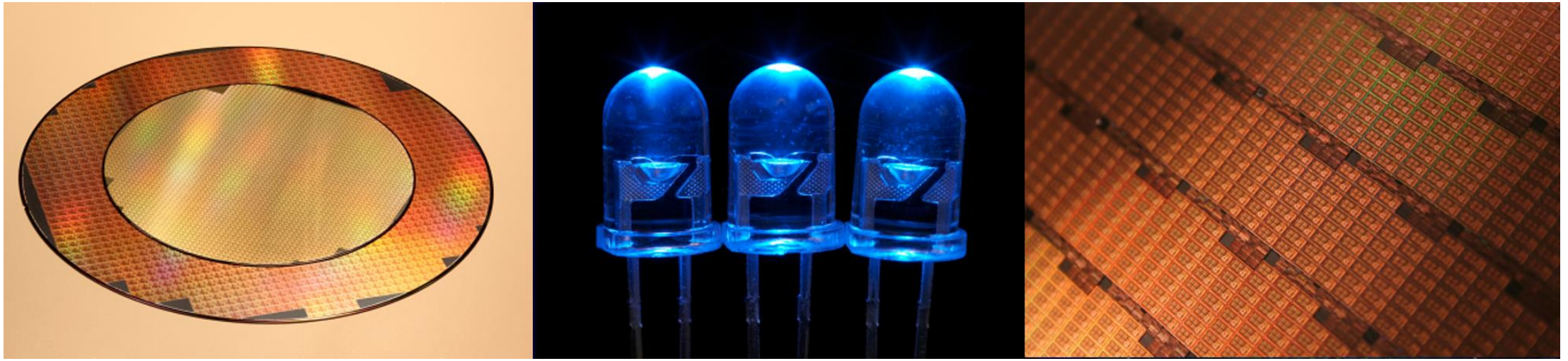

Market Trend of Global Semiconductor Wafer Market and Implications for China Semiconductor Wafer Industry Development

全球半导体硅片市场趨勢介紹與對中国半导体硅片产业發展的影响分析

2020 中国半导体大硅片论坛

Nov 5, 2020

FLAGSHIP INTERNATIONAL 旗舰国际

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Outline纲要

- Introduction 公司简介
- Semiconductor Industry Evolution and Semiconductor Materials Industry Development Trends 半导体产业演进与半导体材料产业发展趋势
- Market Trend of Global Semiconductor Wafer Market 全球半导体硅片市场趨勢介紹
- Implications for China Semiconductor Wafer Industry Development 對中国半导体硅片产业發展的影响分析
- Summary总结

Introduction 公司简介

Overview 概要

1. ***旗舰国际是Linx Consulting亚太区的合资伙伴公司***

2. ***We help our clients to succeed by creating knowledge and developing unique insights at the intersection of electronic thin film processes and the chemicals industry on a global basis***

3. ***The knowledge is based on a core understanding of the semiconductor device technology; manufacturing processes and roadmaps; and the global structural industry dynamics***

4. ***This knowledge is leveraged to create advanced models, simulations and real-world forecasts***

5. ***Our perspectives are by direct research and leveraging our extensive experience throughout the global industry value chain, including:***
   - Experience in global electronics and advanced materials and thin film processing industries
   - Experience in the global chemicals industry
   - Experience at Device Producers
   - Experience at OEMs

Linx Consulting Service Portfolio
产品与服务

- **Full Service**
  - Forecast Service
  - Technology Trends

- **Multi-Client Reports**
  - IC Materials
    - CMP
    - Deposition
    - Patterning
    - Cleaning
    - Gases
    - Bulk Chemicals
    - Packaging

- **Proprietary Projects**
  - Market Planning
  - M & A
  - Growth and Diversification
  - Supply Chain Optimization
  - Technology Commercialization
  - Strategic Planning
  - Voice of the Customer
  - Market Diligence

- **Econometric Semiconductor Forecast**
  - Financial planning
  - Sales and Operational planning
  - Forecasting

  With Hilltop Economics LLC

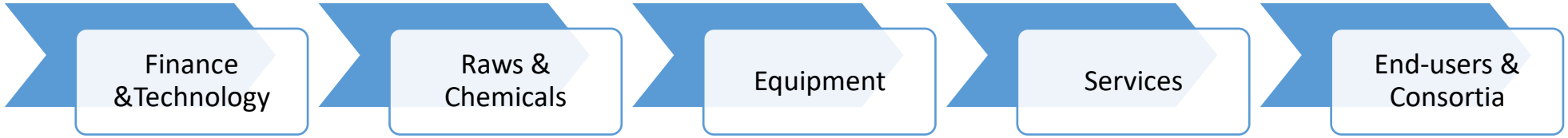
- **Cost Modeling**
  - Client demand modeling
  - Product development
  - Bill of Materials quantification

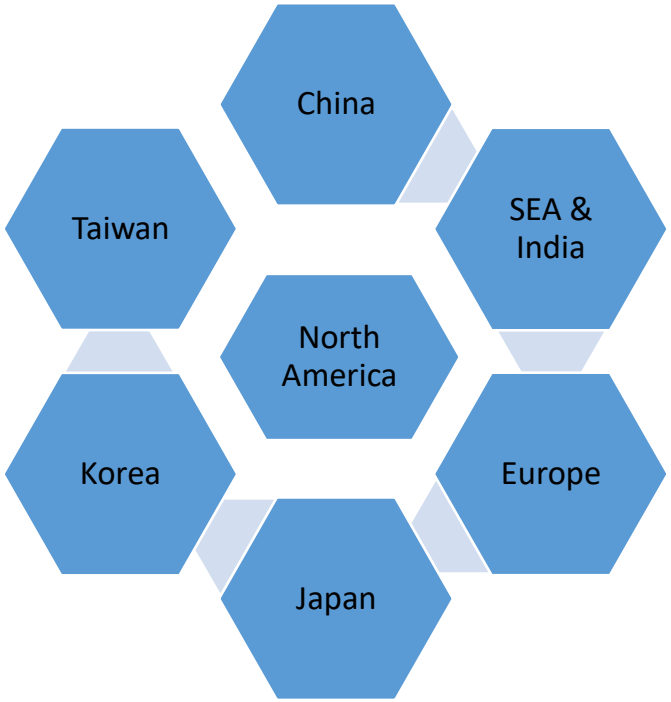
  With IC Knowledge, LLC

- **Conferences**
  - The Business of Cleans & SPCC
  - Electronic Gases

- **Silicon Wafer Analysis**
  - Wafer demand segmentation
  - Forecast modeling

Customer Base in Semiconductors
半导体客户群





Linx International Conferences 国际会议

- SPCC 2020 Virtual Conference : 半导体清洗与污染控制 (Aug 31, 2020 – Sep 2, 2020)
- ESG 2020 Virtual Conference: 电子特殊气体與氣相沉積材料 (Oct 13, 2020 – Oct 15, 2020)

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Semiconductor Industry Evolution and Semiconductor Materials Industry Development Trends

