GREENMANTLE

Chip War

Implications for Japan and Industrial Policy

January, 2023

Chris Miller

Executive Summary

1. How Semiconductors Have Shaped the World Order
2. Russia, Ukraine and the Future of High-Tech Warfare
3. The China Chip Choke
4. How Supply Chains are Shifting
5. How the Chip Industry is Changing
6. Implications for Japanese Industry

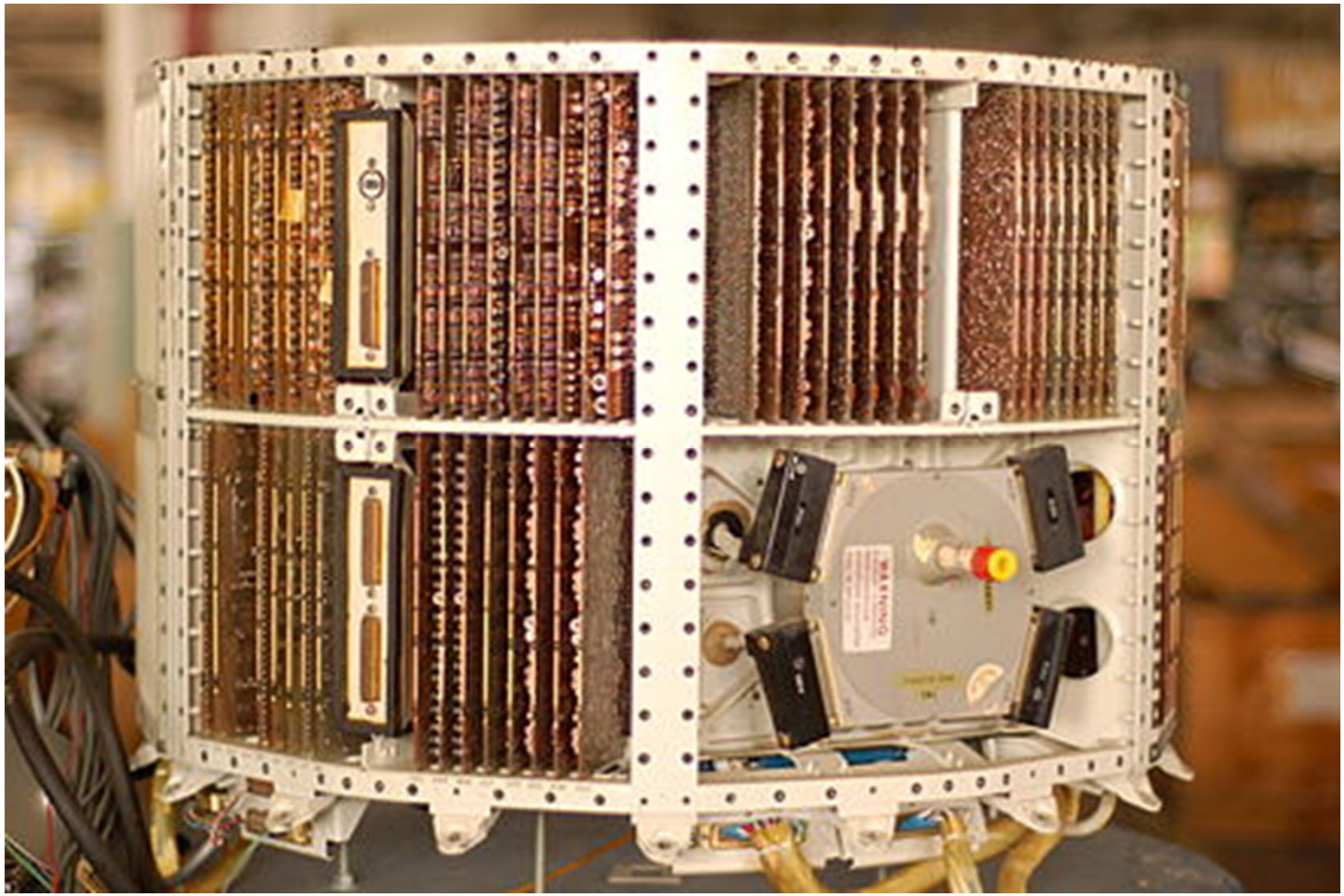
1. How Semiconductors Have Shaped the World Order

The chip industry emerged from the Cold War arms race, requiring computers small enough to fit in missiles

Source – *Dave Fields*

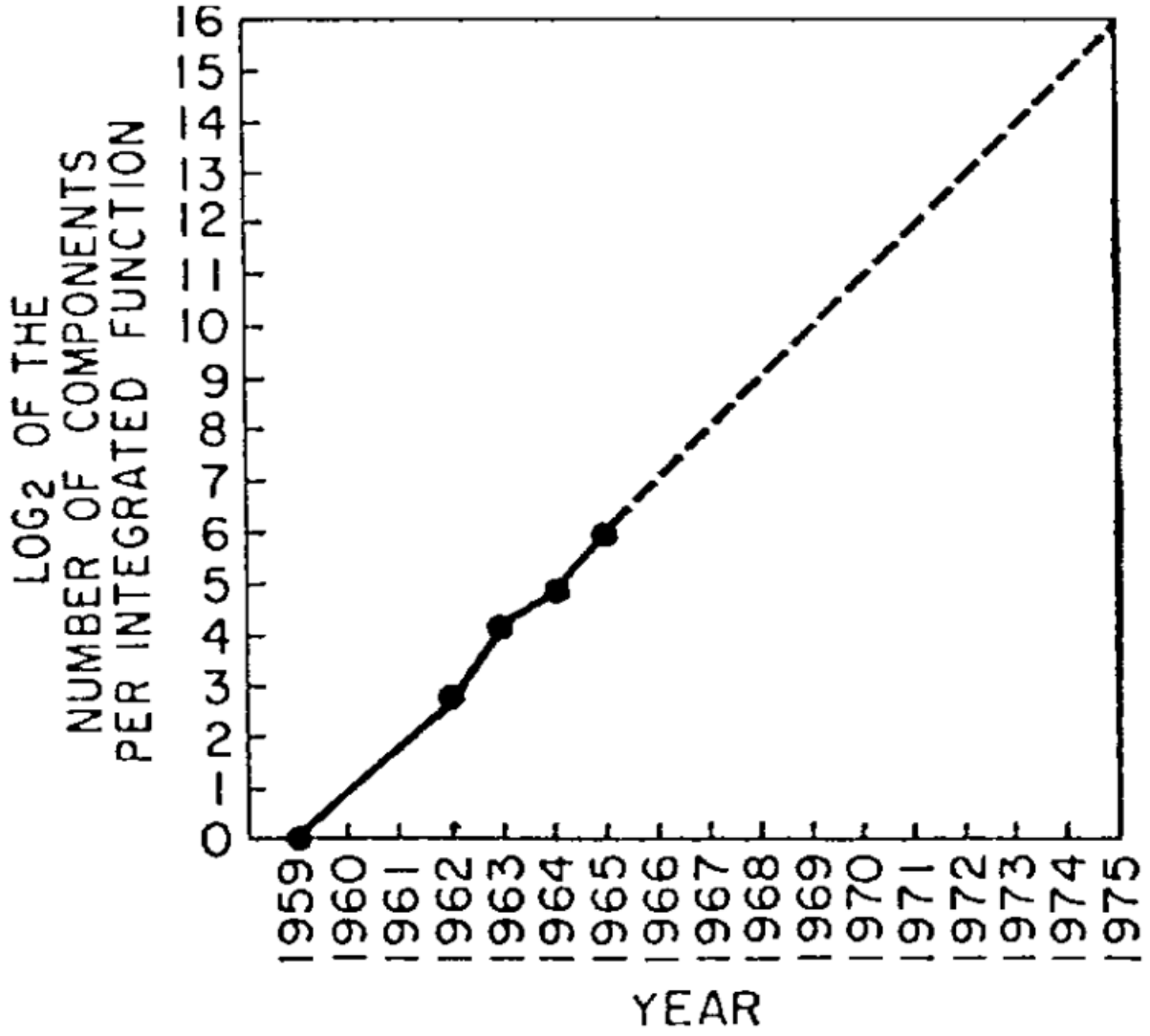
The first major chip contracts were for NASA rockets and nuclear missiles

