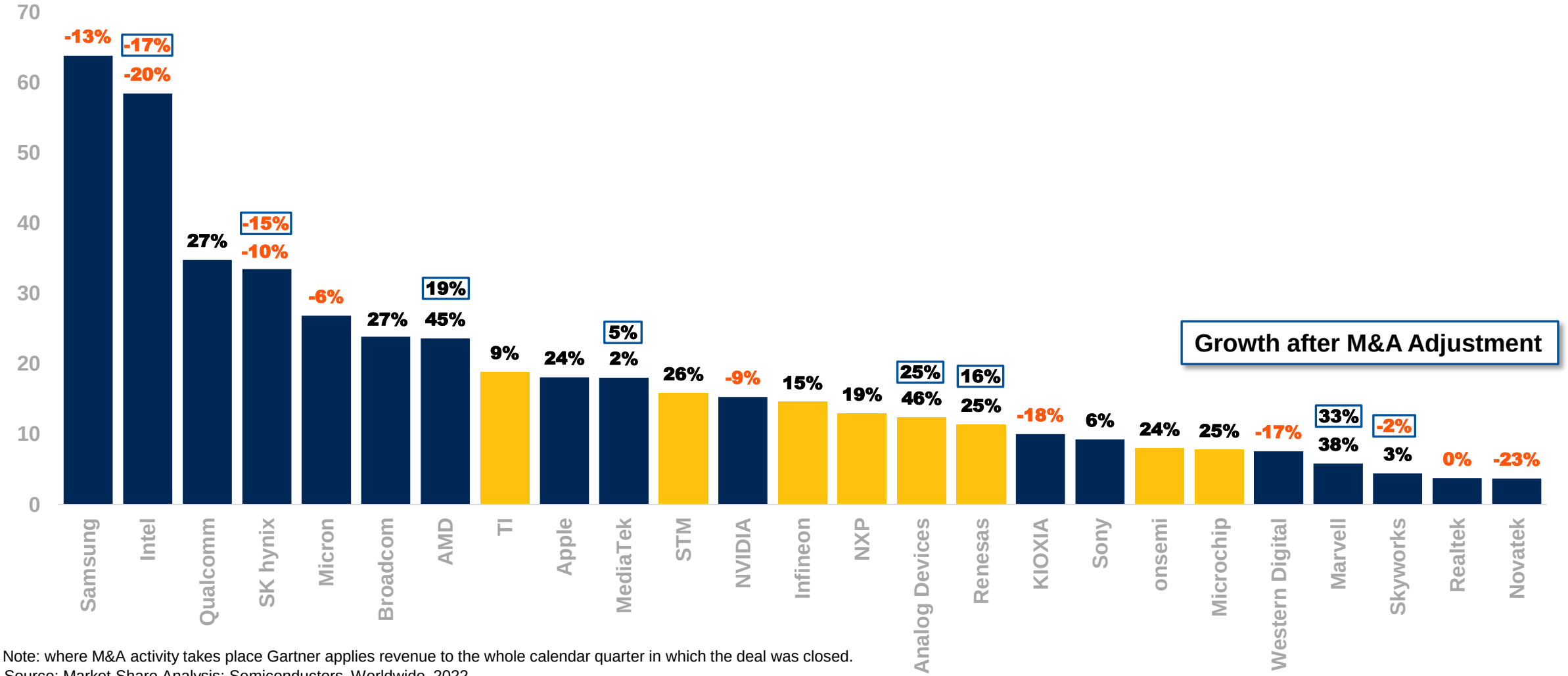


Automotive & Industrial are The New Growth Drivers



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.

Source: Market Share Analysis: Semiconductors, Worldwide, 2022

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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".

