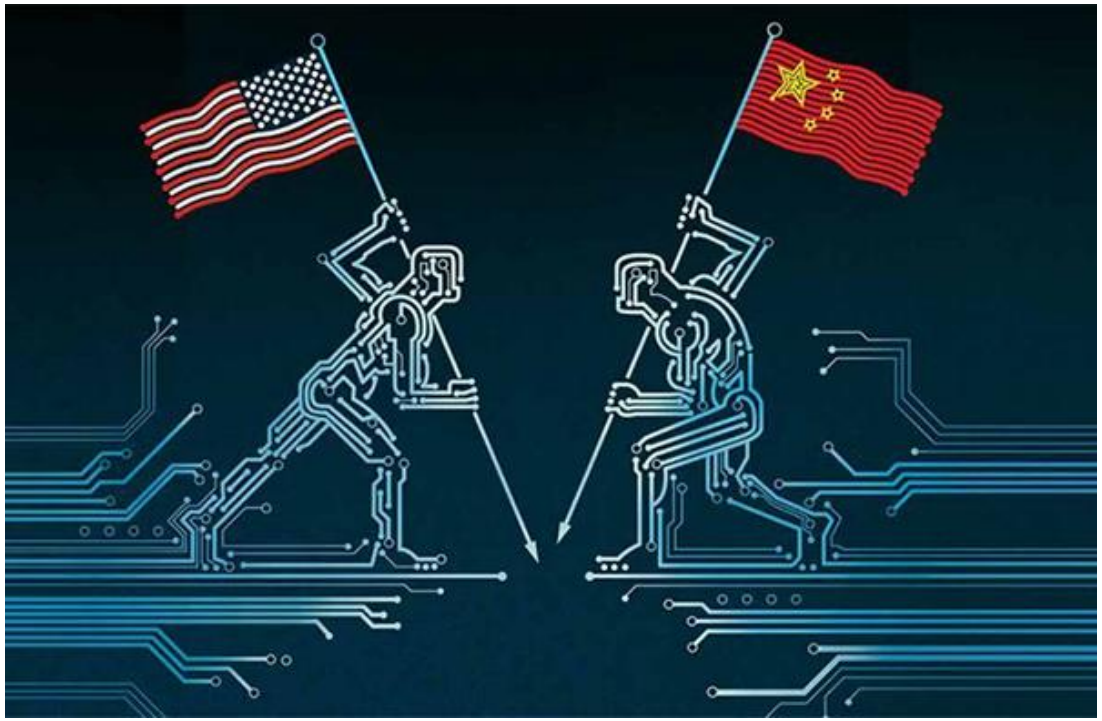
성균관대학교
SUNG KYUN KWAN UNIVERSITY(SKKU)

The China's Rise in Semiconductor Industry

The US, China & South Korea's Semiconductor Industrial Strategy



2022.11.2

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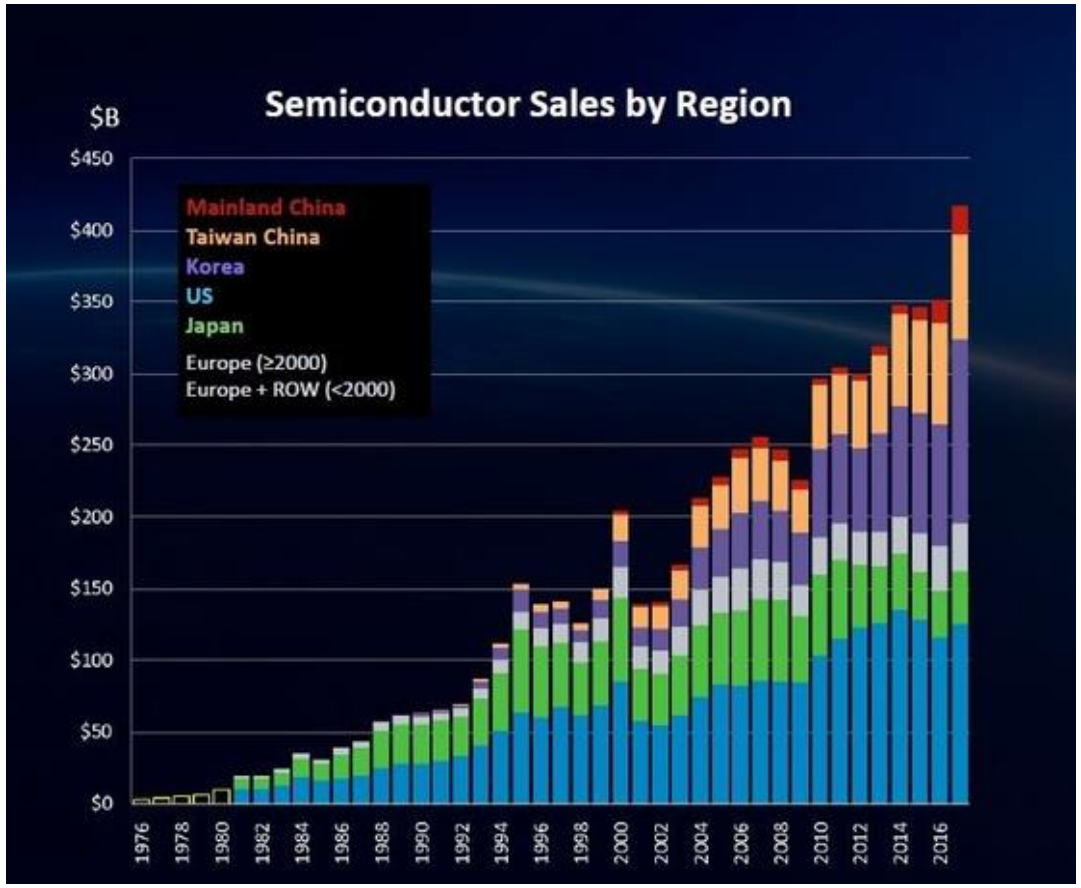

Shift of semiconductor industry:

US (before 1970s) → Japan (1970-2000s) → S. Korea & Taiwan (2000-2020s)

→ S. Korea, Taiwan, China, & US (2020s-)