Minuteman ICBM Guidance Computer



Source – *U.S. Military*

In 1965, Gordon Moore noted that computing power was growing exponentially

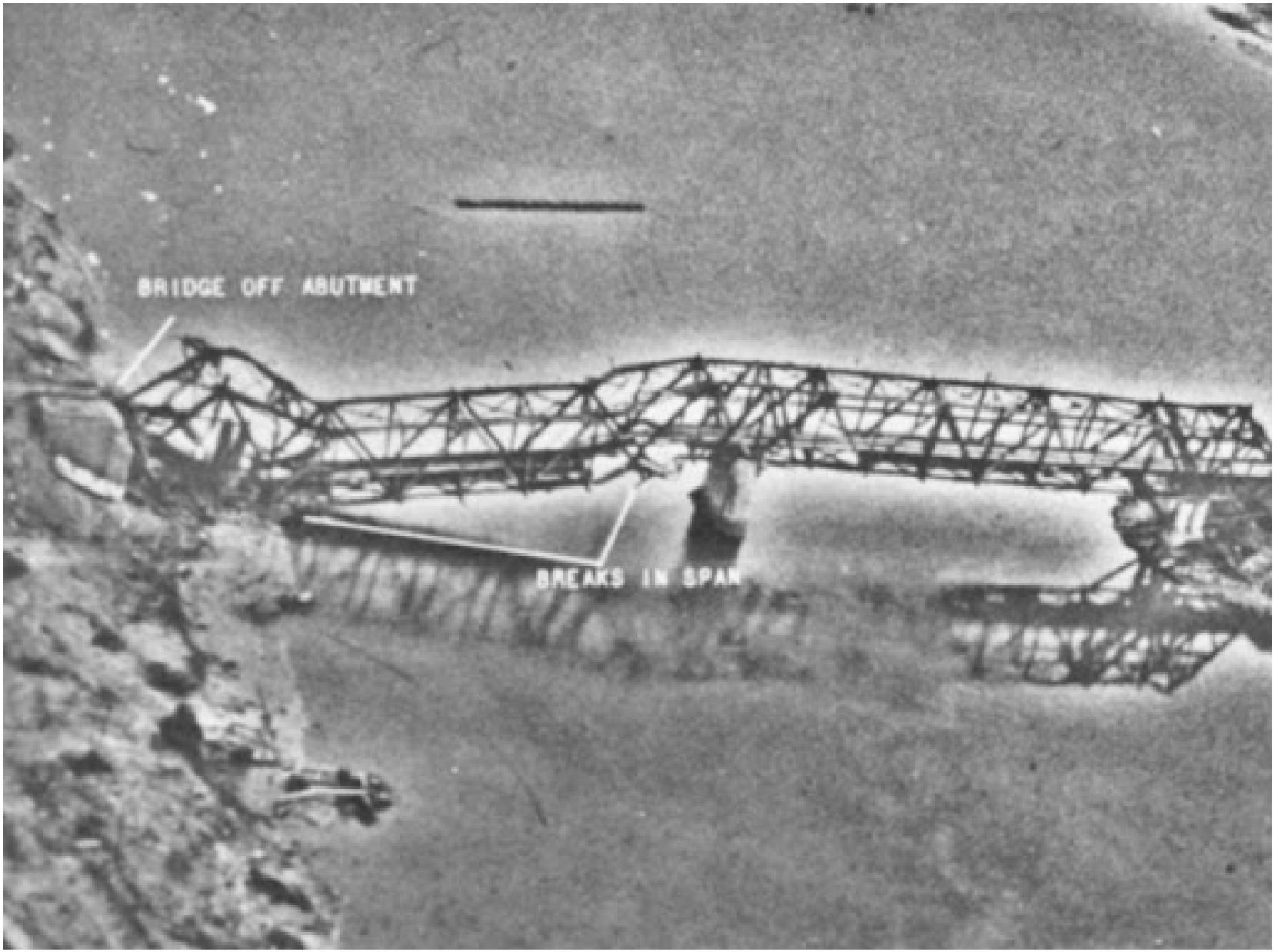


Source – *Gordon Moore, "Cramming more circuits"*

Allowing computing power to be deployed in all manner of devices

Source – *Dallas Morning News*

This facilitated revolutionary changes in military tactics



Source – *U.S. Military*

2. Russia, Ukraine and the Future of High-Tech Warfare

Today, governments are interested because chips are crucial to today's military systems

Western powers have sent hundreds of Javelin anti-tank missiles to Ukraine. Each one has over 200 semiconductors inside.

Source – *Lockheed Martin*

Ukraine is succeeding in part by its innovative use of high tech, semiconductor-enabled systems

Starlink low earth orbit satellites have helped Ukraine communicate throughout the war

Source – *Financial Times*

Ukraine can strike targets with precision deep behind the front lines

HIMARs systems have transformed the war by combining satellite guidance with U.S.-provided signals inteligence

Source – *Yahoo News*

Many of Russia's cyber attacks were thwarted by Ukraine's defenses—with help from Microsoft and Google

Source – *Microsoft*

Future warfare will only be more reliant on computing, sensing, and communications

DARPA visualization of future military systems, heavily networked, using advance sensors, deploying electronic warfare and directed energy weapons.

Source – *DARPA*

It will also rely on autonomous systems, requiring AI training in data centers plus powerful edge processing

China's GJ-11 Drone

Source – *South China Morning Post*

3. The China Chip Choke

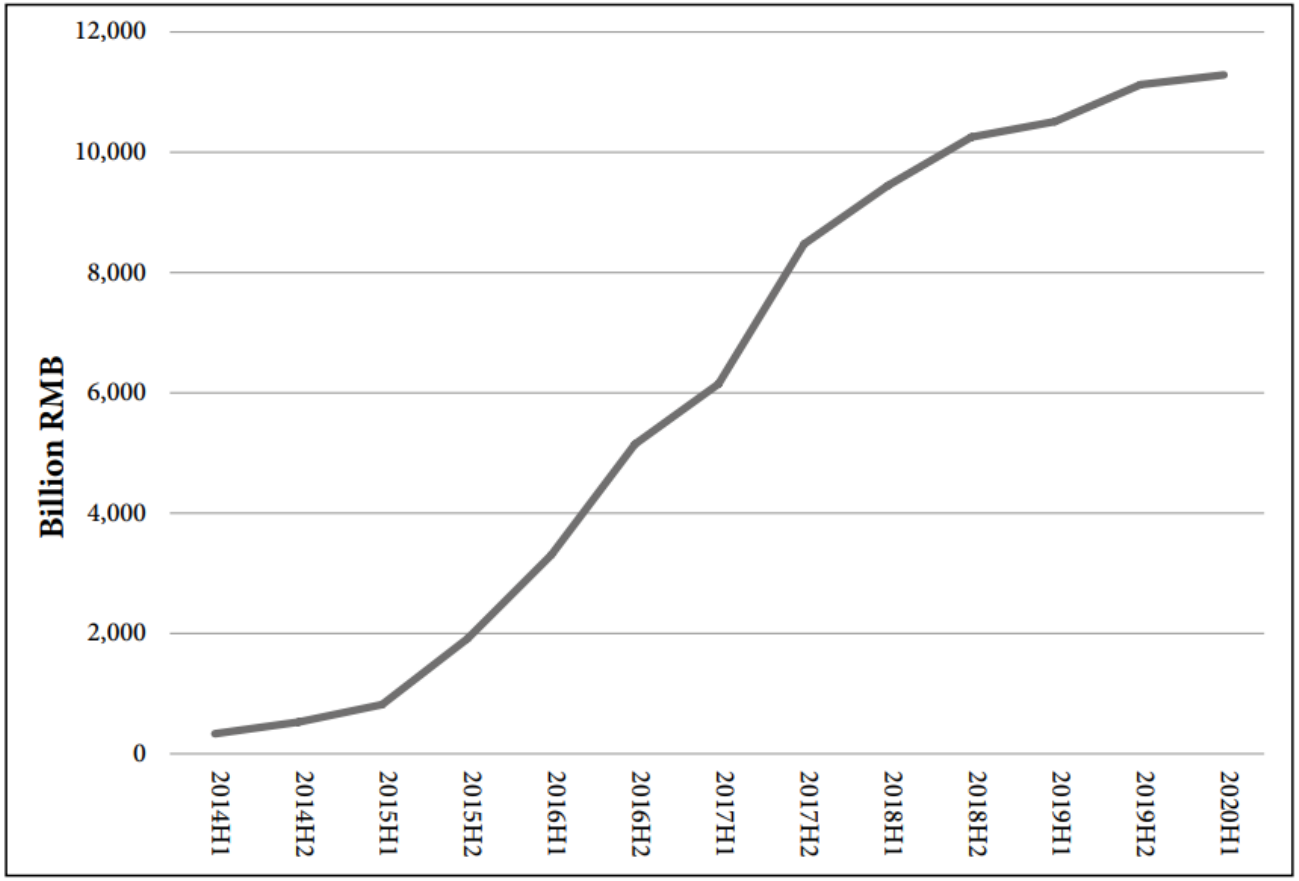
Though China's military depends on chips, its semiconductor industry is comparatively small