半导体产业演进与半导体材料产业发展趋势

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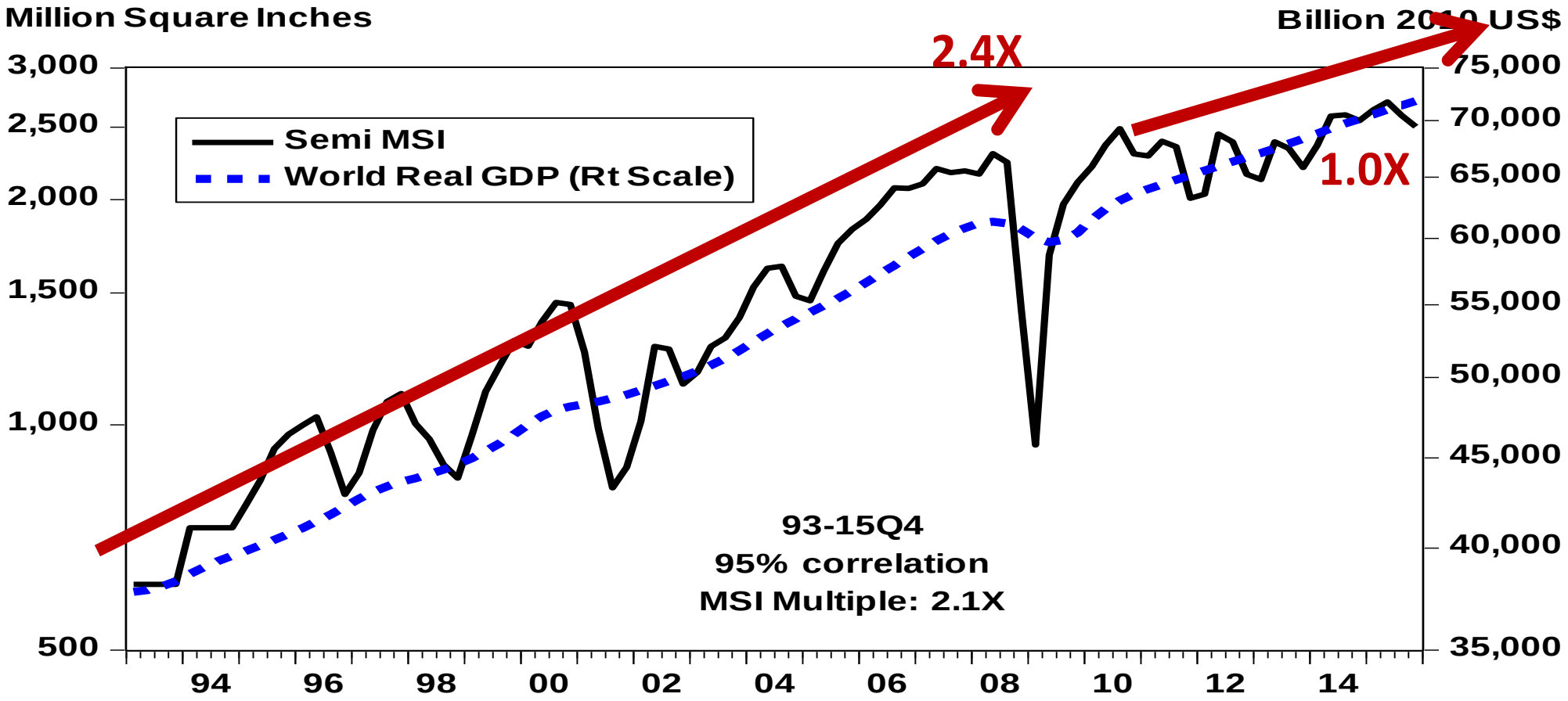
Silicon Capacity Follows GDP Closely
半导体与GDP成长关联性历史分析

Does semiconductor industry become more mature and less cyclic?



Source: Hilltop Economics

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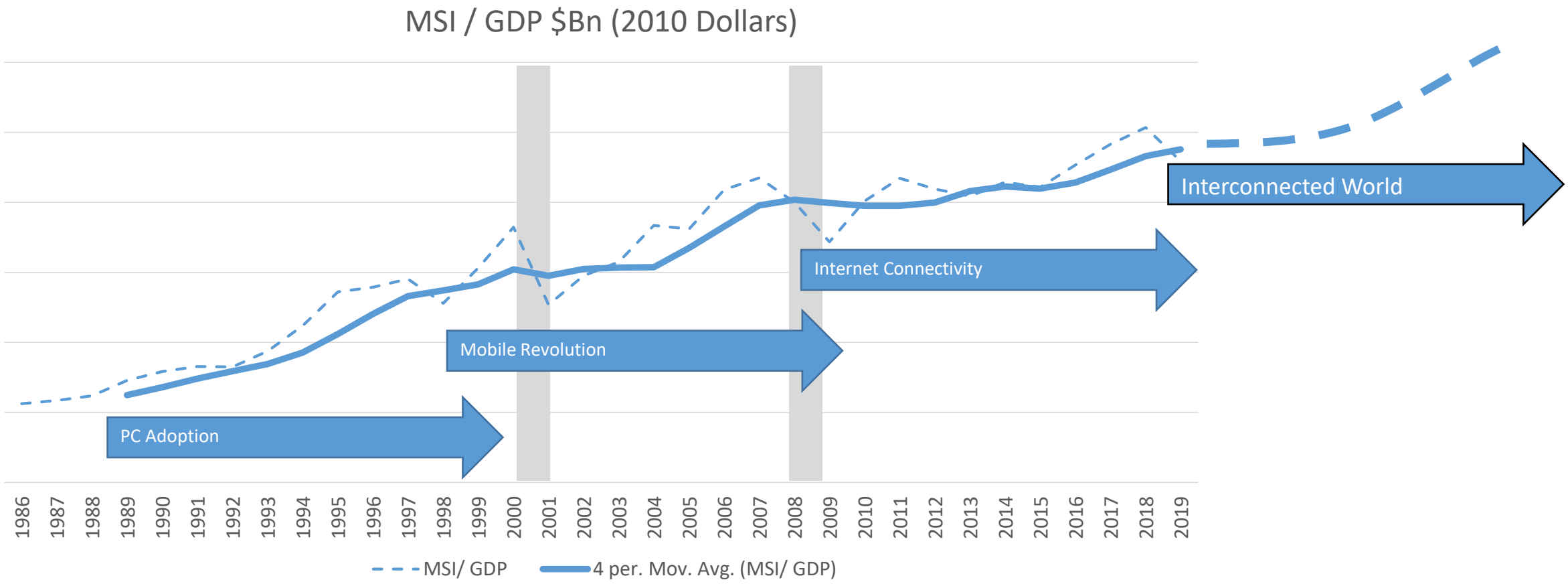
Semiconductor Super-cycles 半导体超级循环



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Enabler of Electronic System Growth Drivers
由5G带动的新一轮半导体超级循环

Internet of Things

Much hyped driver of billions of networked devices generating information for governmental, commercial, consumer, medical, and other information systems.

Virtual Reality / Augmented Reality

Creation of virtual displays of real and simulated environments for military, consumer, commercial and other applications, usually through a novel head display.

5G

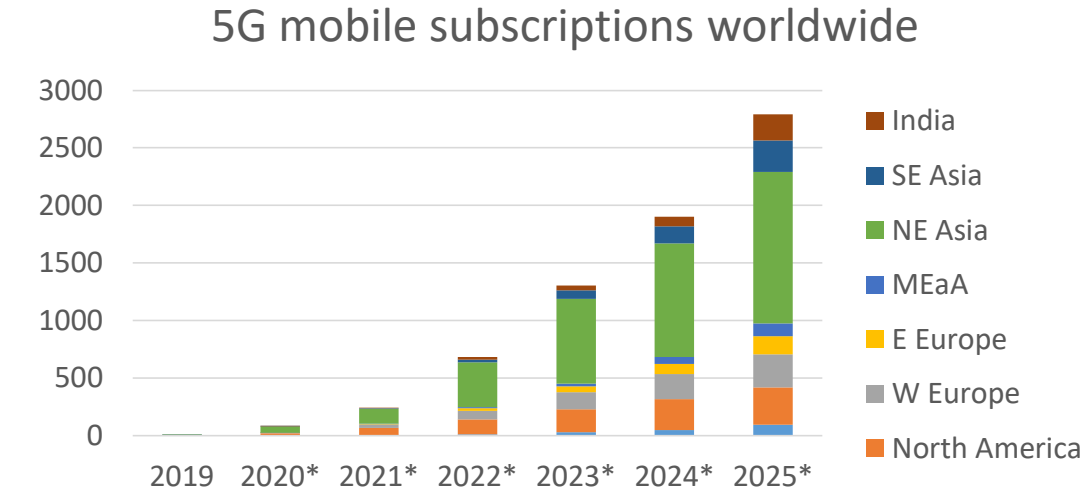
Artificial Intelligence

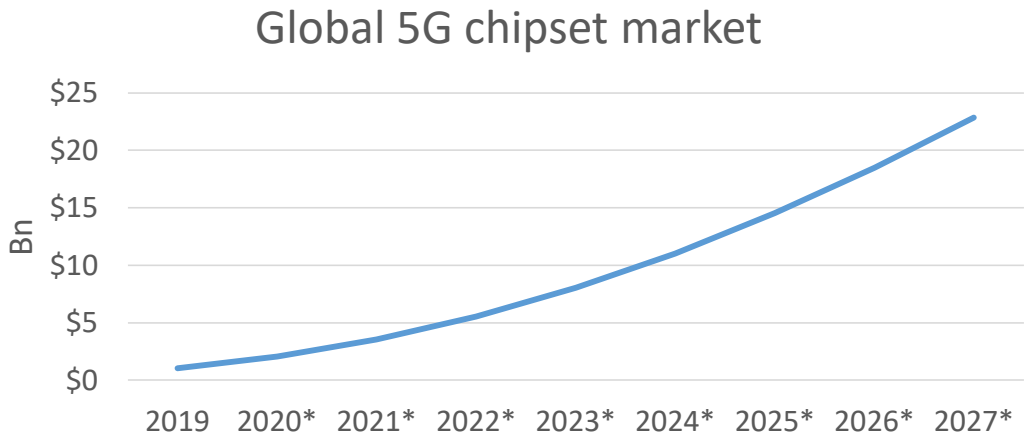
Computer based intelligent learning systems. Edge of cloud computation.