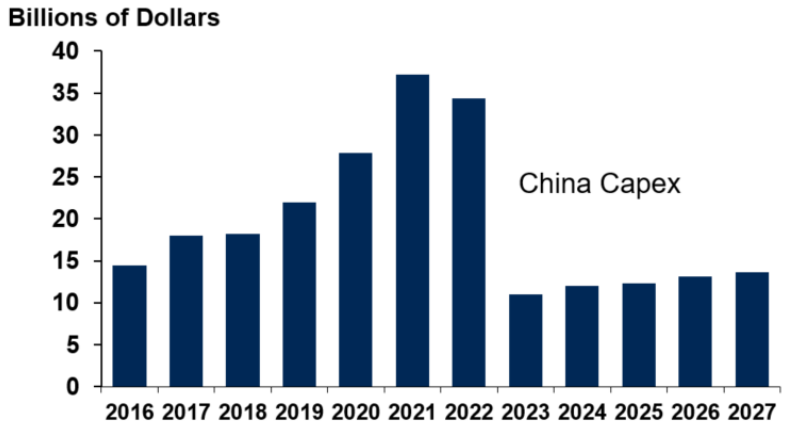

Image Source: https://economictimes.indiatimes.com/small-biz/trade/exports/insights/china-says-us-sanctions-of-companies-will-impact-supply-chain/articleshow/99546817.cms?from=mdr

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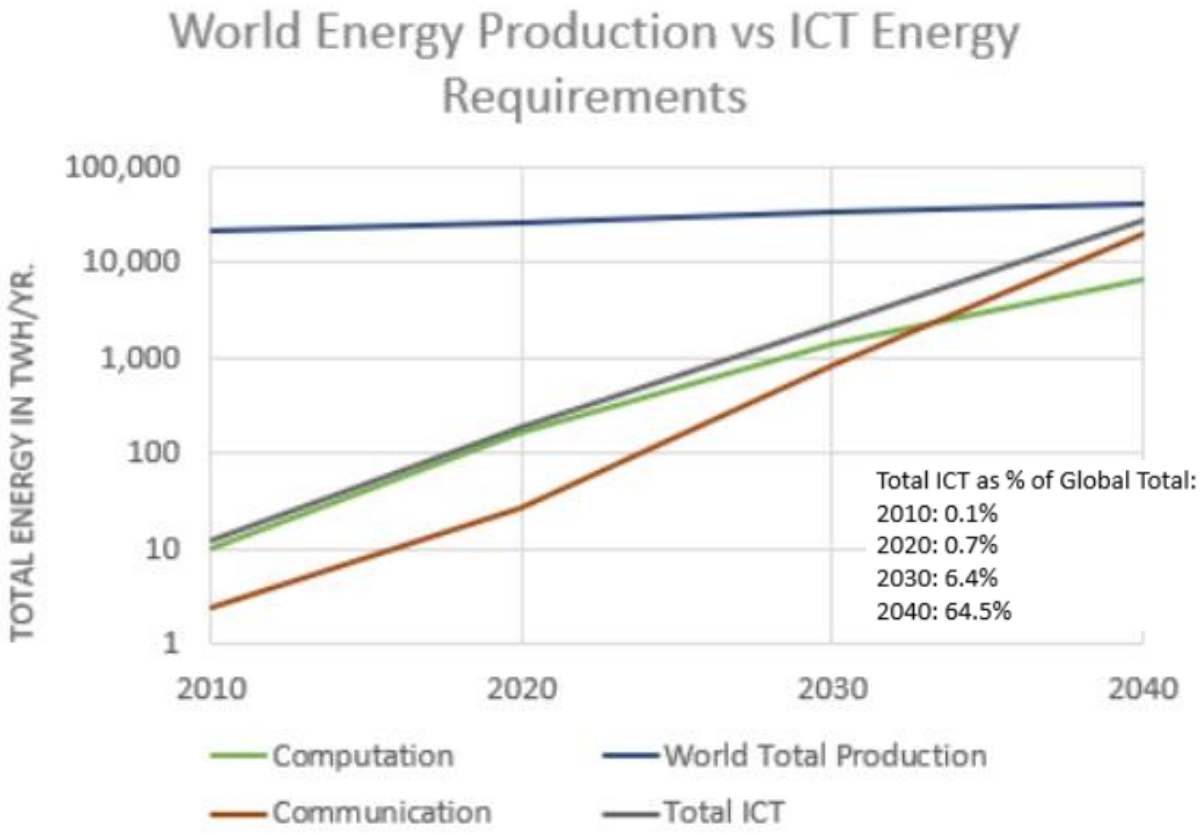
IC power requirements will outstrip WW supply