	Segment Value add	Market shares						
		U.S.	S. Korea	Japan	Taiwan	Europe	China	Other
EDA	1.5%	96%	<1%	3%	0%	0%	<1%	0%
Core IP	0.9%	52%	0%	0%	1%	43%	2%	2%
Wafers	2.5%	0%	10%	56%	16%	14%	4%	0%
Fab tools	14.9%	44%	2%	29%	<1%	23%	1%	1%
ATP tools	2.4%	23%	9%	44%	3%	6%	9%	7%
Design	29.8%	47%	19%	10%	6%	10%	5%	3%
Fab	38.4%	33%	22%	10%	19%	8%	7%	1%
ATP	9.6%	28%	13%	7%	29%	5%	14%	4%
Total value add		39%	16%	14%	12%	11%	6%	2%

Saif Khan, et al, CSET

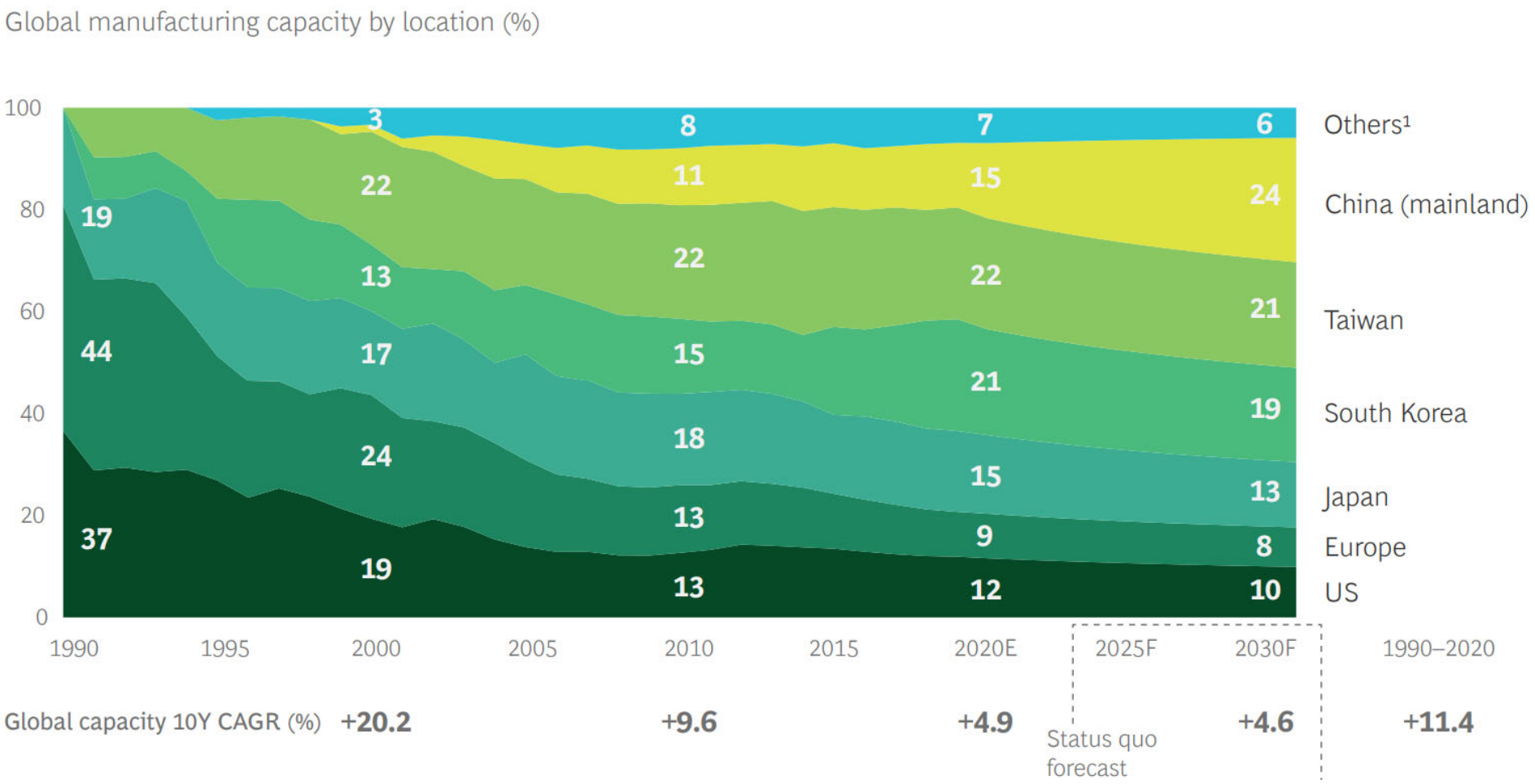
China has poured government funds into its chip industry…

Figure 4.1: Government Industrial Guidance Funds: Cumulative Fund-Raising Scope



Source – *Barry Naughton,* "Rise of China's Industrial Policy"

But most of the money is going to build out low-end fabrication capacity



Source – SIA/BCG, "Government incentives and U.S. Competitiveness in Semiconductor Manufacturing"

China remains hugely reliant on imported machines and components

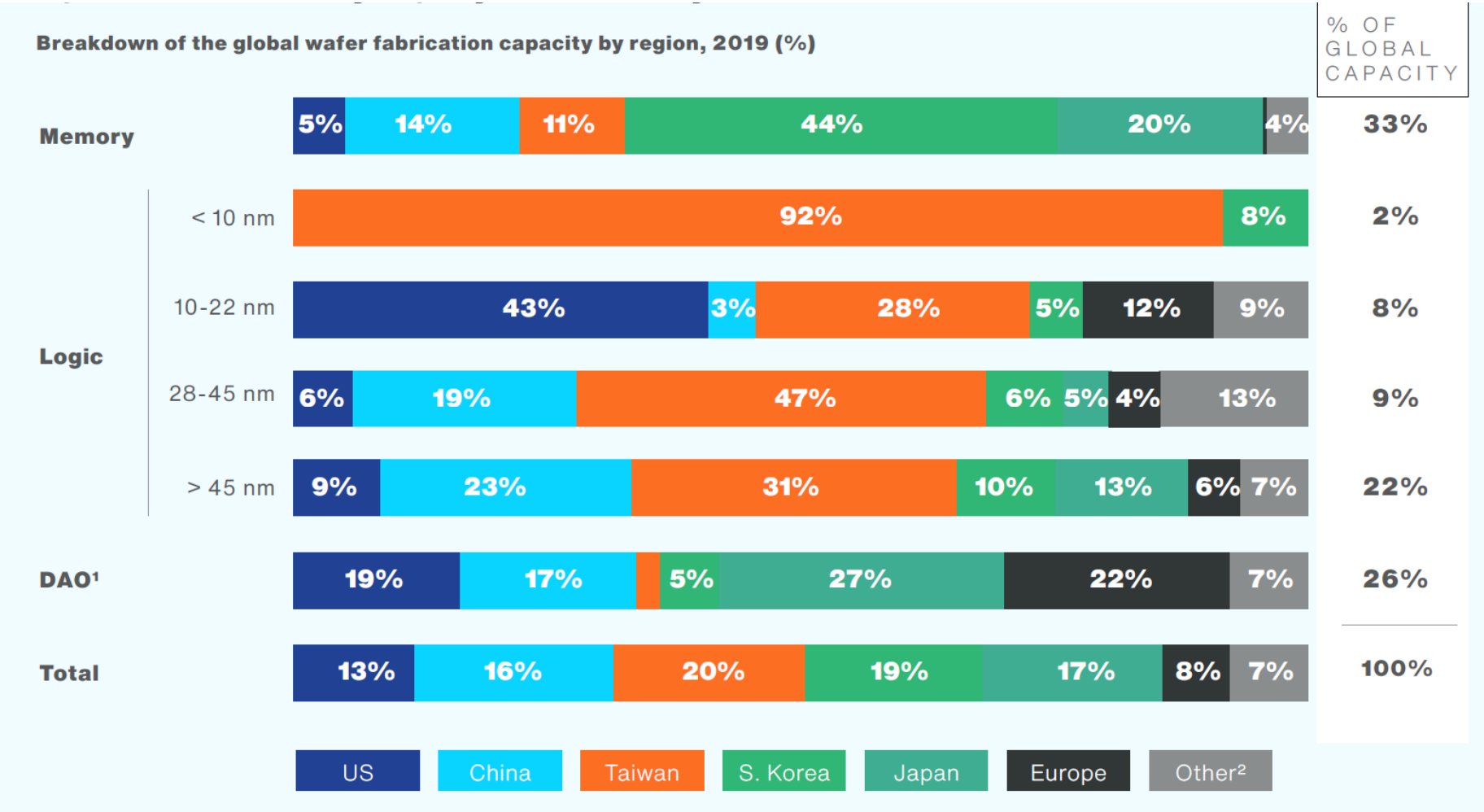
Today, China relies extensively on imports in the following areas:

- Chip design software
- Chip designs (though these capabilities are improving)
- Advanced processor and DRAM logic chips
- Most types of chipmaking machinery
- Many types of ultra-purified chemicals and materials

Table 3: China's competitiveness across supply chain segments

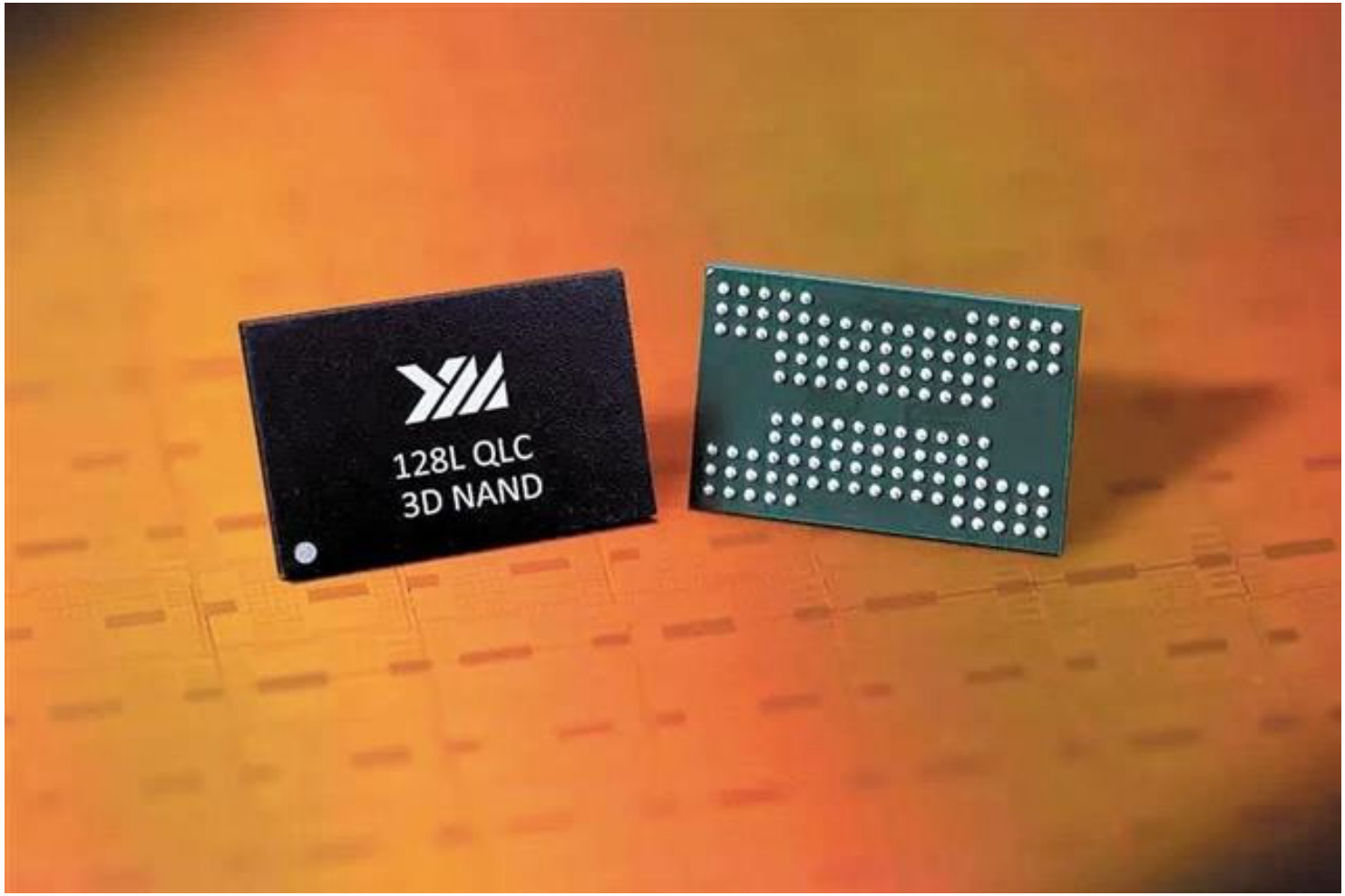
Source – *Saif Khan, et al "The Semiconductor Supply Chain," CSET*

And the entire world depends on advanced fabrication from Taiwan and South Korea



Source: Semiconductor Industry Association

The U.S. has imposed punishing export controls on Chinese chipmakers like YMTC and SMIC



Source – *Digitimes*

Foreign chip firms have almost completely halted investments in China

NIKKEI Asia

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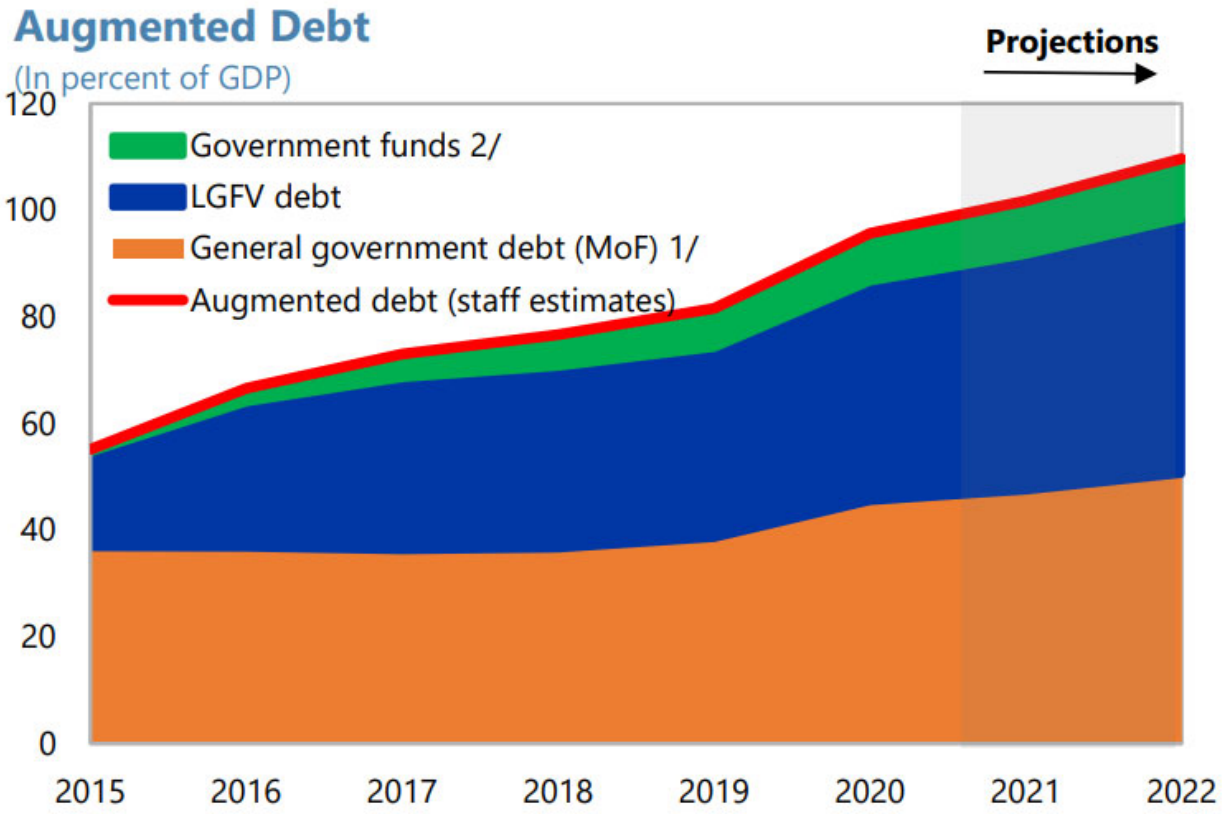
SEMICONDUCTORS