Autonomous Vehicles / ADAS

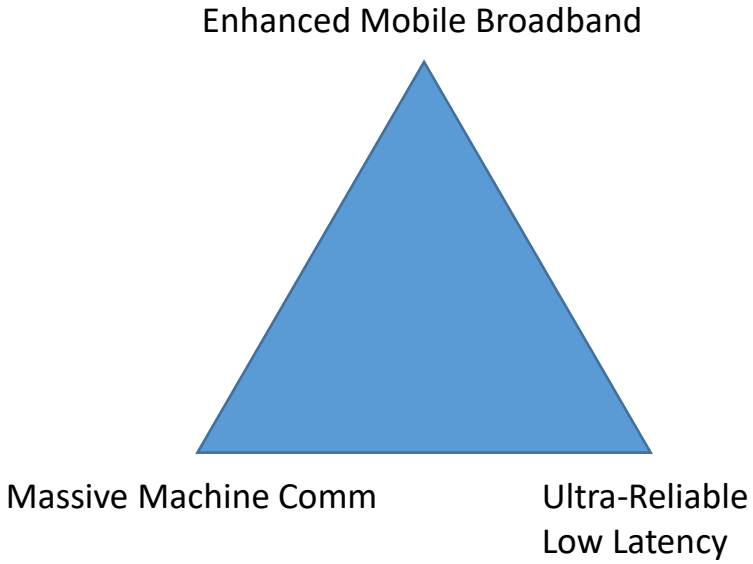
Sensor systems supporting vehicle based computer systems offering various degrees of driver assistance including fully autonomous driverless vehicles.

5G Started to Enable IoT From 2019
2019年起由5G趨動的IoT成長





	Peak Rate	Density	Mobility	Latency
5G	20 Gbps	1E6 / km^2	500 kmh	1 ms
4G	1 Gbps	1E4 / km^2	300 kmh	10 ms



Source: Alibaba

Source: Statista

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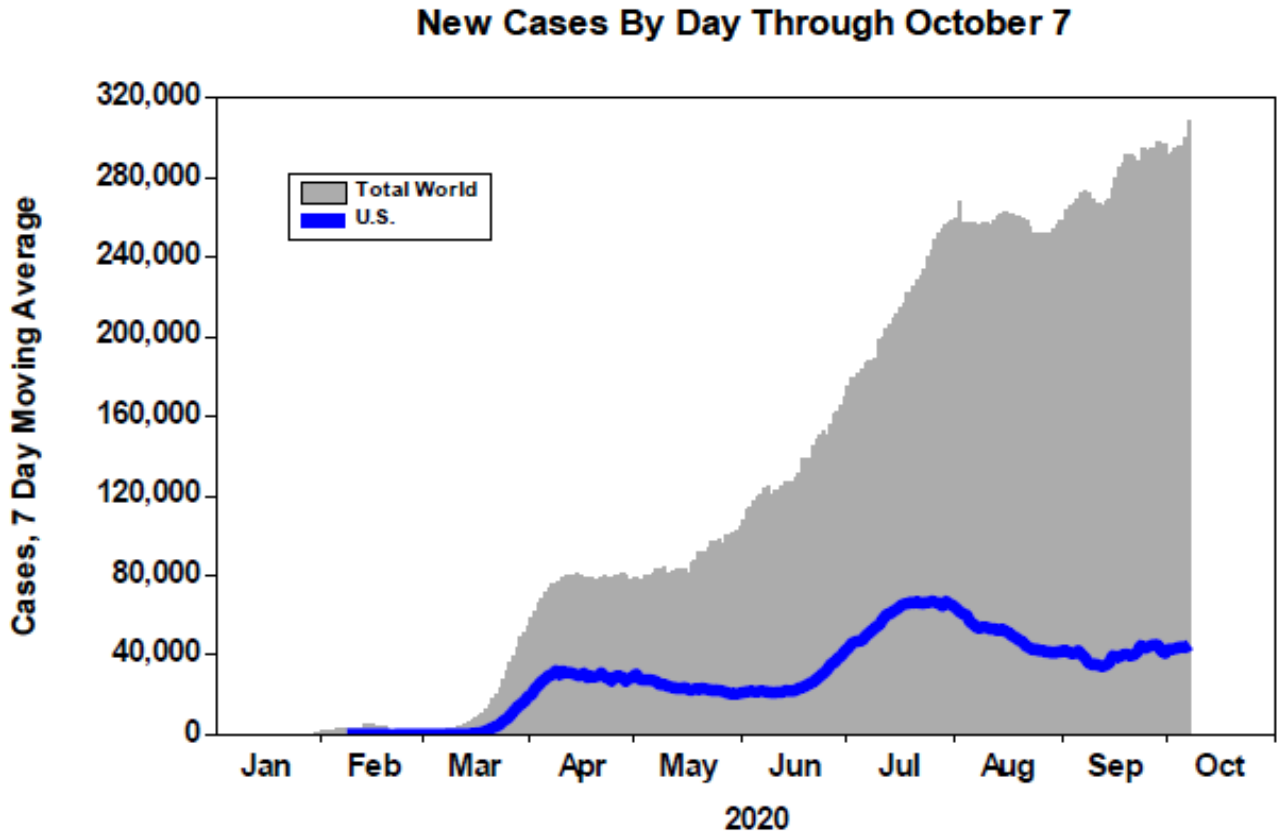
Covid-19 Is Changing The World in 2020
2020年新冠肺炎改變了世界

The Covid-19 Pandemic Produces a Severe Shock

More than 36 million cases, still rising ~1%/day



Sources: Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) 10/7/2020; WHO Covid-19 Dashboard

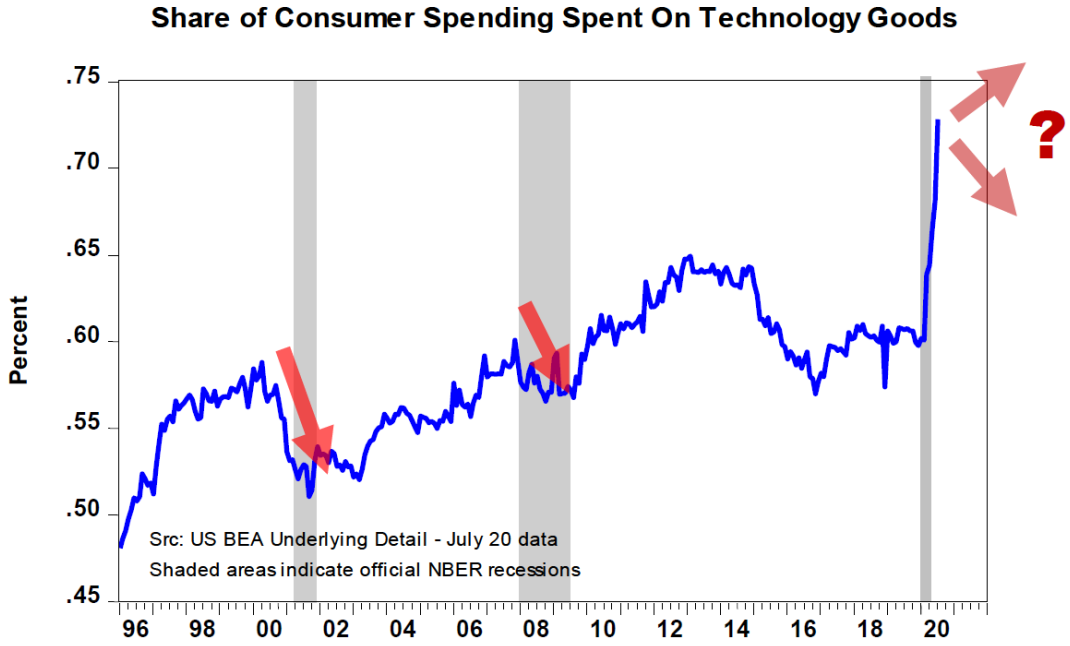
Not a Typical Downturn
2020非典型經濟衰退

Normal Behavior in Recessions:

- Consumers cut spending on discretionary items including technology goods
- Businesses delay investment in new PCs, equipment, etc. to conserve cash and wait for capacity utilization to recover

Pandemic Recession Behavior:

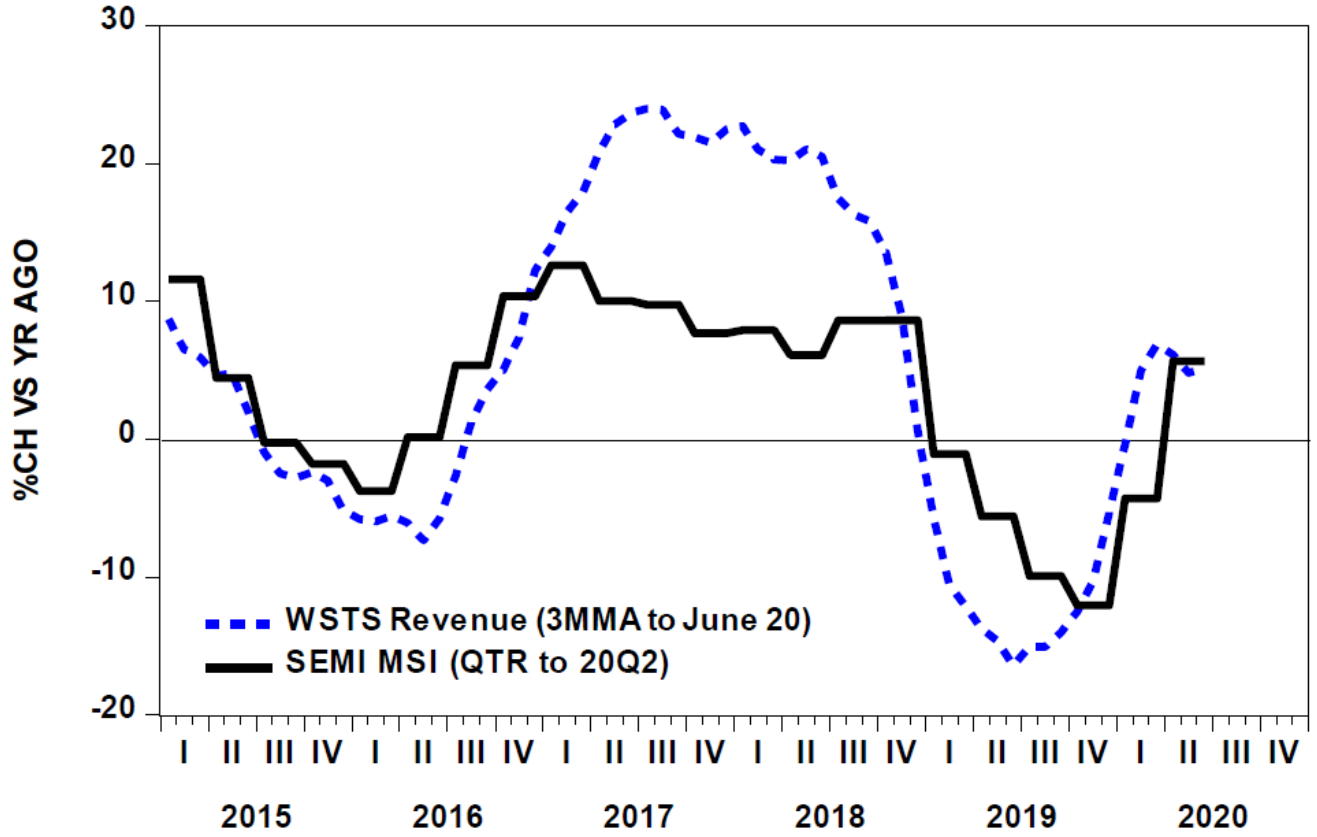
- Lock-downs, work-from-home, remote education all contribute to a spike in spending
- Real GDP severe declines come from declines in services (travel & entertainment, discretionary activities



Source: Hilltop Economics

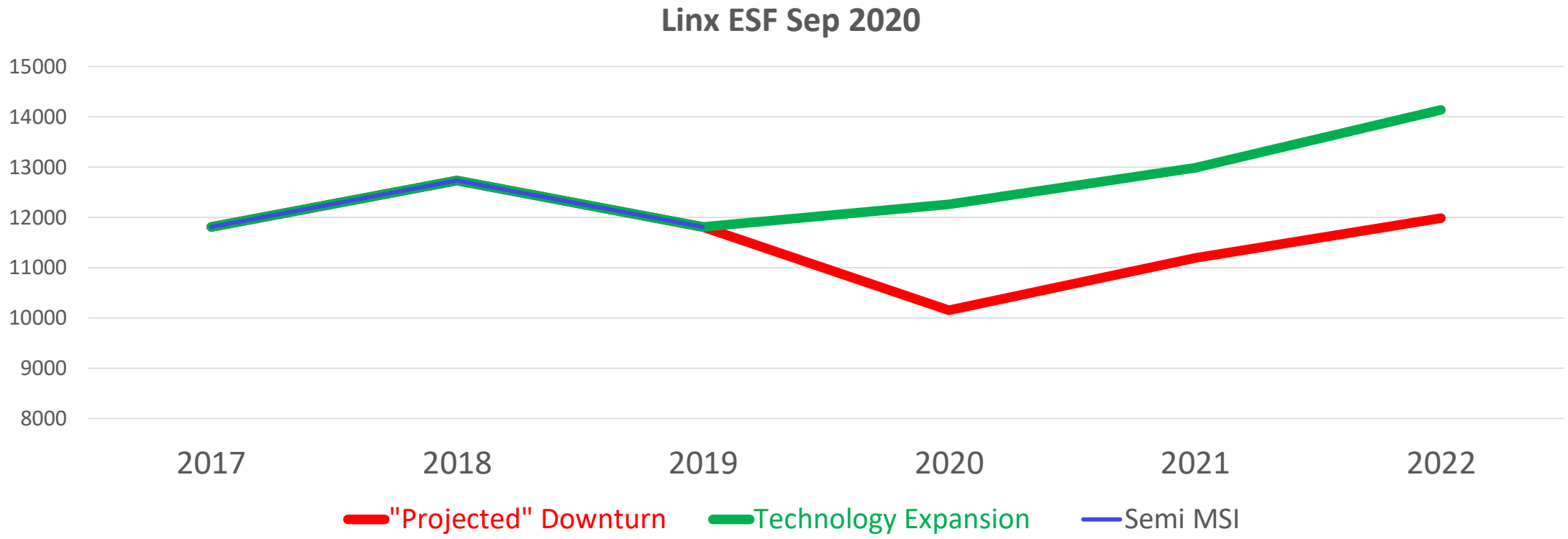
Semi Industry Grows in 2020
2020年半導體產業持續成長

Semiconductors (MSI and Revenue) Returned to Growth in 2020



Source: Hilltop Economics

Linx Silicon Growth Scenario – Most Likely
Linx硅產能需求成長預測模型



Aggressive Tech Spending (45%) Key Inputs - % CHANGE	2018	2019	2020	2021	2022
MSI	7.8	(7.2)	3.8	5.9	8.9
Global Real GDP (SAME AS ESF)	3.0	2.3	(4.7)	5.0	3.6
PC Units	(0.9)	1.7	1.1	(2.2)	0.5
Smartphones	(3.9)	(2.3)	(7.9)	15.2	4.9