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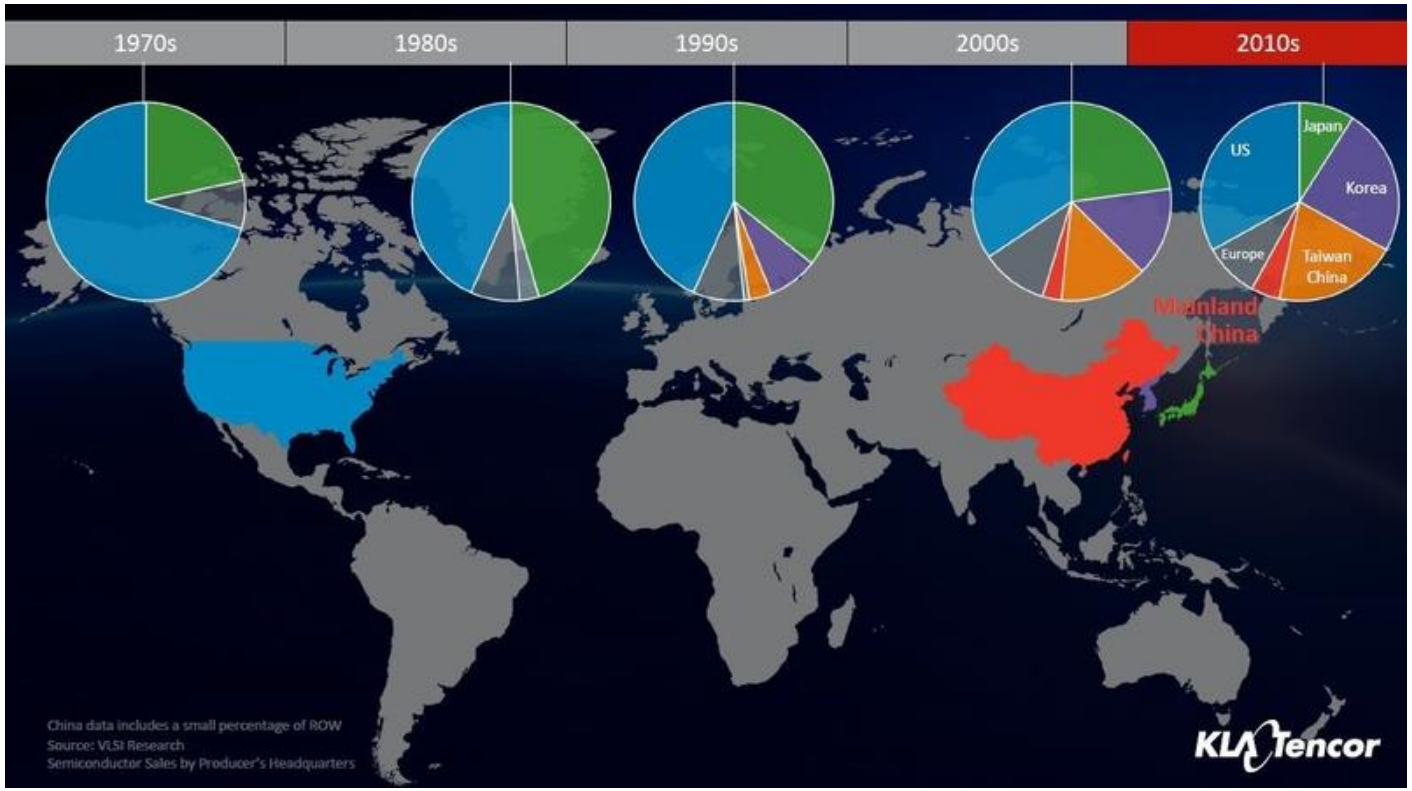
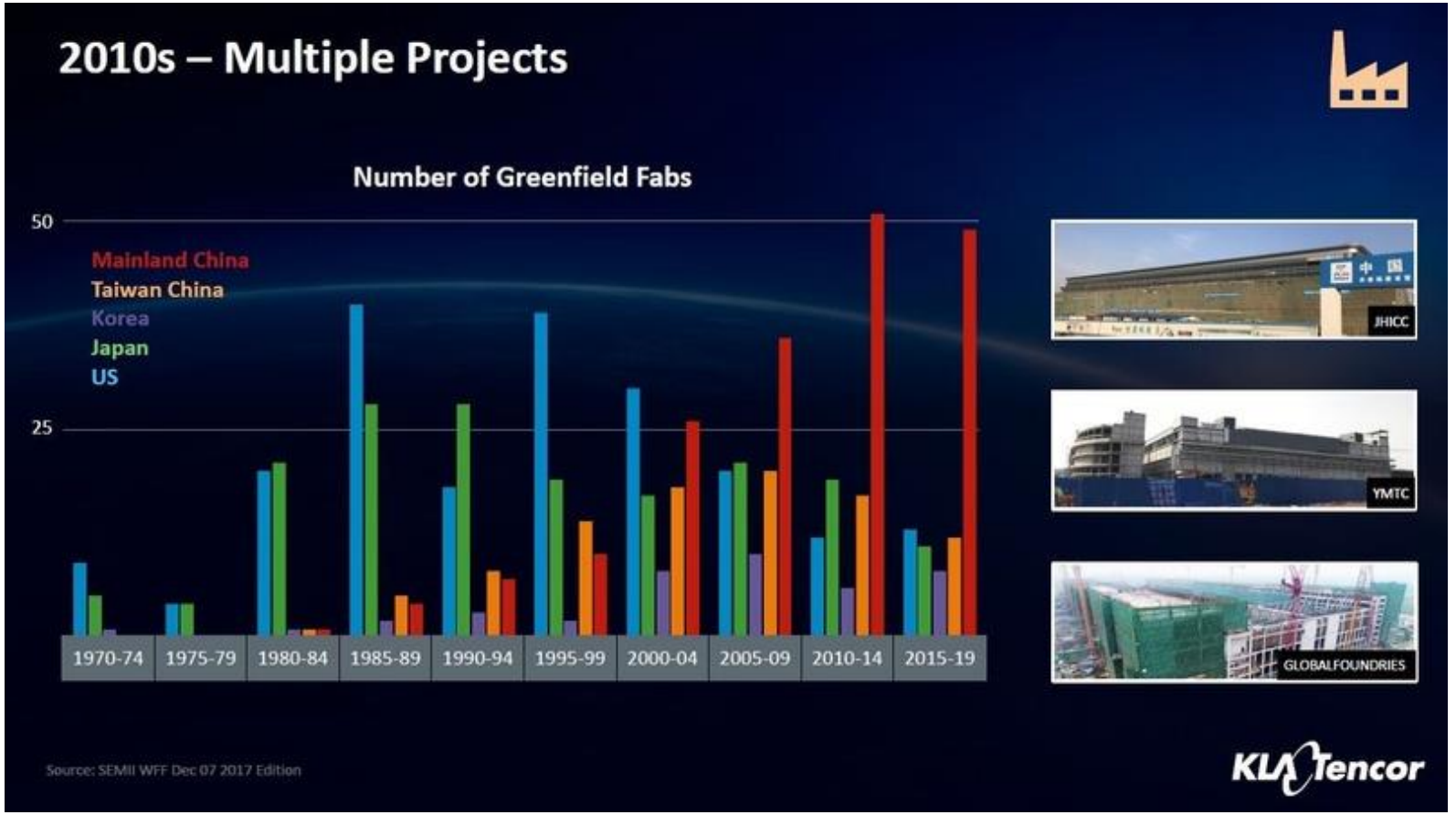


Hegemony in semiconductor industry:

- Global sales: US (25-30%) vs. China (20-25%)
- S. Korea & Taiwan: occupying over 85% of semiconductor foundry
- S. Korea, US, & China: occupying over 90% of memory chip (DRAM, 3D NAND)
- US, Japan, & Netherlands: occupying over 90% of semiconductor fabrication equipment