SK Hynix halts Chinese chip plant upgrade over U.S. restrictions

Memory chip supplier had sought to install advanced production equipment from ASML

Source – *Nikkei Asia*

China wants self-sufficiency, but mastering chipmaking technology will take years—and cost billions



Sources: Ministry of Finance (MoF); and IMF staff calculations.
1/ Data through 2020, 2021 estimated, 2022 projection.
2/ Government guided funds and special construction funds (social capital portion only).

Source – *IMF*

As tensions intensify, they may not only stay in the technological sphere

FINANCIAL TIMES myFT

US-China trade dispute + Add to myFT

US to probe claims that top Chinese chipmaker violated ban on Huawei

YMTC said to have sold semiconductors that incorporated American technology to smartphone maker

Bloomberg
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Politics

Top Economist Urges China to Seize TSMC If US Ramps Up Sanctions

- Policy proposal made in speech on US-China relations
- Research group overseen by China's economic planning agency

Rubio, McCaul Demand Tougher Protections Against Chinese Semiconductor Maker SMIC, Warn of Possible Beijing-Moscow Coordination

MAR 17 2022

Washington, D.C. — U.S. Senator Marco Rubio (R-FL) and U.S. Representative Michael McCaul (R-TX) sent a letter to U.S. Department of Commerce Secretary Gina Raimondo urging the Department to strengthen Entity List rules for China's Semiconductor Manufacturing International Corporation (SMIC) and expressing concern that Beijing may divert technology to Moscow to evade U.S. sanctions. Their letter follows requests in March 2021 and December 2020.

"We have written to the Commerce Department twice to express these concerns, imploring the department to take all steps necessary to strengthen American economic security," **the lawmakers wrote**. "Since our last communication on the topic in March 2021, SMIC has posted record earnings, announcing soaring profits

Source – *Publication Title*

4. How Supply Chains are Shifting

Meanwhile, supply chains are shifting, driven by governments and companies

- The CHIPS and Science Act will spend $39B on fabrication incentives, $11B on R&D and around $2B on other chip programs
- DARPA's Electronics Resurgence Initiative is funding new techniques for chip design, security, RF and other topics
- The Commerce Department has imposed new controls on tech transfer abroad

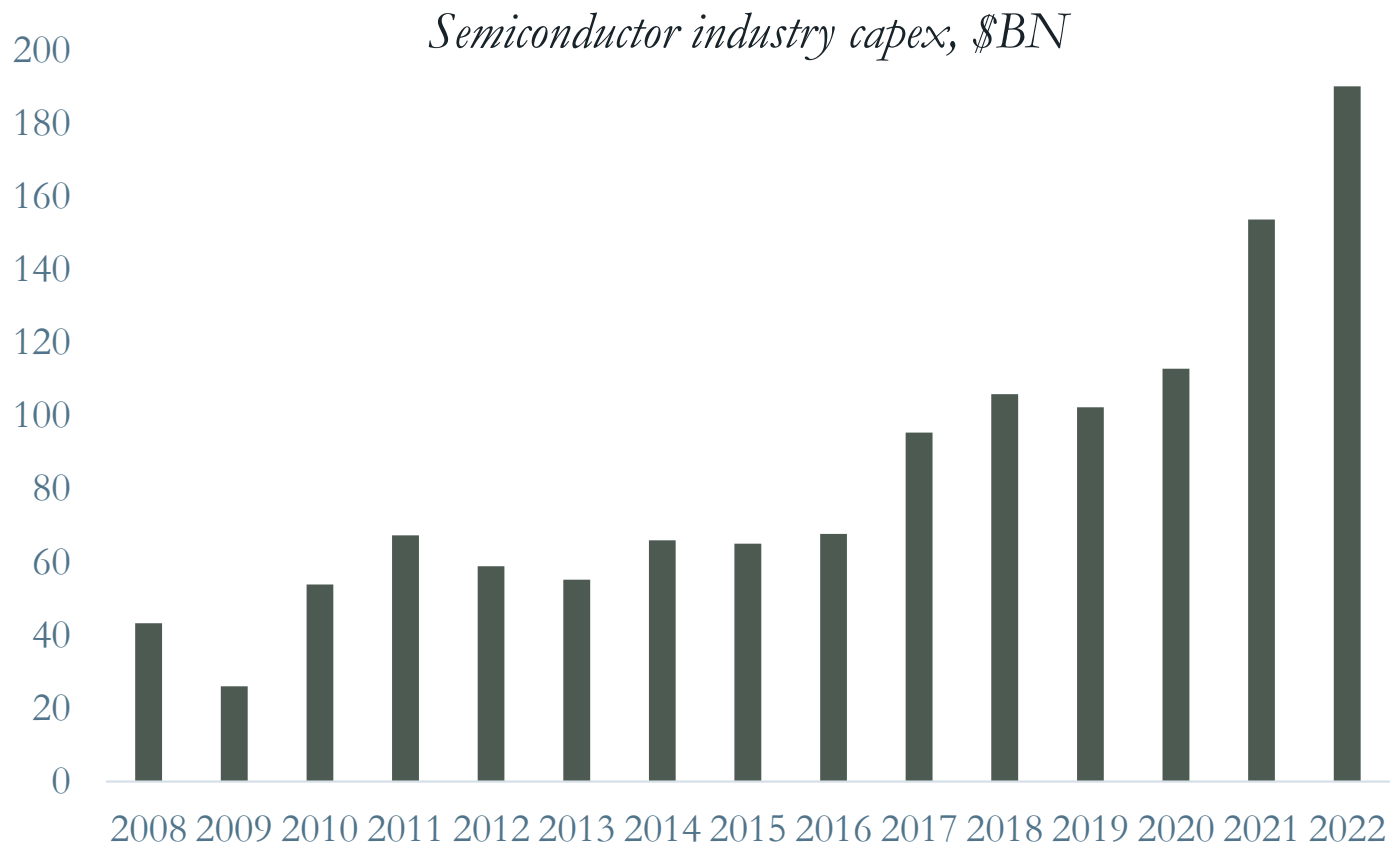
Source – *Publication Title*

Chips funding around the world

- **India –** subsidizing lagging-edge fabrication as well as design and materials
- **European United –** preparing a ~40-50 billion Euros Chips Act
- **Japan –** supporting new fabs such as TSMC's new facility
- **Taiwan –** providing a new 25% tax credit for R&D
- **South Korea –** considering a 25% tax credit on capital investment