KeyFocus - Wafer Fab Materials
主要半导体材料(晶圆厂材料)分类

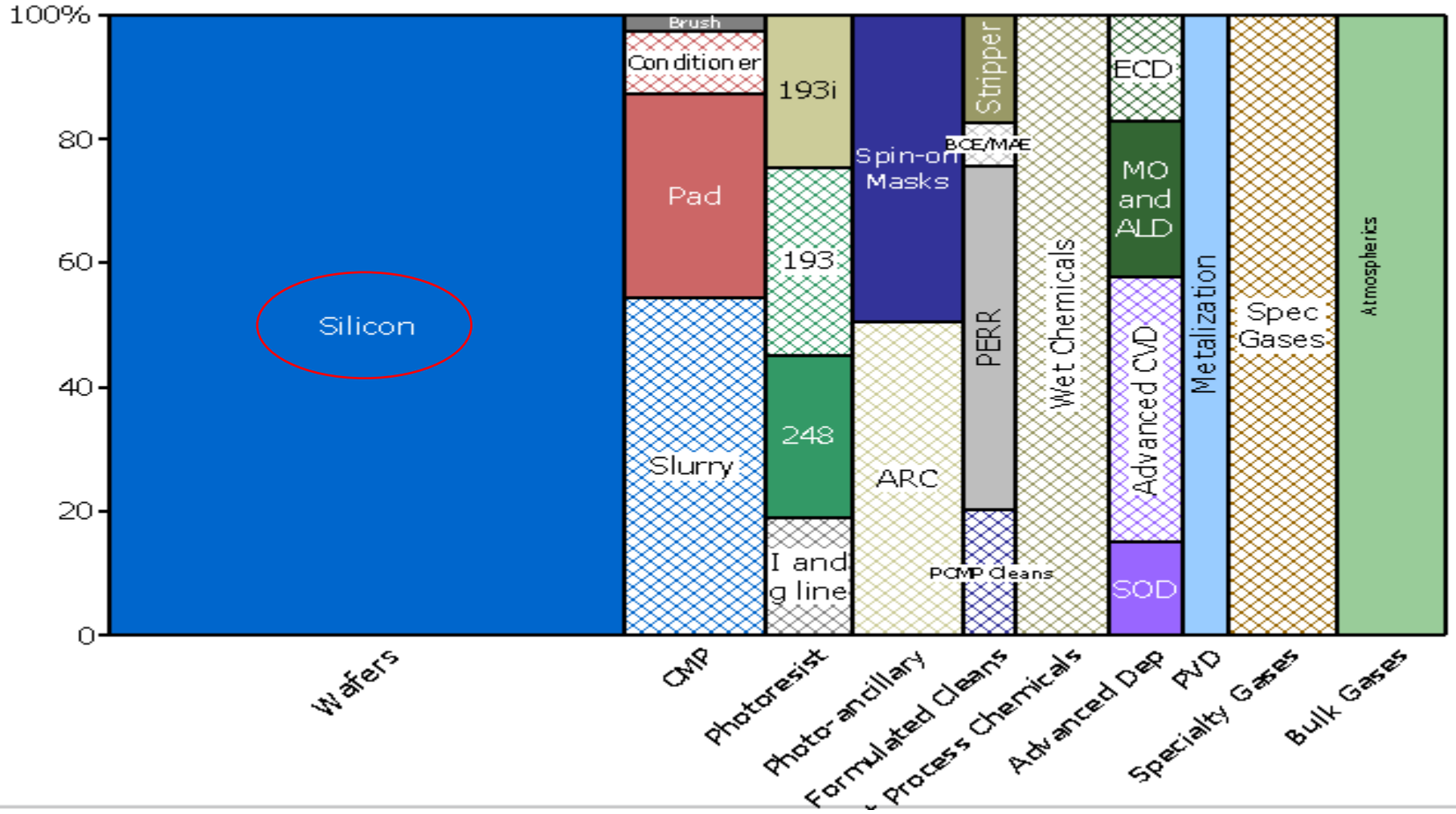
- **Wafer 硅片 (Direct Materials / 直接材料)**
  - Production substrates of ultrapure silicon formed into wafers.
- **Deposition** 沉积材料
  - Liquids, solids, and, gases that are used in various techniques for film deposition.
- **Lithography / Patterning** 光刻材料
  - A group of formulated chemicals that are used in spin on processing to transfer design patterns from masks onto the wafer surface.
- **Chemical Mechanical Planarization – CMP** 化学机械研磨
  - Pads and slurries that are used to remove unwanted materials and leave ultra flat surfaces.
- **Bulk Wet Chemicals & Formulated Cleans** 湿式化学品与配方清洗液
  - Pure chemicals, and chemical mixtures that are used to remove remnants of previous processes, and contamination to enhance yield.
- **Bulk Gas** 大宗气体
  - Gases that are supplied in large quantities both for use in complex processes, and to provide acceptable processing environment.
- **Specialty Gas** 特殊气体
  - Specialty gases, and gas mixtures used for etching, deposition, and other purposes in wafer manufacturing.

Semiconductor Wafer Fab Materials (WFM)
半导体材料市场分类

$28.3 billion market in 2019

100’s of material categories

1000’s of SKUs



Market Trend of Global Semiconductor Wafer Market

全球半导体硅片市场趨勢介紹

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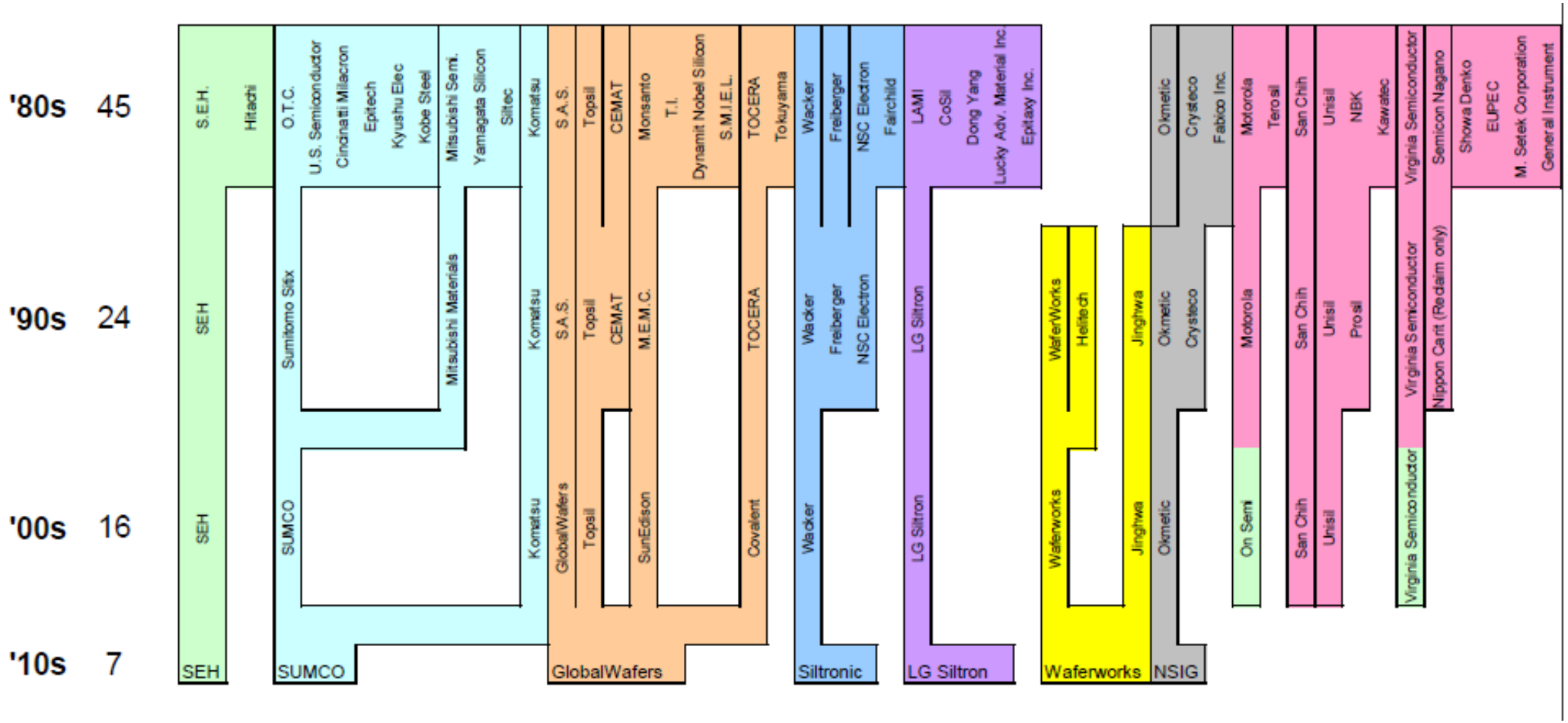
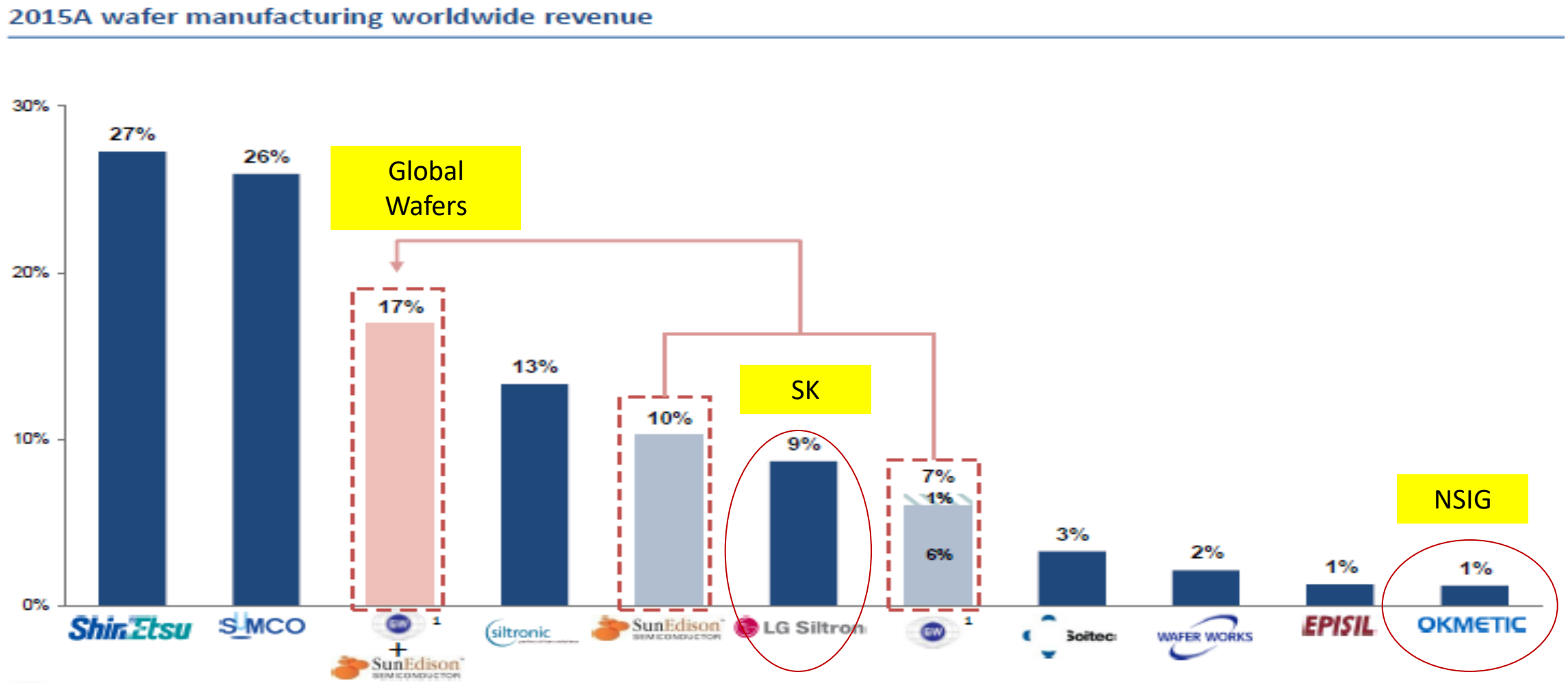
Topics 議題