The China's rise in semiconductor industry

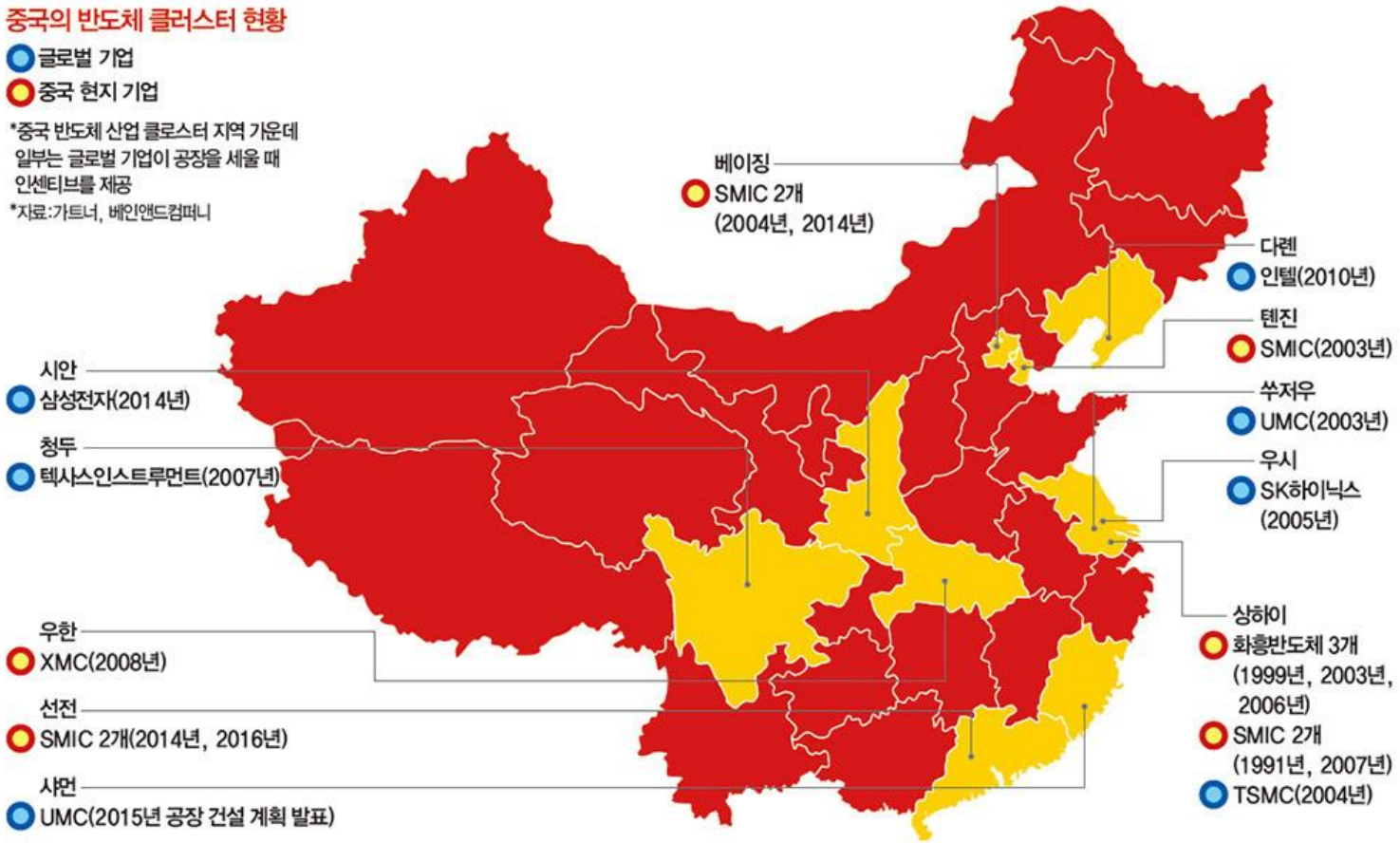


Rapid growth of semiconductor industry in China since 2010s

- Driven by the Chinese government (Federal & State)
- Forming diverse industrial ecosystems over the country

The China’s rise in semiconductor industry

Cluster map of China’s Semiconductor Industry



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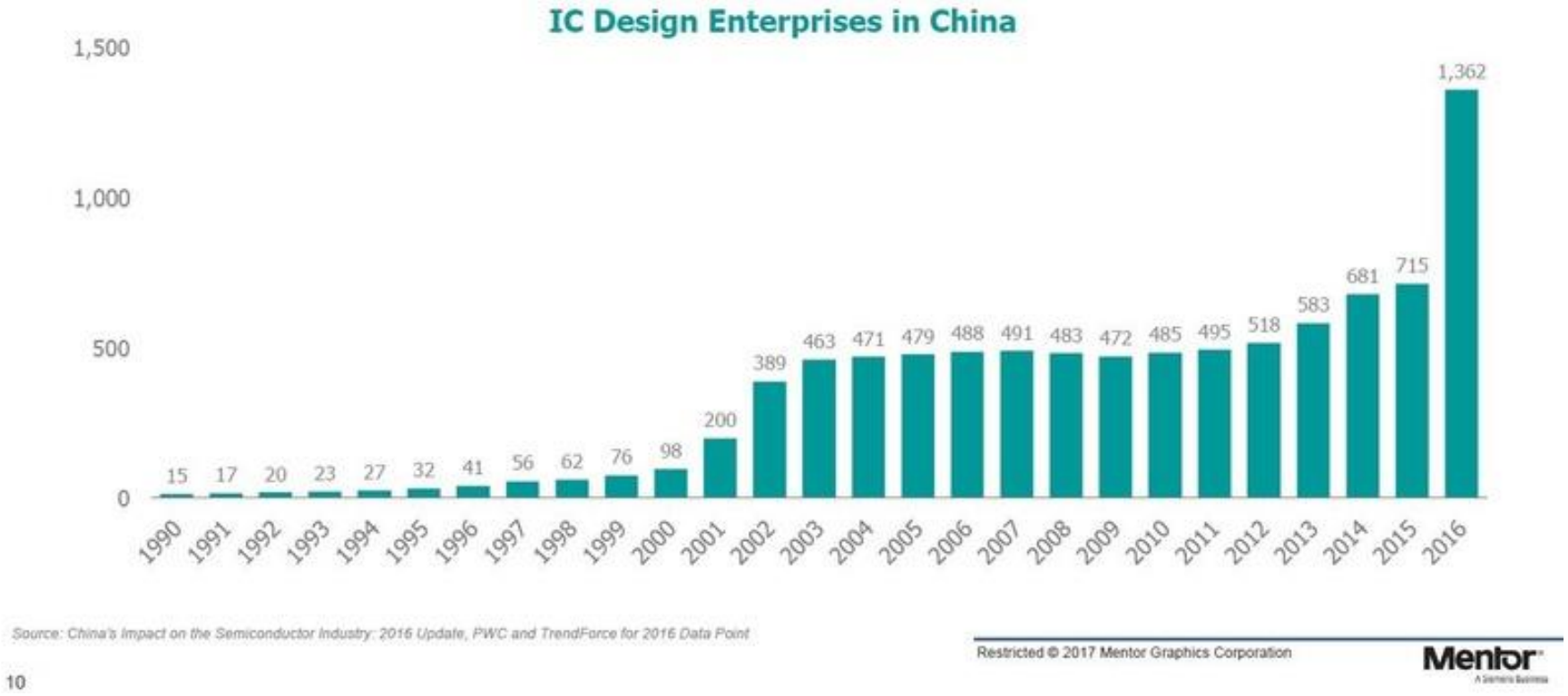


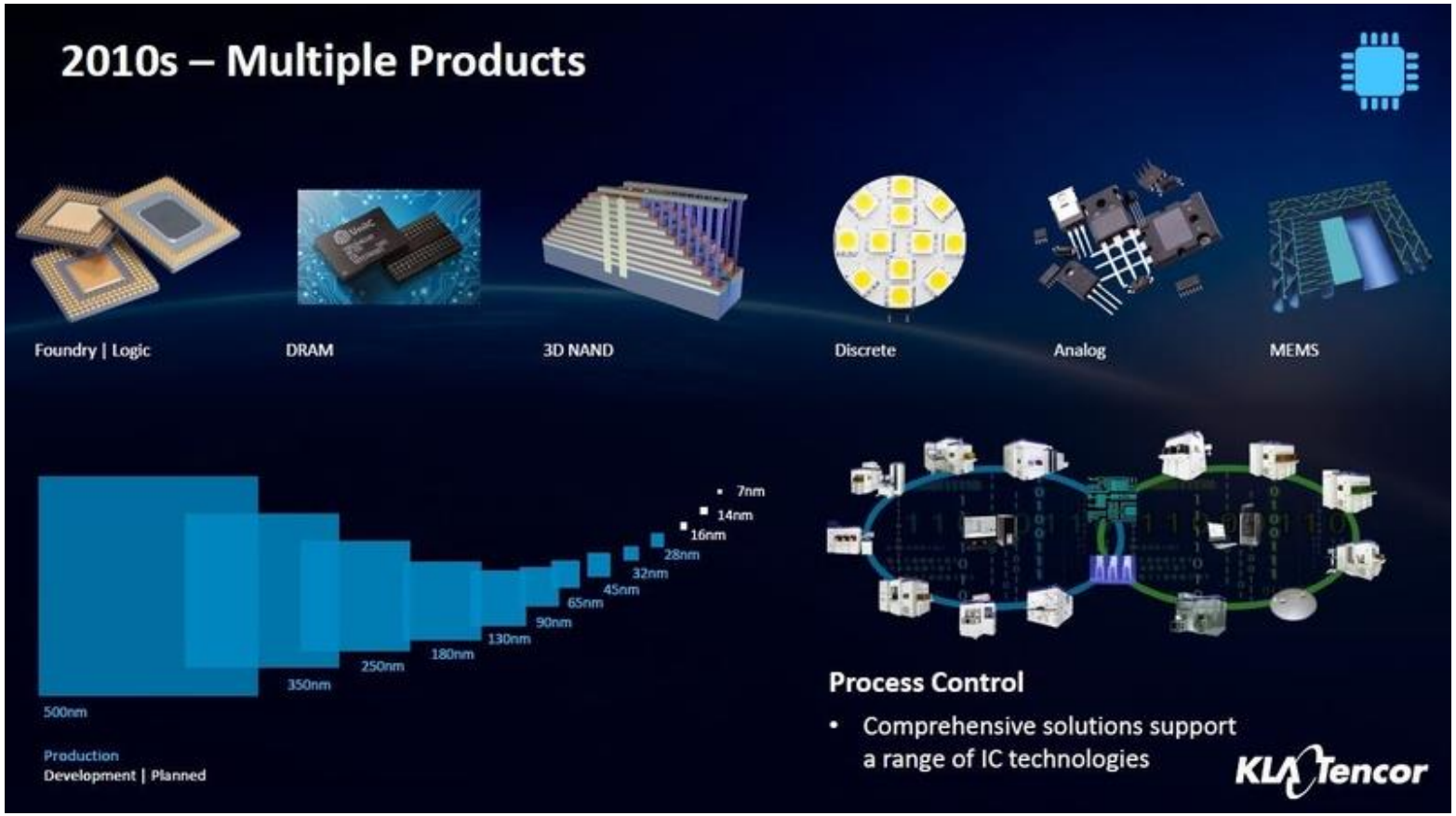
Source: China's Impact on the Semiconductor Industry: 2016 Update, PWC and TrendForce for 2016 Data Point