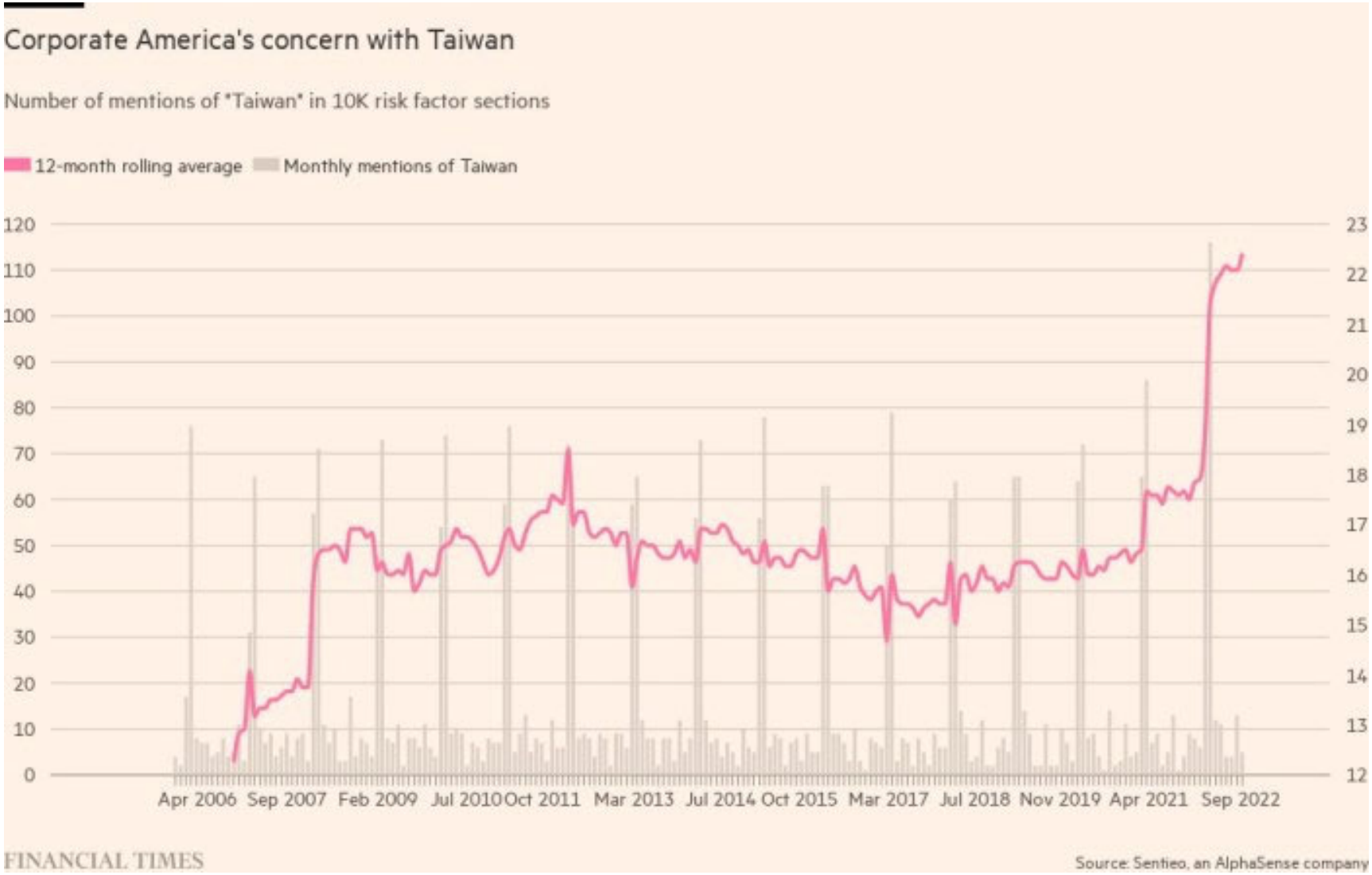
Source – *Publication Title*

Capital expenditure on chips has skyrocketed



Source – IC Insights

Governments aren’t the only player. Companies are worried about Taiwan risk.



Source – *Financial Times*

TSMC, the world's largest chipmaker, is building new fabs in the U.S., Japan, and probably Germany

TSMC's new facility in Arizona.

Source – Phoenix Journal

Electronic device makers are reducing use of Chinese components and China-based assembly

NIKKEI Asia

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SUPPLY CHAIN

Dell looks to phase out 'made in China' chips by 2024

'This trend looks irreversible,' supplier exec says of tech industry's production shift

Dell has also asked suppliers of other components as well as product assemblers to help prepare capacity in countries like Vietnam. (Photo by Ken Kobayashi)

CHENG TING-FANG, Nikkei Asia chief tech correspondent

January 5, 2023 11:48 JST ● Updated on January 5, 2023 15:31 JST

Electronics assembly continues to shift toward Vietnam

Apple will reportedly begin producing some MacBooks in Vietnam in 2023 as it shifts from China

PUBLISHED TUE, DEC 20 2022•9:04 AM EST | UPDATED TUE, DEC 20 2022•4:00 PM EST

Ashley Capoot
@ASHLEYCAPOOT

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KEY POINTS

- Apple will begin producing some of its MacBook computers in Vietnam, according to a Nikkei Asia report.
- The move reflects the tech giant's continued push to expand its manufacturing beyond China.

Countries with limited electronics industries, like Mexico, are attracting attention

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Notebook brands eye Mexico as possible production hub

Aaron Lee, Taipei; Eifeh Strom, DIGITIMES Asia | Tuesday 23 August 2022 | 0 Like 0

BIZ FOCUS

Even India is attracting attention—and pouring in government funds

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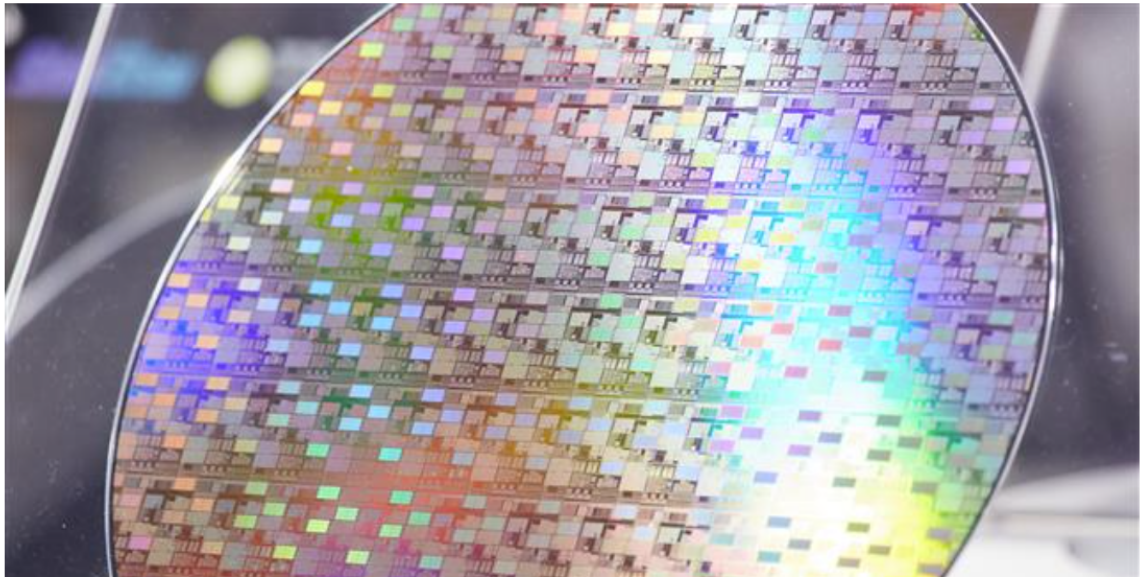
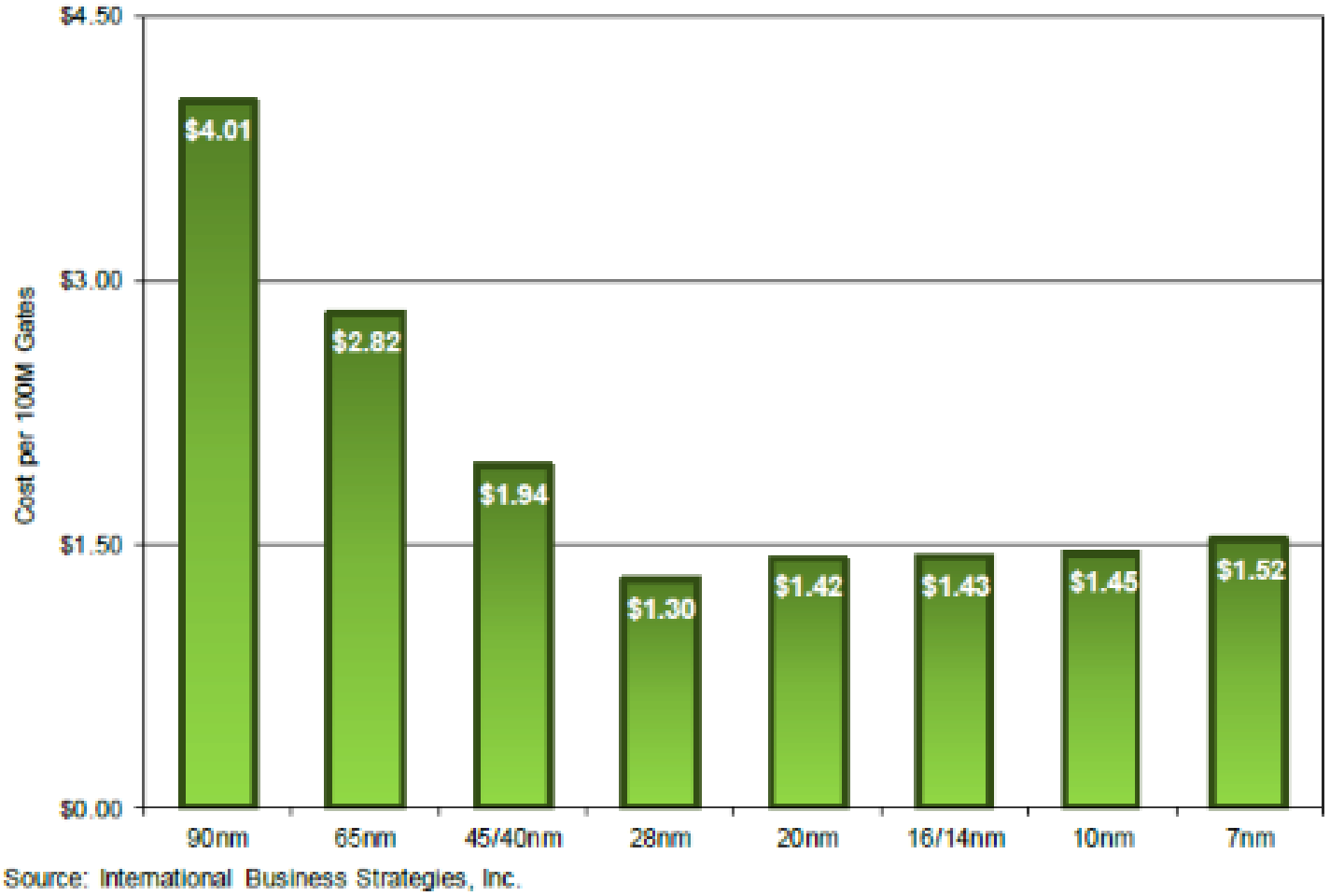
India reportedly to approve Vedanta-Foxconn's chip fab project