- Industry Evolution
- Supply: Wafer Production
- Demand: Segmentation
- Growth Forecast
- Tier 1 Supplier Analysis

Industry Evolution 硅產業的演進



Impact on Market Landscape by M&A
硅產業的收購整併



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Wafer Supply Chain Evolution
硅產業的變化對比

Significant consolidations in last 20 years

1998

Very Fragmented Market with Over 25 Players

ATMI (Formerly Lawrence) · Crysteco · MACOM Semiconductor Products · MEMC · Moore Tech · Puresil Technaflex · unisel · Komatsu Electronic Metals · Mitsubishi · Nittetsu Denshi · Sumitomo Sitix Silicon · Shin-Etsu Handotai · Showa Denko · Toshiba Ceramics · OKMETIC · Siltronix · TOPSIL · Wacker Siltronic · LG Siltron · Posco-Huls · Episil · Taisil · Wafer Works

Today

Top 5 Players Account for >90% Market Share

GlobalWafers · Shin-Etsu · SUMCO · LG Siltron · siltronic

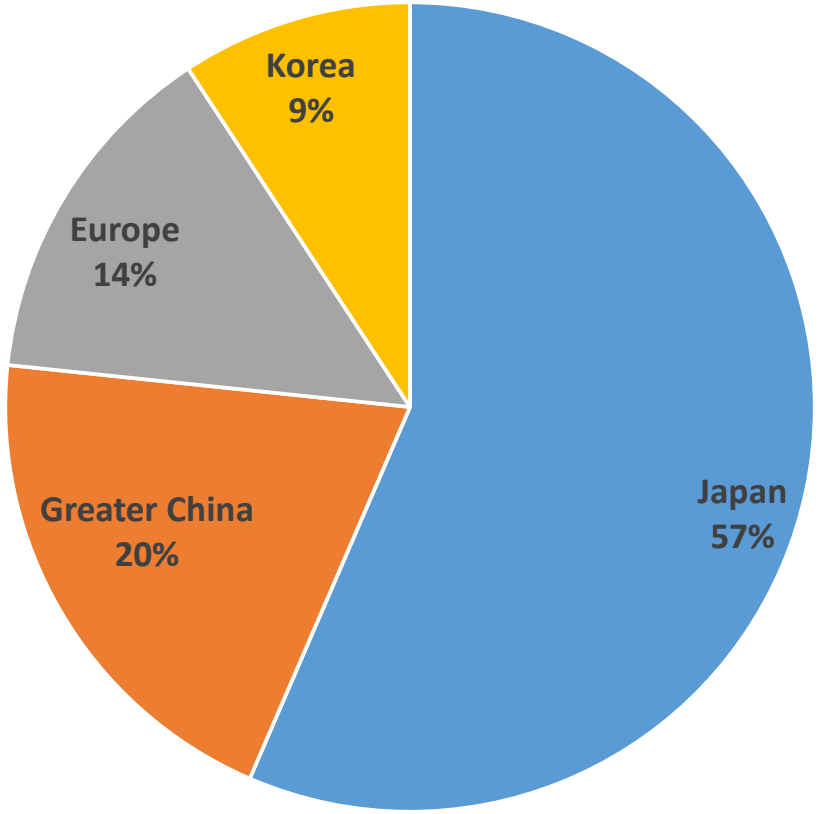
Consolidated around 5 Players[1]

Source: Global Wafers

Suppliers by Region
硅產業的地區分布

SK Siltron

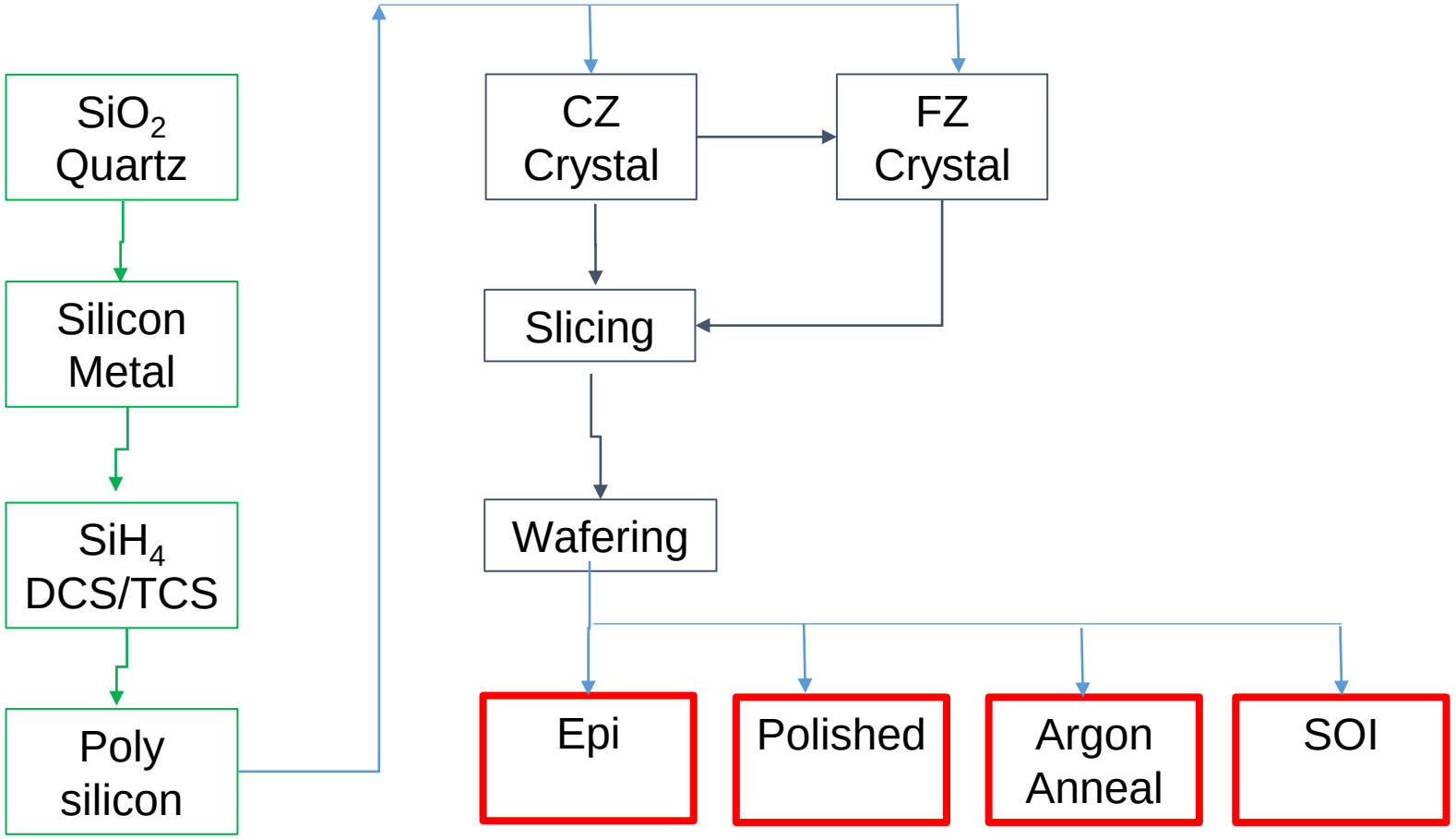
Siltronic
Soitec
Okmetic (NSIG)