Mentor

Notable points

- Fast & vast growth of fabless (design companies for semiconductor chips)
- Indicating fundamental growth in the industrial ecosystem
- Indicating demand growth in diverse chips (from memory to electrical system chips)
- Implying AI- or AIX-driven chip demand (GPU, NPU, TPU, etc.)

The China’s rise in semiconductor industry



Notable points

- Hierarchy in the industry: From design to fabrication, from fabless to foundry, from materials to devices, from equipment to technical IPs, from legacy chip to AI

The China's rise in semiconductor industry

China 14th 5-year plan to see IC foundry capacity expand 40%, says Digitimes Research

Driving forces

- China's 5-year plan (12th (2011-2015), 13th (2016-2020), 14th (2021-2025), beyond)
- Accumulated investment for 14th 5 yr plan: ~$20 bn (Government), ~$100 bn (Private)
- Government support: subsidies, tax exemptions, fund raising, long-term investment, expansion of training programs for engineer at universities

The China’s rise in semiconductor industry

What will happen next?

- Keep growing: > 50% of global demand will be from China up to 2025 ($200-300 bn)
- Design sales: $48 bn (2020) → $65 bn (2025)
- OSAT (packaging & test): $ 40 bn (2020) → $60 bn (2025)
- Foundry: $32 bn (2020) → $70 bn (2025)

What will this happen?

- 75% of smartphones, 80% of tablet PCs, 90% of laptops, 50% of digital TVs, 90% of display panels, 60% of communication chips/set-top boxes are produced in China
- Government’s will to increase in the investment
- Nation-wide technology innovation over all sub-areas of the industry

The China's rise in semiconductor industry

What are the pitfalls facing China's growth? *Interior factors*

- Low efficiency (duplicated investment, R&D, University-driven innovation)
- Low stability (when without government subsidies)
- Low ROI (weak competitive power in global market)
- Rapid growth of number of closed companies (increase in bad debts)
- Tech scam & corruption of the Government & companies
- Duplicated investment (risk of bubbles)

The China's rise in semiconductor industry

What are the pitfalls facing China's growth? *Exterior factors*

- Statecraft: Long-term policy of the US on reorganizing/reconstructing GVC of semiconductor
- Sanctions: Expansion of technology gap (i.e., Foundry, GPU, & DRAM)
- Pin-point ban: Deviation from the global standard (i.e., GAAFET, MBCFET, CFET, & beyond)
- Cost rise: Heavy dependences on import (low self-sufficiency (~17%))
  facilities/equipment (~90%), materials (~80%), devices (~75%), & products (~75%)
- Future direction: Diversion in future tech (discrepancy in next generation semiconductors)

Bloomberg

Technology

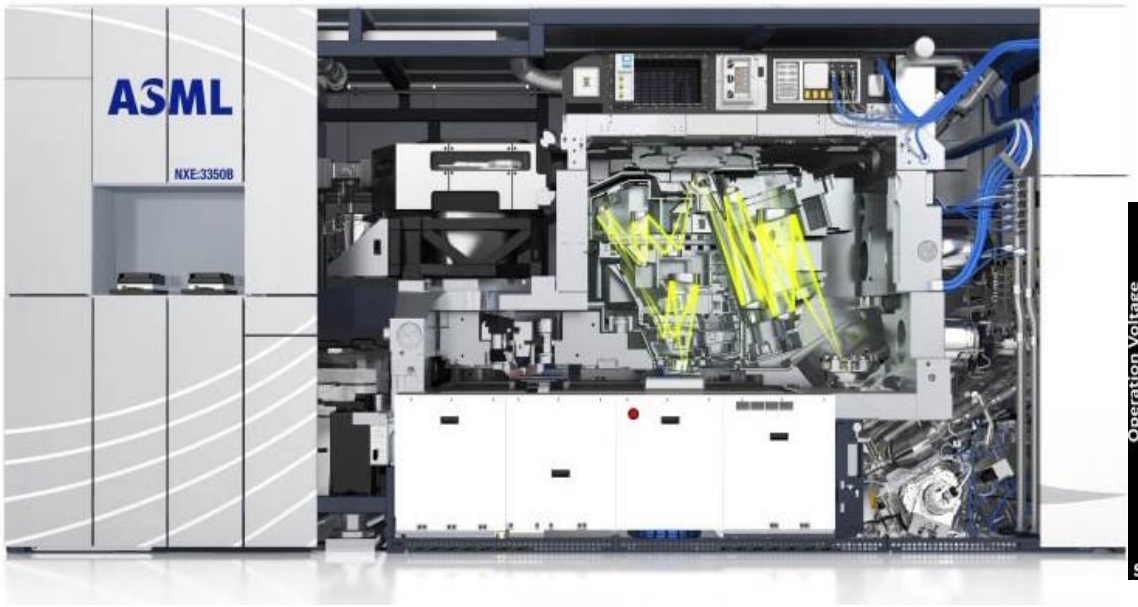
China's Days as World's Factory Are Over, IPhone Maker Says

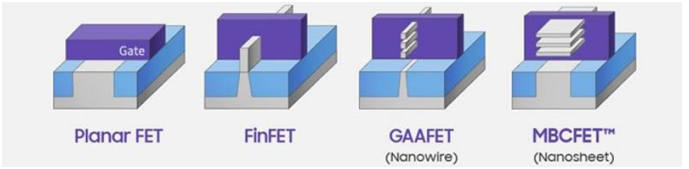
By Debby Wu

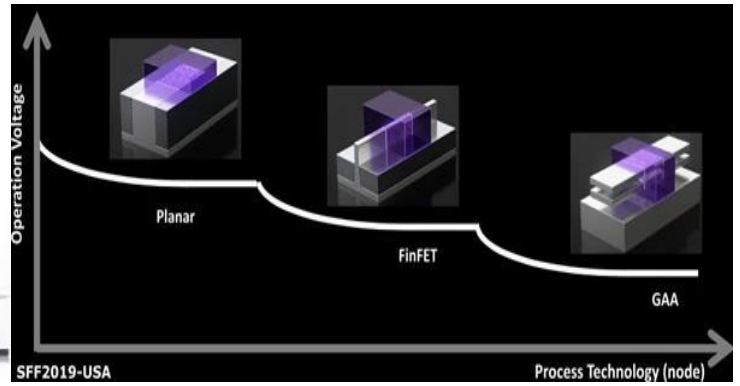
August 12, 2020, 2:04 AM EDT *Updated on August 13, 2020, 12:49 AM EDT*