Jingyue Hsiao, DIGITIMES Asia, Taipei | Thursday 12 January 2023 | 0 Like 0



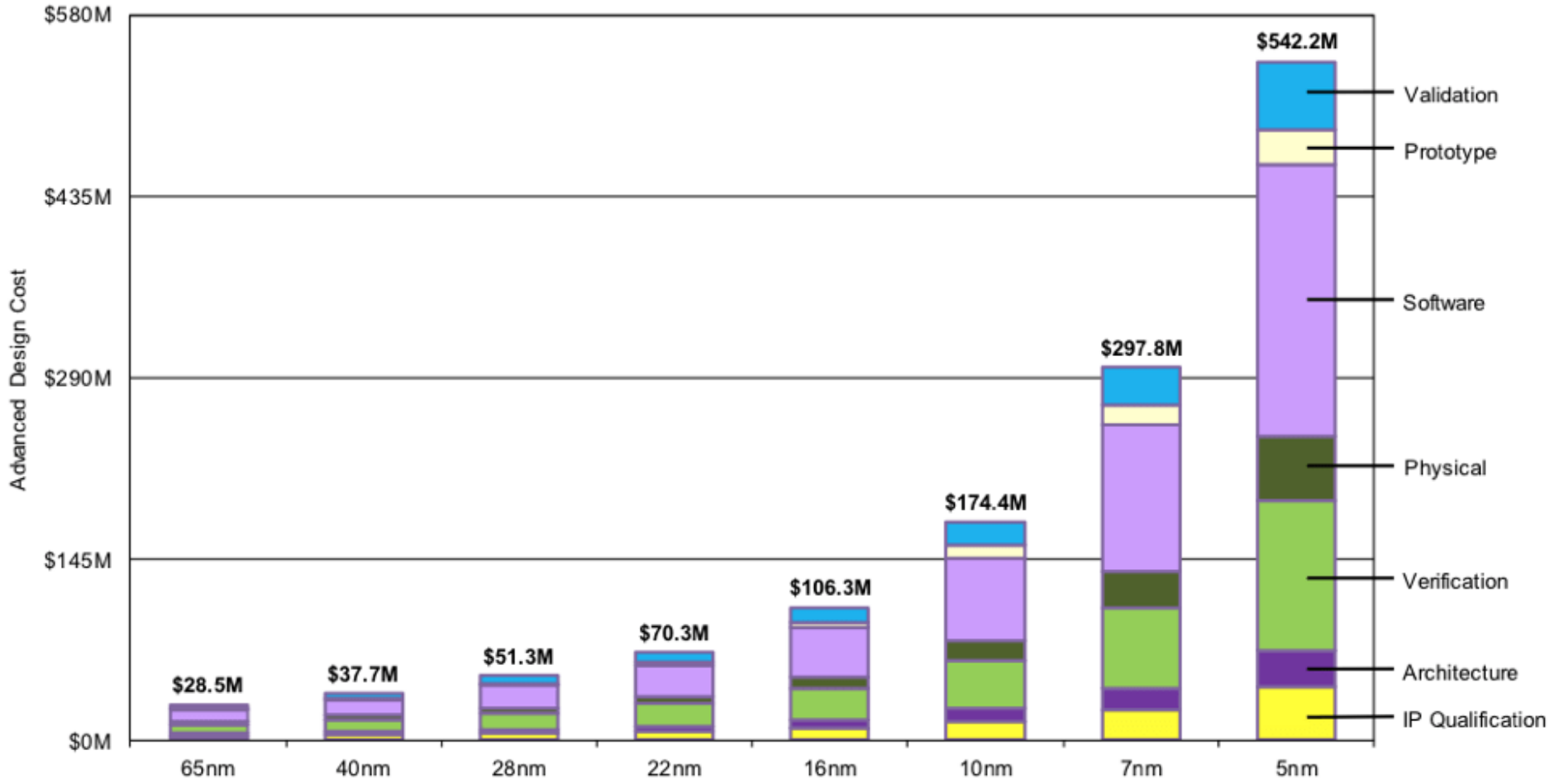
5. How the Chip Industry is Changing

Moore's law has stopped delivering lower costs per transistors



Source – *Handel Jones, International business Strategies*

Even designing leading edge chips is getting brutally expensive



Source – *Semiconductor Engineering*

Open sources architectures like RISC-V reduce IP costs, so are growing rapidly

The computational demands of training AI requires new architectures and better interconnects