GlobalWafers (TW)
Waferworks (TW)
Episil (TW)
Simgui (CN)
Zing Semi (CN)
Ferrotec-GW (JP)
QL Elec - JRH (CN)
Gritek (CN)
MCL (CN).....

Shinetsu (SEH)
Sumco

Silicon Production Process Flow
硅片生產工藝與成品



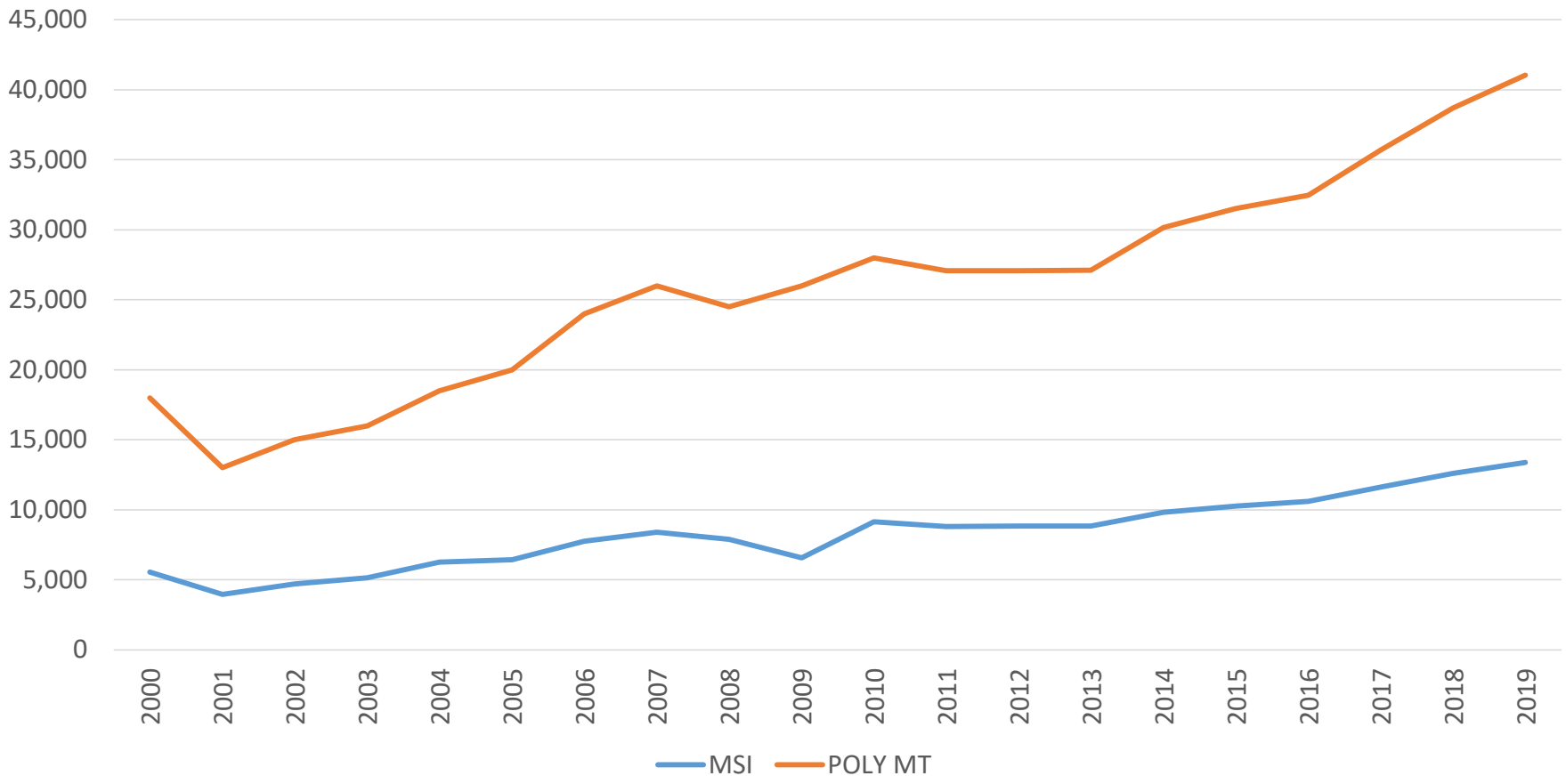
Final Products to Customers

Source: SMG

Important Materials

Polysilicon
Dopant
Crucibles
Graphite / SiC
Quartz
Slicing wire
Slurry
Grind wheels
CMP Pad / Slurry
Etchants
Clean Chemicals
FOSBs

Semiconductor Silicon Production Trend
半導體硅原料使用成長趨勢



In 2019 41,000 MT will be required for13,367 MSI of Silicon for semiconductor applications.

This represents about 4.8% of polysilicon output.

Poly silicon requirement is
≈ 3MT / MSI
= 0.34kg /12” wafer
= 0.15kg / 8” wafer

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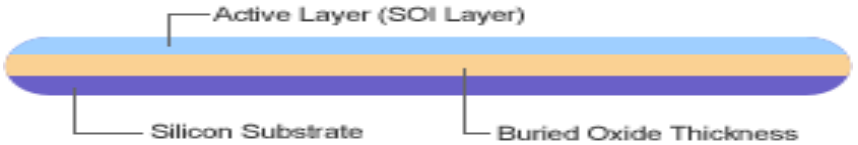
Segmentation by Wafer Types
硅片分類

- ***Polished :*** Polished wafers are silicon wafers with one or both sides polished to a mirror surface. Our polished wafers are superior in properties such as flatness and cleanliness. They have earned an excellent reputation for high quality and precision that meets the needs of the ULSI age.

- ***Epitaxy :*** Epitaxial wafers are the traditional wafers to achieve surface integrity by putting various thickness epitaxial silicon layers. Thin Epi wafers are commonly used for leading edge MOS devices. Thick Epi or Multi-layered epitaxial wafers are used for the devices mainly to control electric power, and they are contributing to improving the efficiency of energy consumption.

- ***Annealed :*** There are two types of annual wafers : H2-annealed and Ar-annealed.
  - *H2-annealed* wafer is heat treated in hydrogen ambient, and realized high BMD density which provides gettering ability as well as COP-free zone in the wafers surface region. These properties contributes to have excellent gate oxide quality.
  - *Ar-annealed* wafer is heat treated in Argon gas ambient to prevent out-diffusion of dopant from wafer surface and to have flat resistivity profile in depth. It serves the same quality as H2-annealed wafer in other aspects.

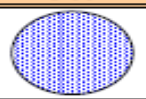
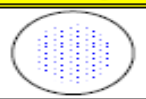
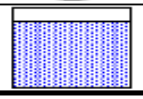
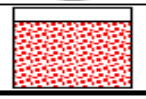
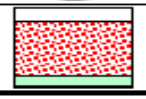
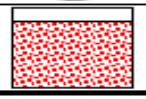
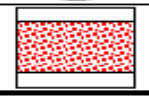
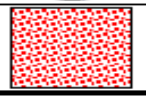
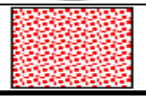
- ***SOI (Silicon-On-Insulator) :*** Silicon-On-Insulator wafers are a three layer material stack composed of the following: an active layer of prime quality silicon (device layer) over a buried oxide layer (box) of electrically insulating silicon dioxide, over a bulk silicon support wafer (handle). SOI wafers are unique products for specific end-user applications like power devices and MEMS to achieve high breakdown voltage, low energy consumption and high performance of MEMS. This is possible due to their SOI structure.