Banning Hwawei to produce 5G AP chips

The China’s rise in semiconductor industry







Details on techno-economic sanctions of the US on China’s semiconductor industry

- Prohibition of importing EUV lithography (ASML, 2019)
- Prohibition of using technical IPs on next FET Chips (MBCFET & GAAFET, 2020)
- Prohibition of importing DUV lithography & related equipment (ASML, LAM, Applied Mater, etc., 2022)
- Prohibition of using GPU (AMD & NVIDIA, 2022): Targeting China’s AI & AIX (including military purposes)
- Next movement (predicted): Equipment, OSAT, Memory, Design IP, Materials, & beyond

The reorganization of the global value chain in semiconductor industry

AMD's acquisition of Xilinx ($35 bn, 2020)

AMD | XILINX

Intel's acquisition of Altera ($17 bn, 2015)

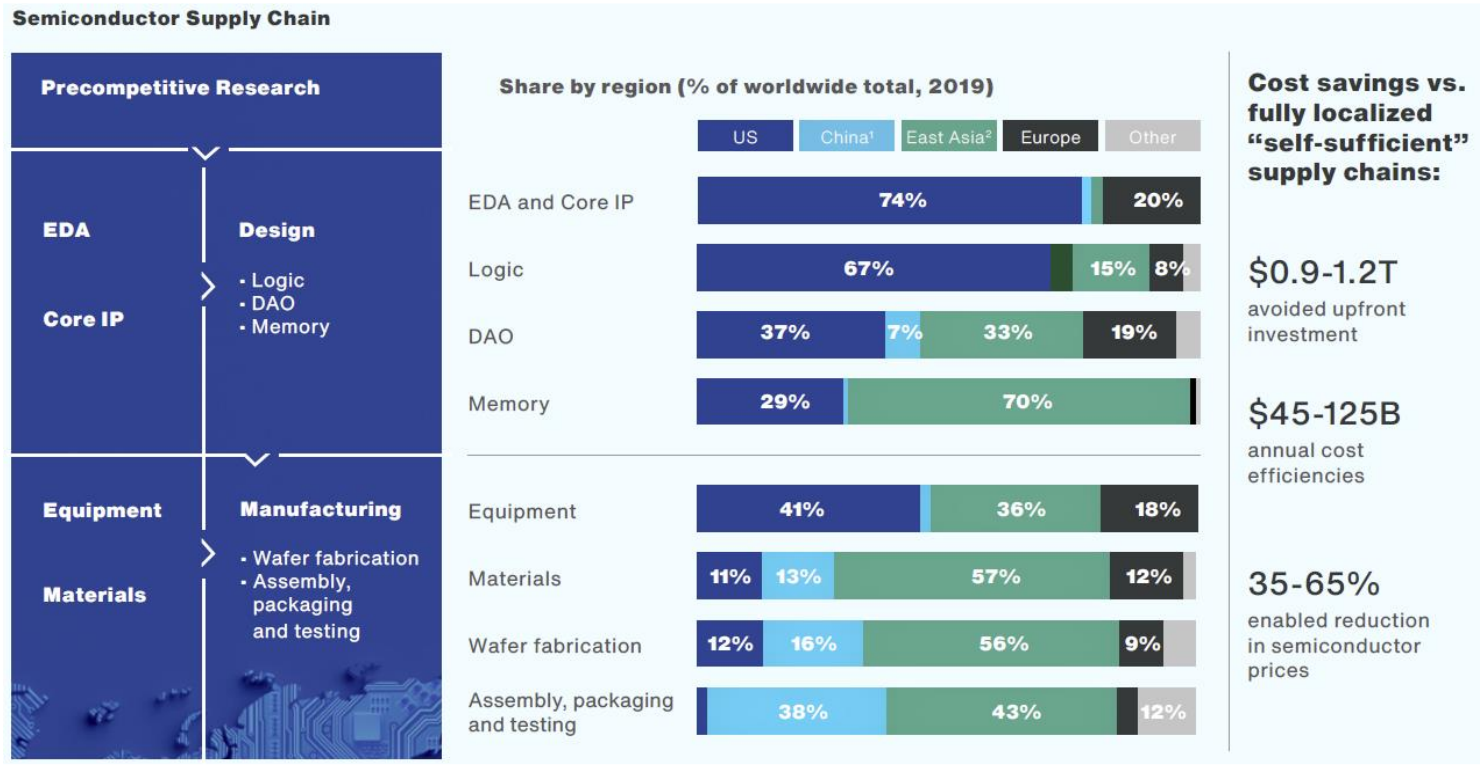
ALTERA
now part of Intel

SK Hynix's acquisition of Intel's NAND ($9 bn, 2020)

Recent trend in the reorganization of global semiconductor industry

- Big M&A: among hardware (HW)-software (SW), SW-applications, SW-SW, HW-AI, etc.
- Changes in the global supply chain: cost spike
- Formation of econo- & techno-political blocks: IPEF, QUAD, AUKUS, & Chip4
- Protectionism: Reshoring (Chip-for-America, IRA) & friend-shoring trend
- Regional uncertainty: Russia-Ukraine war
- Global crisis: Climate crisis (RE100, requirement for the carbon neutrality)

The reorganization of the global value chain in semiconductor industry

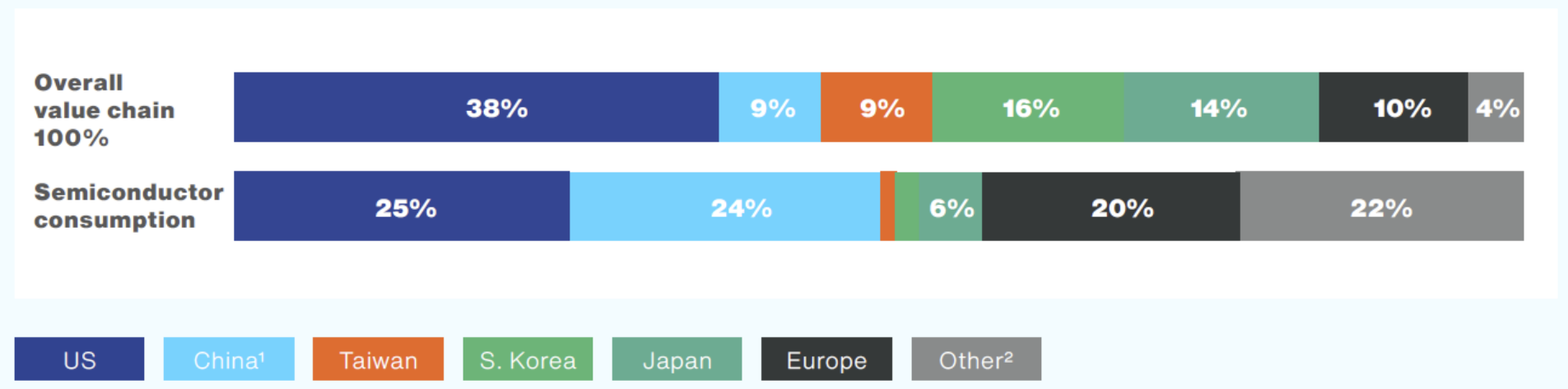


Source: SIA report (2020)

Global value chain in semiconductor industry:

- Foundry: S. Korea (Samsung electronics) & Taiwan (TSMC)
- Design IP (EDA): US (Cadence, Synopsis)
- Fab equipment: US (LAM, Applied Mater.), Japan (TOK), & Netherlands (ASML)
- Memory: S. Korea (Samsung, Hynix), US (Micron), Japan (Kioxia), & China (YMTC)
- Materials: US (LAM, Applied Mater), Japan (Sinetsu, TOK), Korea (Dongjin)
- Device: US, Japan

The reorganization of the global value chain in semiconductor industry



Source: SIA report (2020)

Key players in the global value chain in semiconductor industry:

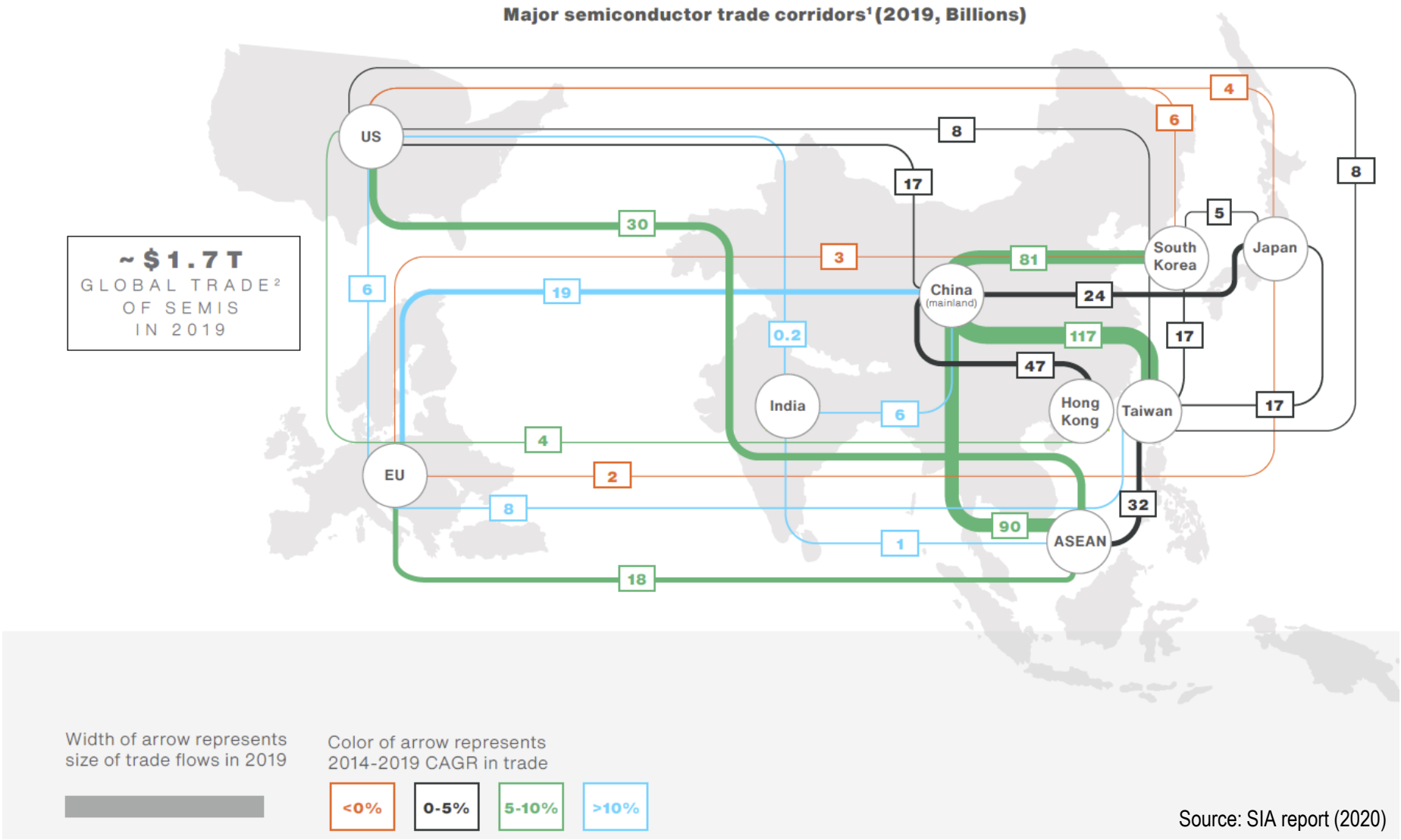
1. Overall value share: US, S. Korea, Japan, EU, China, Southeast Asia, Taiwan
2. Overall market size: US, China, Southeast Asia, EU, Japan, S. Korea, Taiwan

East Asia countries (China, Taiwan, S. Korea, & Japan)

shares over 48% value & 34% market.

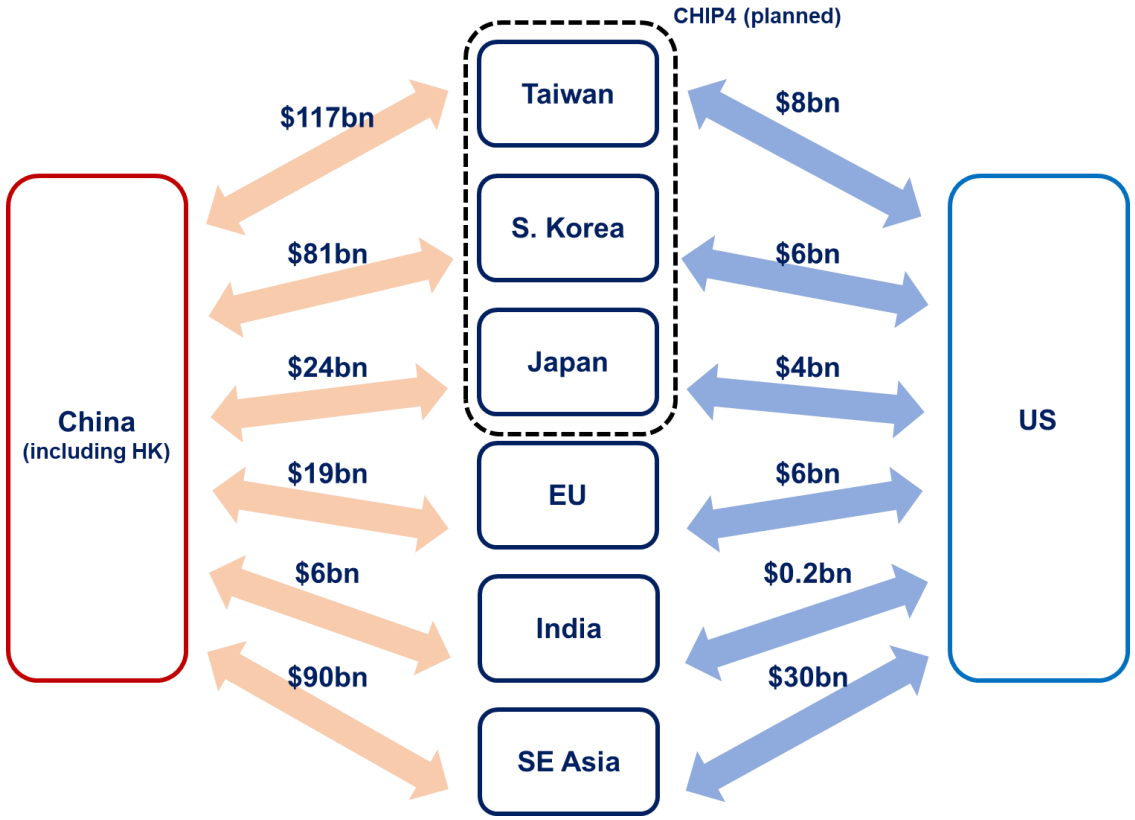
Intensification of inter-dependences among the key players in last 2 decades

The reorganization of the global value chain in semiconductor industry



Source: SIA report (2020)

The reorganization of the global value chain in semiconductor industry



Heavy dependences of Taiwan, S. Korea, & Japan on semiconductor value chain with China & US

→ Large increase in cost for all players if there is reorganization driven by block formation

→ S. Korea & Taiwan will suffer the most severe damage by the reorganization

Impact of US-led restructuring of global value chain

Heavy dependences of key players on semiconductor value chain with China & US

→ Large increase in cost for all players if there is severe reorganization (block formation)

Ex) World-wide semiconductor trade (as of 2020): $1.7 Tn → $1.4 Tn

Additional cost rise:

- $170 bn to $250 bn yearly (for China),
- $50 bn to $150 bn yearly (for US),
- $25 bn to $80 bn yearly (for S. Korea),
- $5 bn to $20 bn (for Taiwan)

Impacts & Sequences:

Reorganization of GVC of semiconductors

→ Spike in overall cost → Increase in prices of chips

→ IT-driven innovation (AI, data-driven, deep-tech, etc.) is slowed down

→ Recession: slowed down economic growth for industries depending on semiconductor