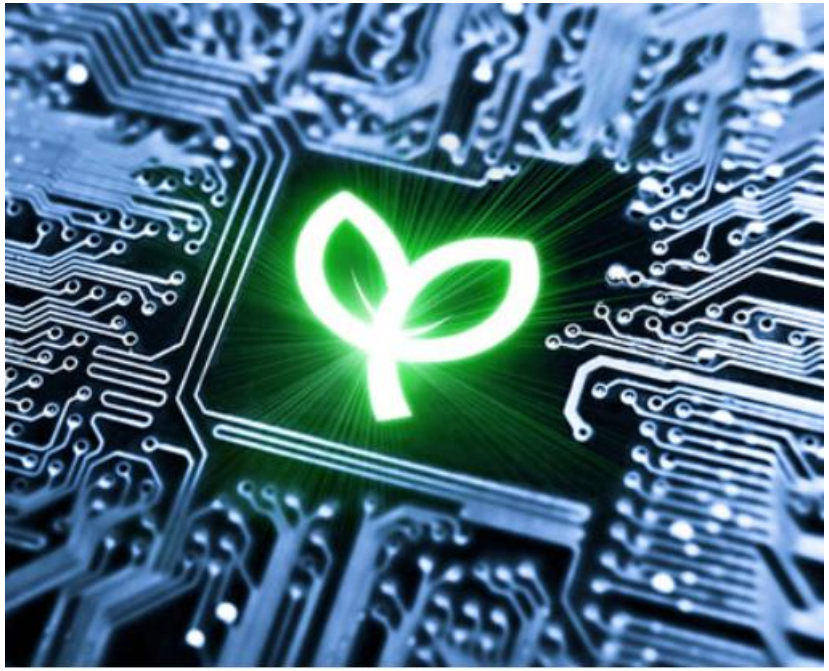


Generative AI

- **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/
International Energy Association World Energy Outlook 2022: Stated Policies Scenario