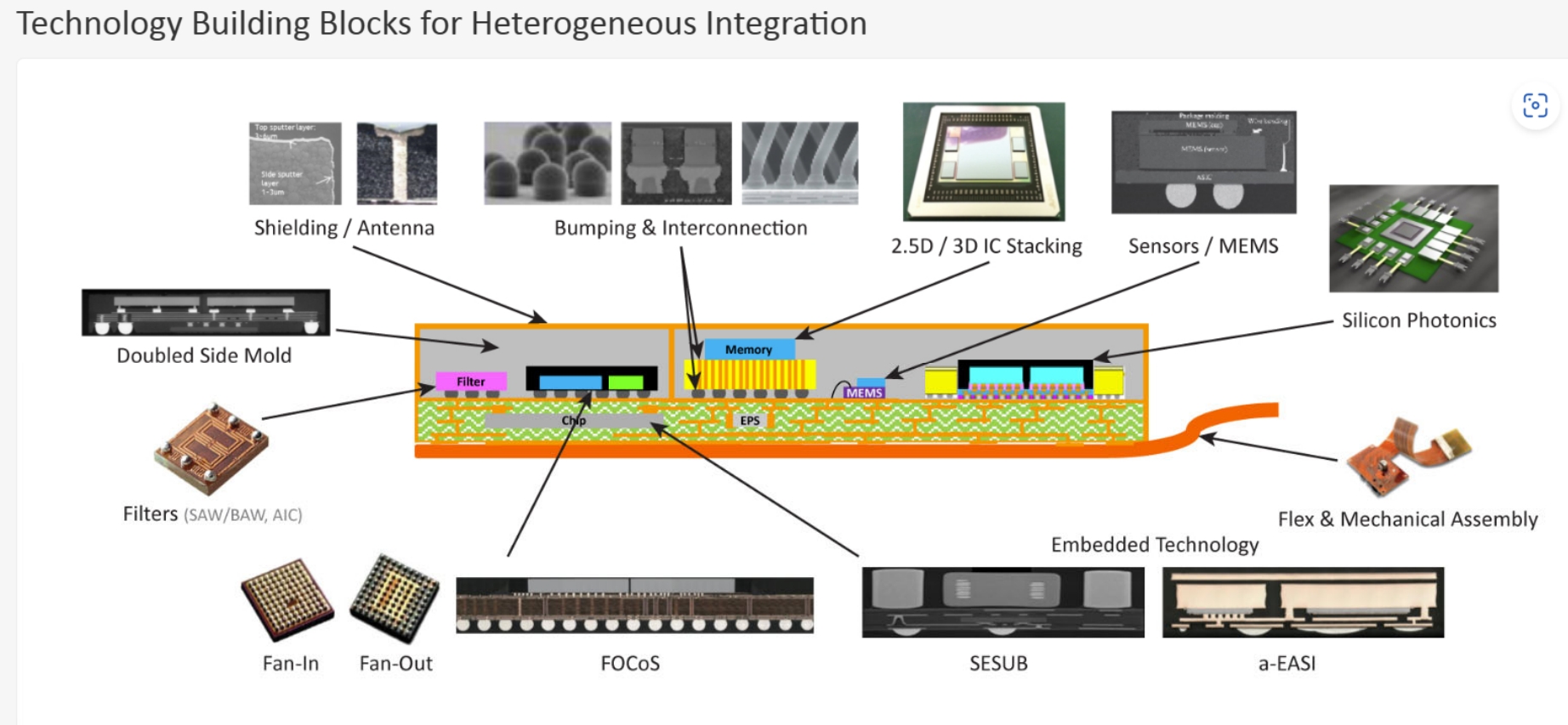
- Nvidia and AMD GPUs continue to displace traditional x86 CPUs in datacenters

- Intel's newest datacenter chips like Sapphire Rapids involve substantial accelerators

- Chip design startups like Cerebras or Groq are mostly focused on designing ASICs for AI

- Amazon, Google and other cloud firms are investing heavily on chip design

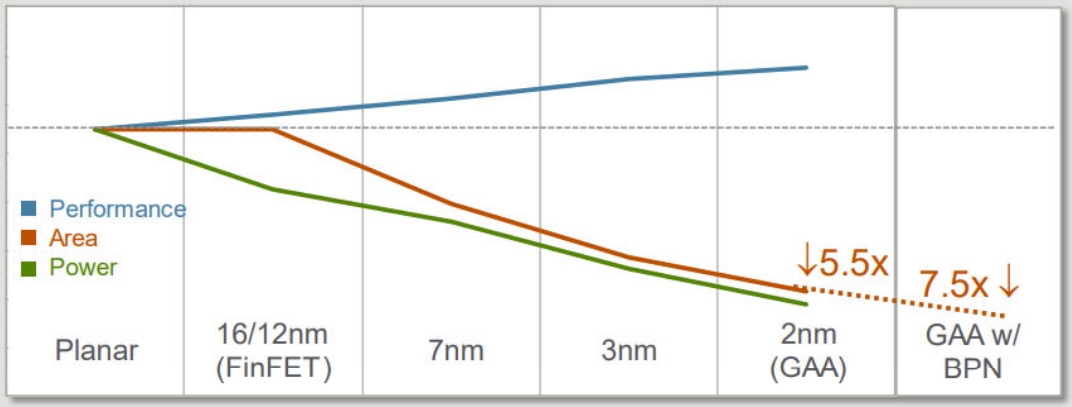
The solution is heterogenous integration of leading and lagging edge chips and features like RF and photonics



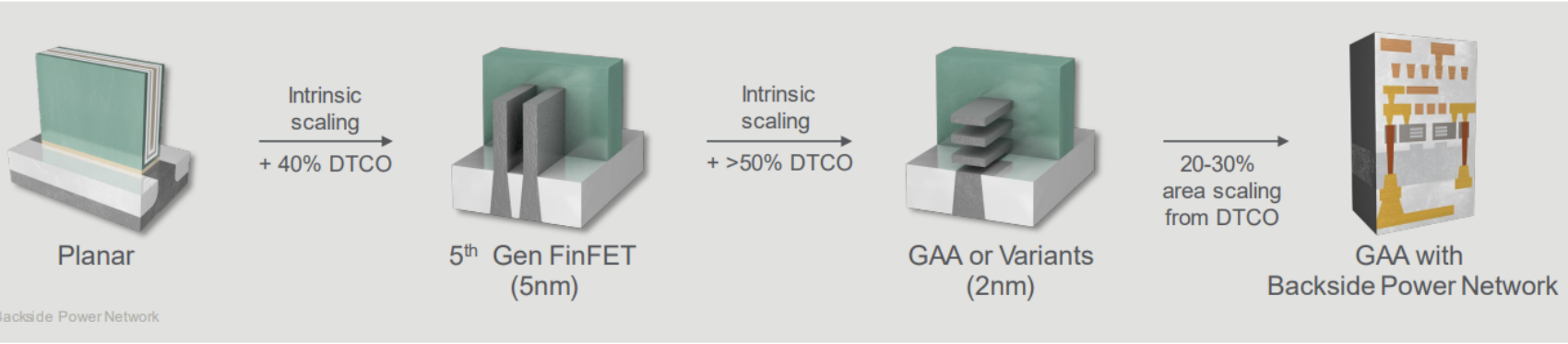
Source – *ASE*

As well as new packaging technologies like backside power delivery

GAA with Backside Power Network for Additional Area Scaling



20 to 30% cell area reduction with Backside Power Network



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6. Implications for Japan

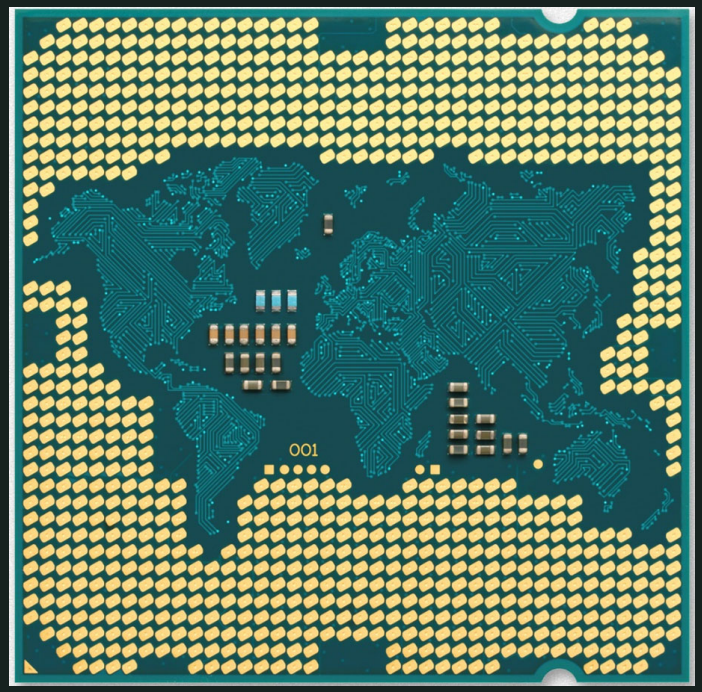
Implications and Conclusions

1. Datacenters and cloud capabilities will be a key driver of semiconductor demand growth

2. Autos are a second major growth segment, requiring more communications and processing capabilities

3. The traditional era of Moore's Law is being replaced by a more differentiated landscape, in which a combination of chip design, software, packaging, and interconnect capabilities will drive progress

4. Tech firms must adapt to technological shifts while de-risking supply chains from excessive dependence on China or Taiwan



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