Long-term aftermath of the reorganization of the global value chain

Scenario #1

- China will pursue its independence in semiconductor technology
  by developing its own industrial ecosystem or supply chain
- Global semiconductor market is divided into two or more blocks (coexistence of two ore more GVCs?)
- Next generation semiconductor roadmap will diverge (coexistence of two or more standars?)
- China falls in future semiconductor tech (including quantum ICT)

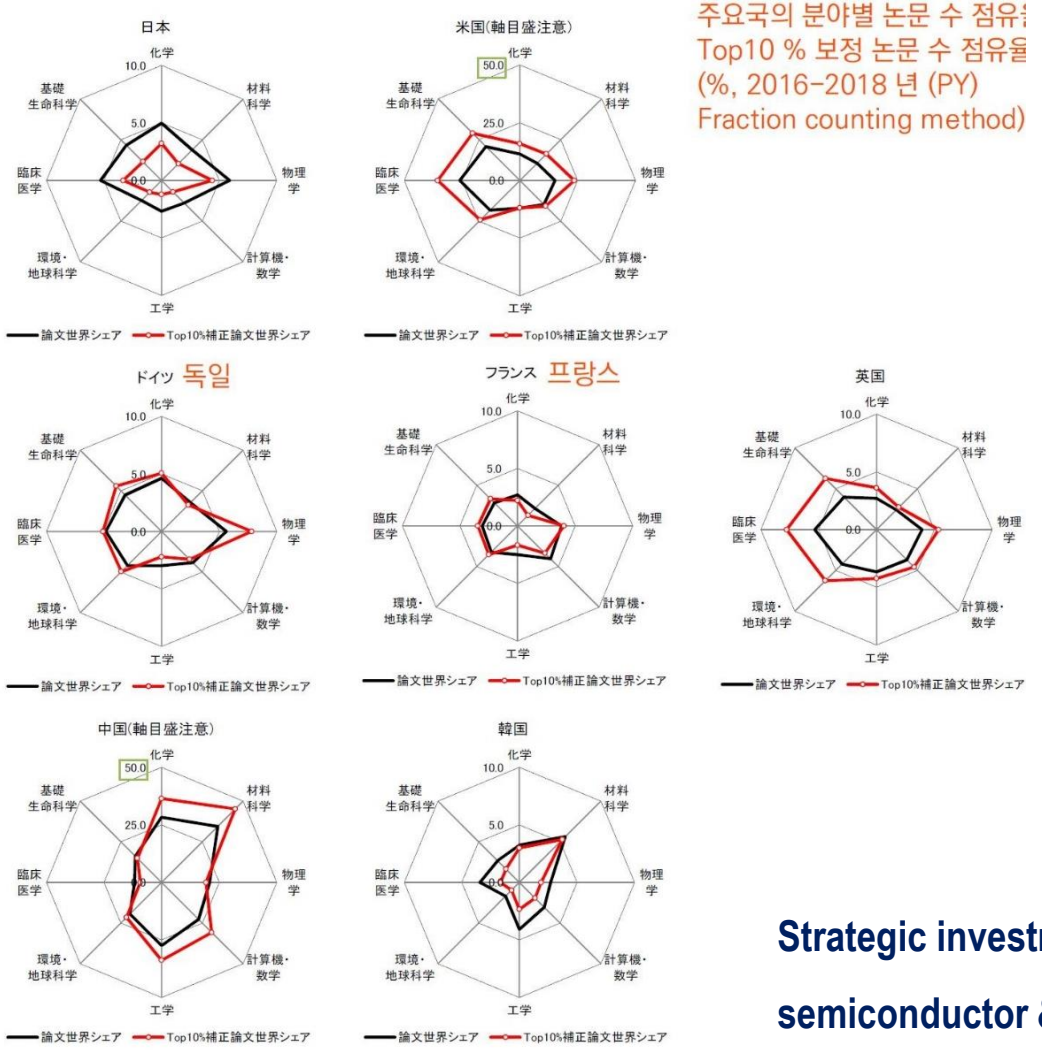
Scenario #2

- US-China will reconcile to recover the global value chain (i.e., US-China semiconductor agreement?)
- Overall cost surge in global semiconductor market can be cooled down.

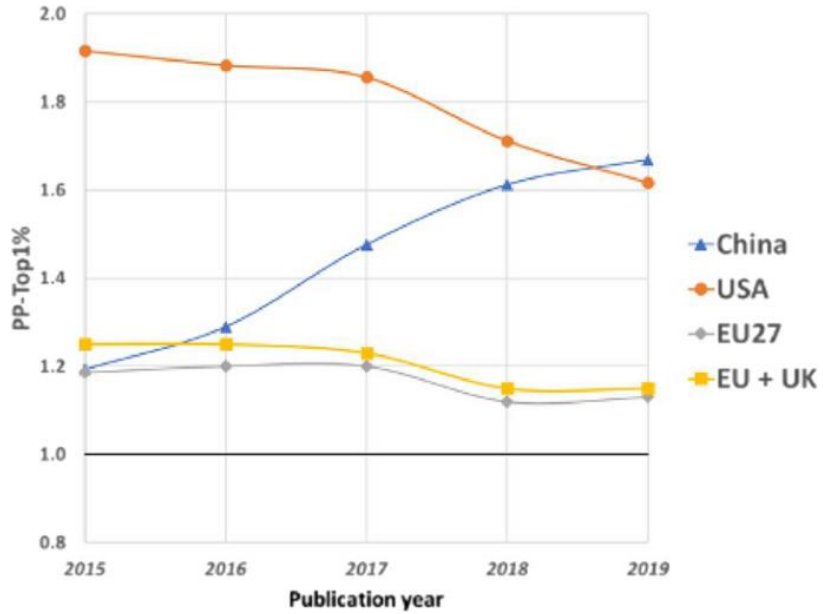
Scenario #3

- Fall of China in semiconductor industry
  (as well as other advanced or deep techs (AI or AIX, Li-battery, self-driving cars, etc.))
- China would get back to US-leading semiconductor GVC as a consumer market rather than a key supplier.

Strategy of Korea in the era of US-China's techno-economic competition



주요국의 분야별 논문 수 점유율
Top10 % 보정 논문 수 점유율
(%, 2016-2018 년 (PY)
Fraction counting method)



Strategic investment in R&D for

semiconductor & related areas focusing on basic science

(i.e., 20-30 yrs difference btn applications & basic science finding)