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/

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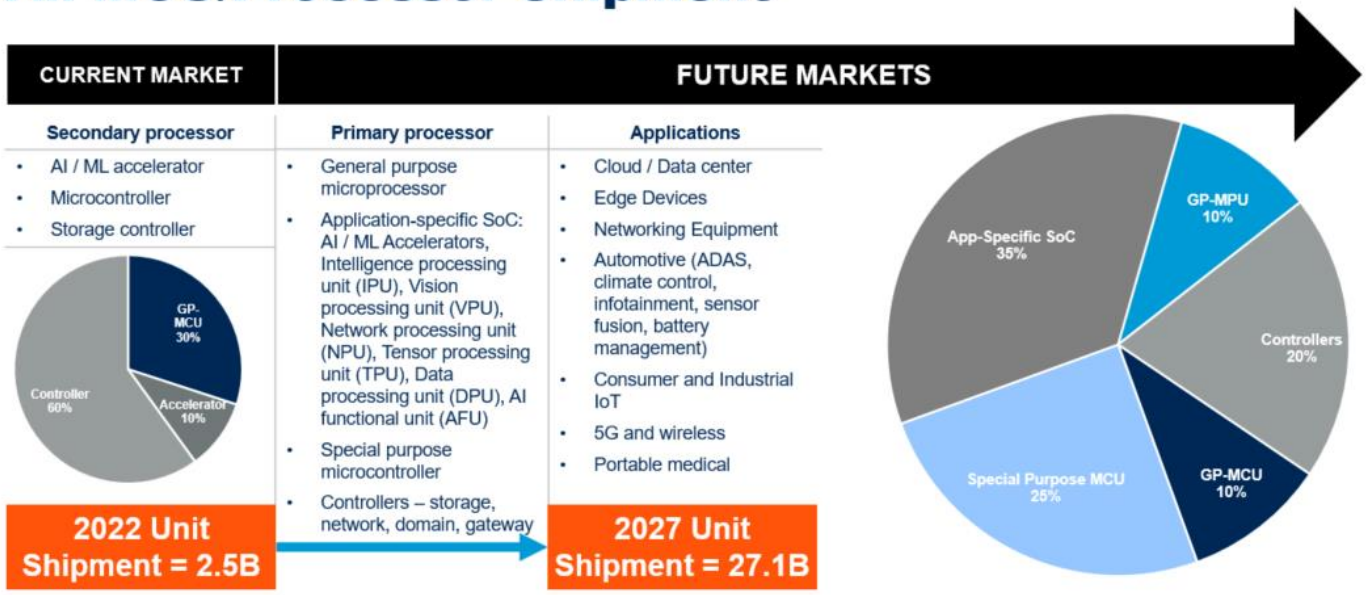
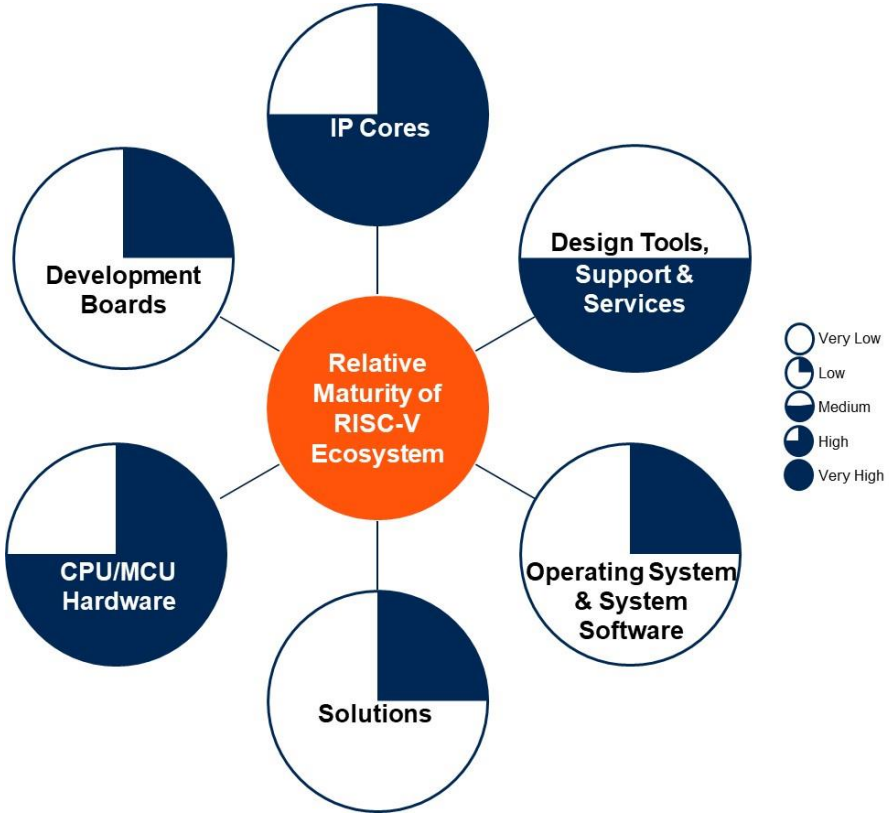
By 2030, RISC-V will mature to become a mainstream processor architecture

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.

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Emerging technologies for growth applications

Impact Radar for 2023

Range
- 6 to 8 Years
- 3 to 6 Years
- 1 to 3 Years
- Now (0 to 1 Year)

Mass
- Low
- Medium
- High
- Very High

Source: Gartner
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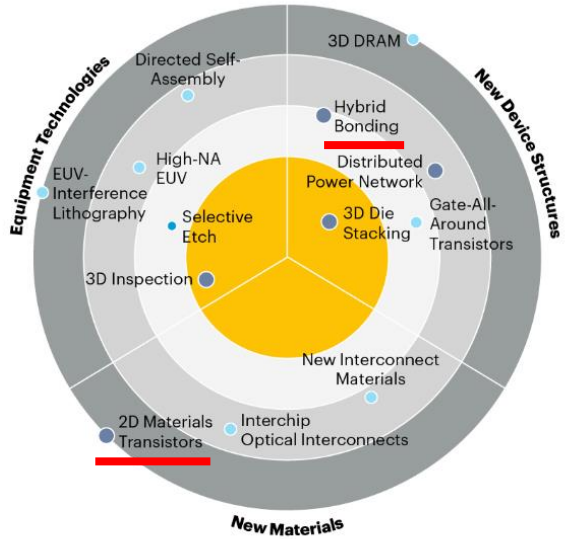
Impact Radar for Semiconductor Manufacturing Technology



Source: Gartner
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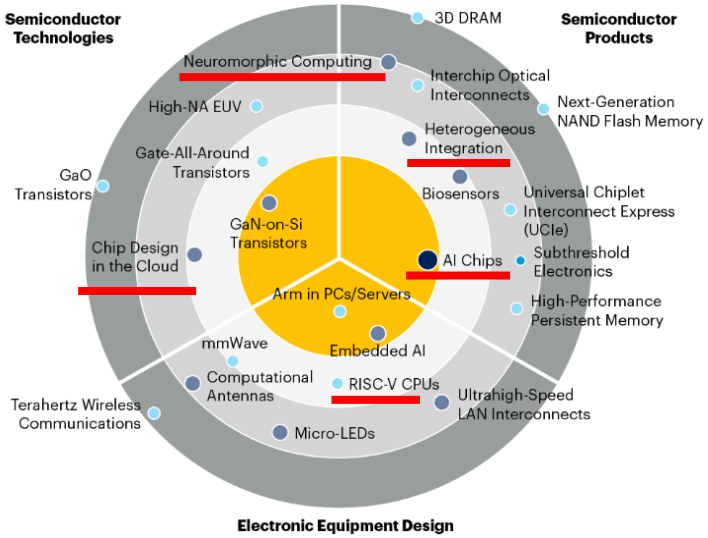
Impact Radar for Semiconductor and Electronics Technologies



Source: Gartner
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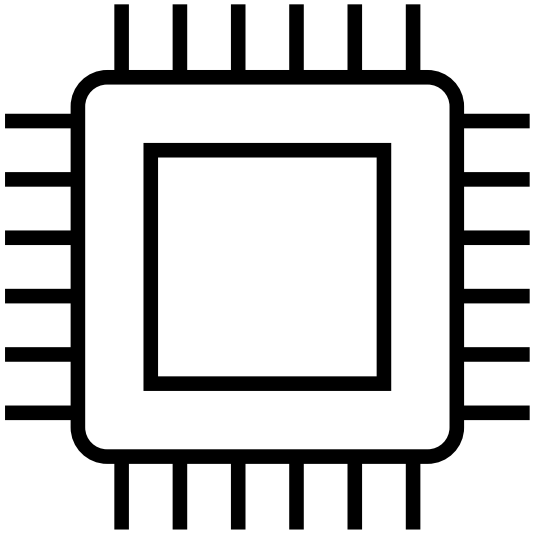
Key Takeaway:

Plenty of Challenges



But converting opportunities will determine winners

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