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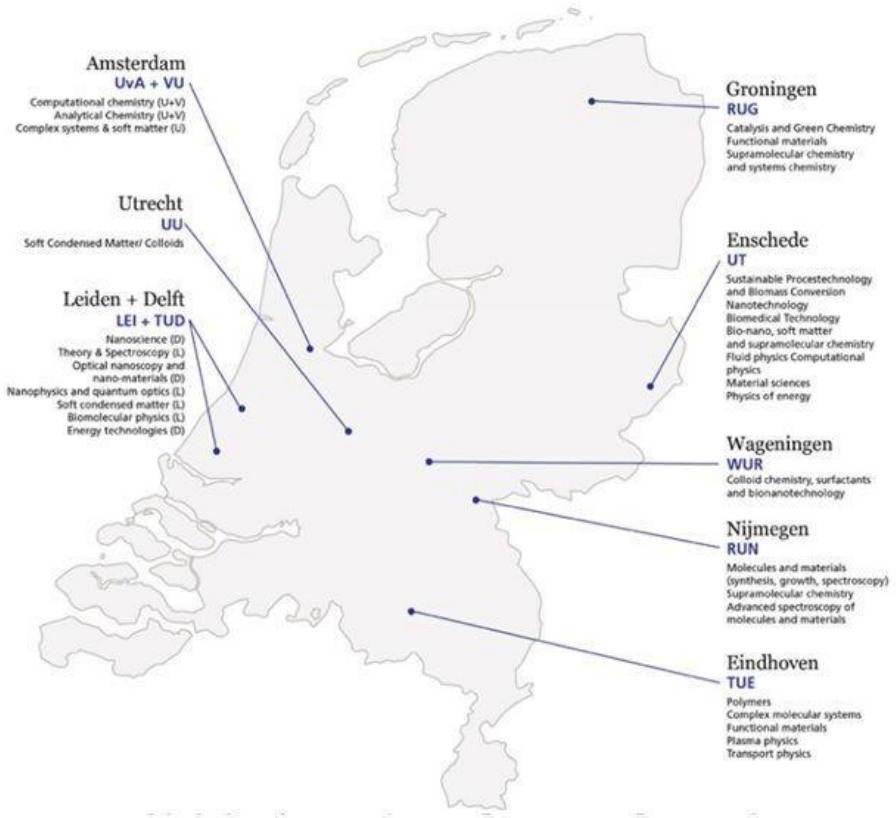
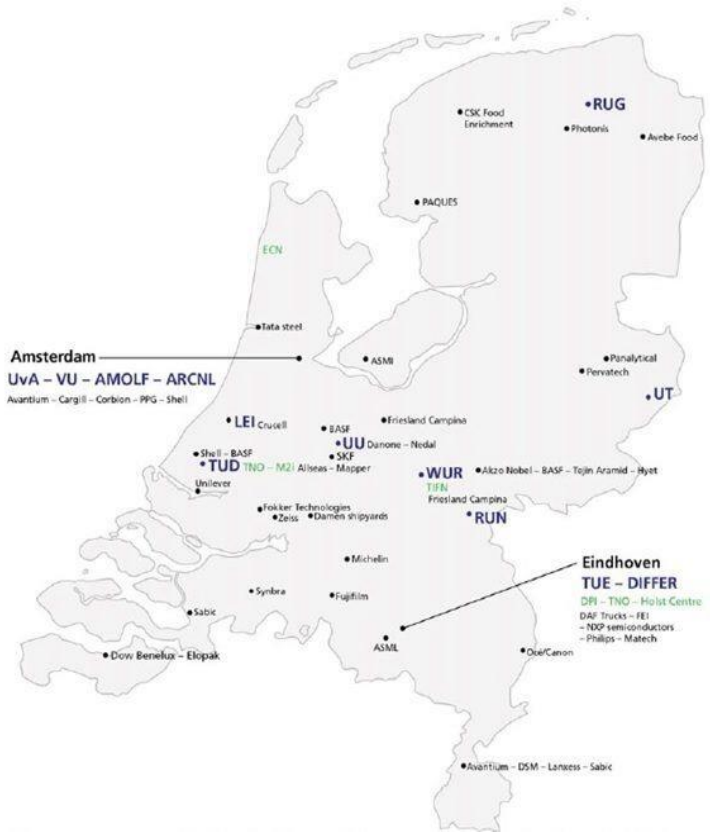




Lesson from Netherlands:

- Formation of strong University-Industry collaboration clusters over the country for deep tech
- Formation of diverse ecosystem for semiconductor industry
  (from materials to equipment, design to future chips)
- Long-term Government's & EU's investment in R&D (i.e., ASML's EUV project)

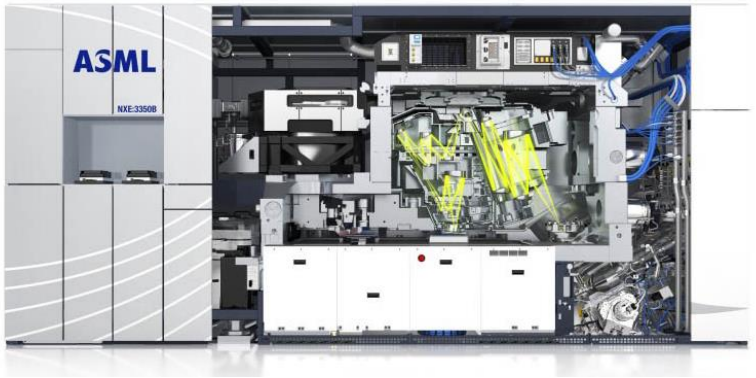
Strategy of Korea in the era of US-China's techno-economic competition

SAMSUNG 삼성전자

ASML

tsmc

suppliers (cameras, software, lenses, etc.)	producers defect inspection and review	producers thin film metrology	producers lithography metrology (CD, Overlay)	producers litho-graphy metrology (CD, Overlay)	research institutes / networks
Adimec	ASML	ASML	ASML	ASML	TU Delft
Frencken	MELLES GRIOT	MELLES GRIOT	MELLES GRIOT	ASM	TNO
Lambert Instruments	AVANTES	AVANTES	NEDINSCO VENLO	Besi	Dutch Optics Centre
luxexcel	MASER	MASER		LITEQ	TU/e
molenaar optics	FEI	PANalytical		MAPPER	UNIVERSITEIT TWENTE.
PhoeniX Software	NanoPhysics	Imato			
TELEDYNE DALSA	NEARFIELD INSTRUMENTS	Ocean Optics			
VDL					
ascentec					
anteryon					



Lesson from Netherlands:

- Formation of ecosystem:

  Not necessarily only for Netherland's companies

- Boundary can be extended to Foreign companies

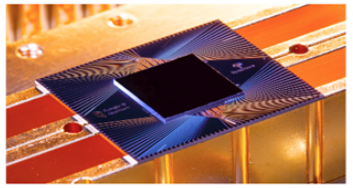
- Technology transfer from Univ to Companies

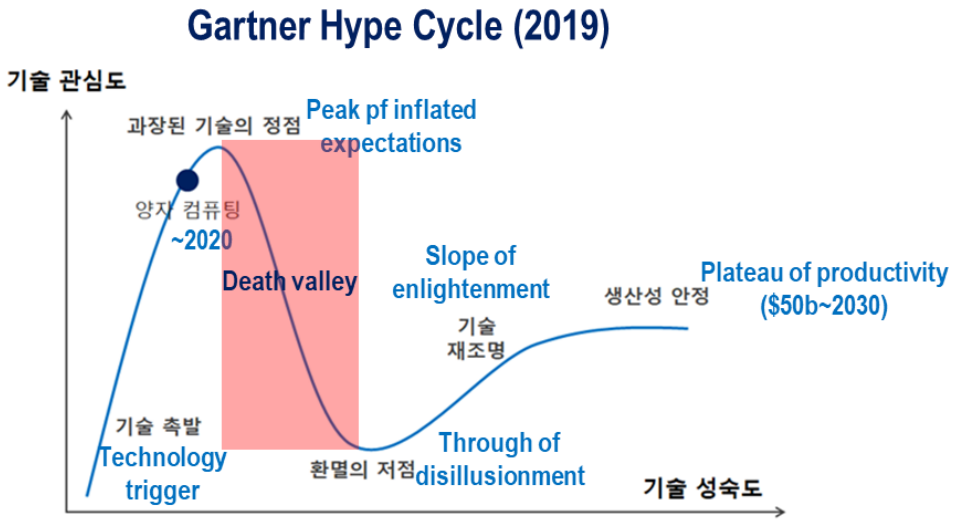
  (adjunct professors, sharing facilities, collaborating network)

Strategy of Korea in the era of US-China's techno-economic competition

IBM Q-system one (2019)

Google Sycamore (2019)





Expanding ecosystem

Enhancing the contemporary tech gaps (memory, foundry, and fabless)

- Revise tech IP strategy (toward pinpoint IP)
- Smart design of materials to chips
- Strategic R&D

Joining the next generation technology standard groups

- Councils for next generation technology standards
- Closed group for quantum computers & ICTs
- Closed platforms operated by NIST & other US national labs
- Collaboration with leading-edge companies (i.e., Google, IBM, Intel, QUALCOMM, etc.)

Conclusion

1. China's growth in semiconductor industry can take over US sooner or later.

2. China's policy & investment in semiconductor industry covers all areas.

3. Reorganization of the global value chain in semiconductor industry can harm all players including S. Korea & Taiwan as well as US & China.

4. Cost rise will slow down techno-economic innovation resulting in economic recession.

5. US's sanction on China will be extended to wider range & longer term.

6. Korea's strategy should be based on open ecosystem, intensive investment in R&D, & joining next technology leading groups.