Key Wafer Performance Spec
各類硅片主要規格指標

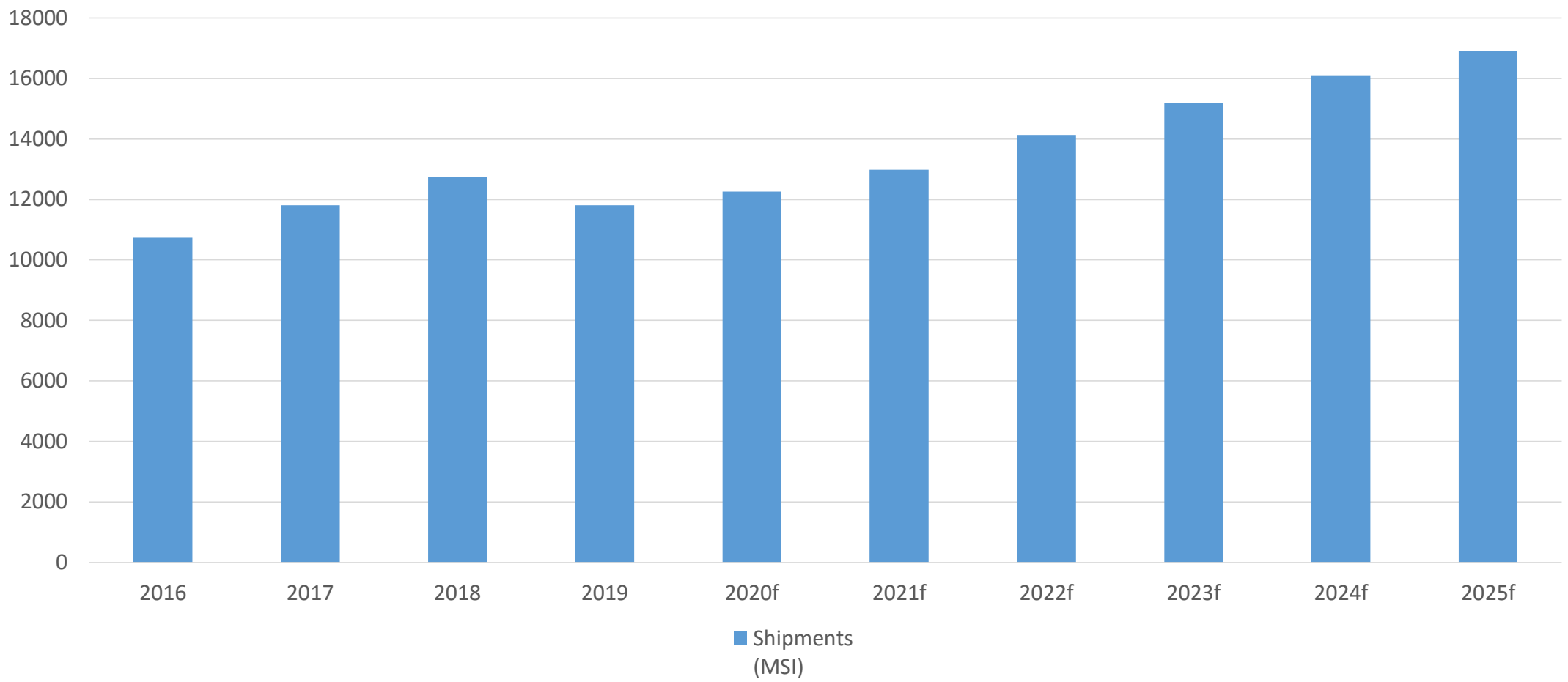
Property index comparison across different wafer types

COP: *Crystal Originated Particle*
BMD: *Bulk Micro Defect*
GOI: *Gate oxide integrity*

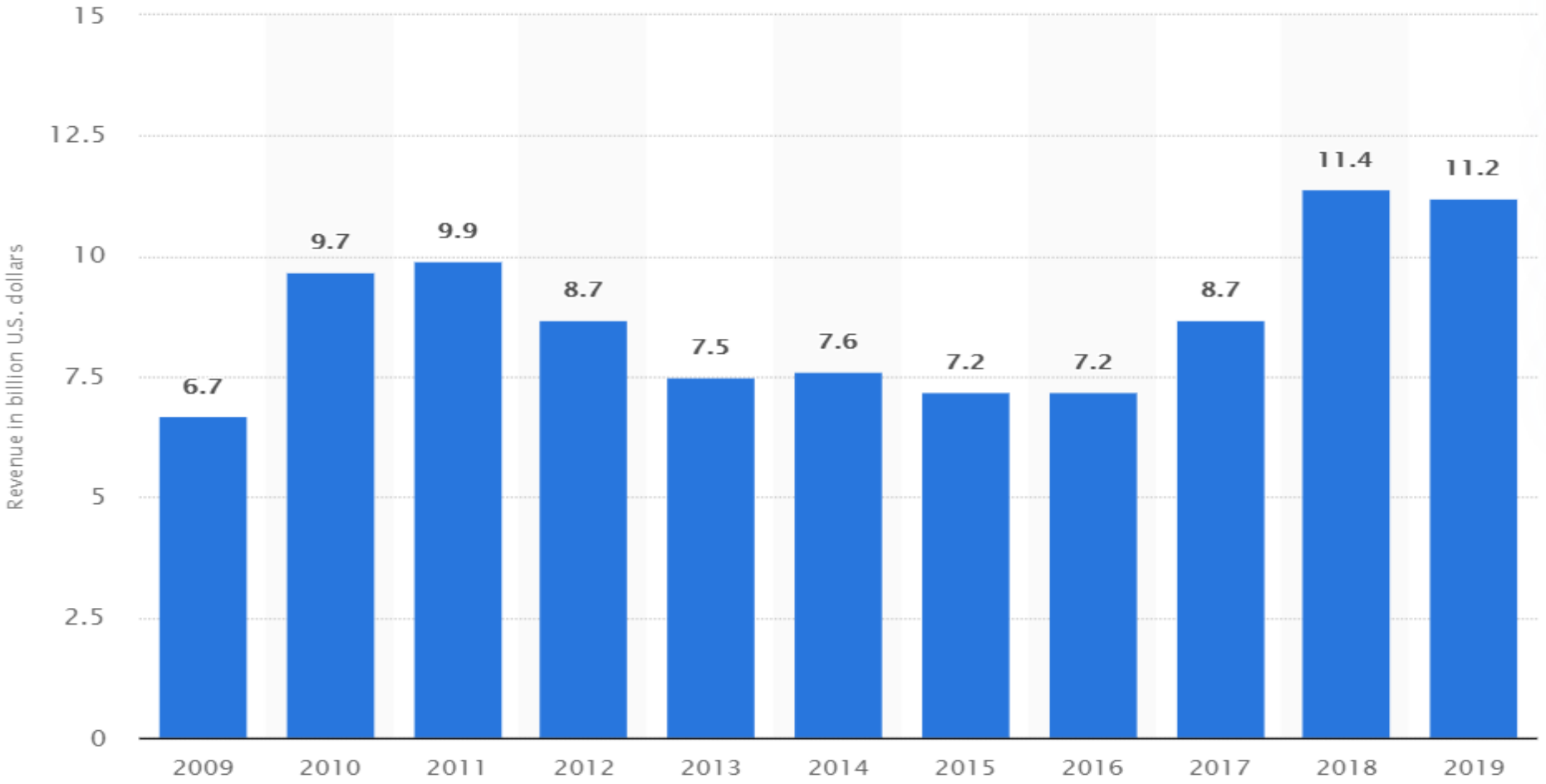
Wafer Line Up		Epitaxial				Annealed	Polished			SOI
		P/P-	P/P+	P/P+CVD	EP-NANA	IG-NANA	Std.	LDC	NPC	
COP / BMD / Oxide	Top View									
	Sectional View									
Performance										
Near Surface Integrity	GOI	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Good	Excellent	Excellent
	COP	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Good	Excellent	Excellent
	Defect Free Depth (um)	Excellent	Excellent	Excellent	Excellent	Excellent	Fair	Fair	Excellent	Excellent
BMD Ability		Fair	Good	Good	Excellent	Excellent	Good	Good	Fair	N/A
Status		Production	Production	Production	Production	Production	Production	Production	Production	Production

Source: SEH website

Global Silicon Wafer Production Output Growth
全球硅片產能成長預測



Silicon Wafer Market Size Evolution
硅片市場規模發展歷史



Source: Statista

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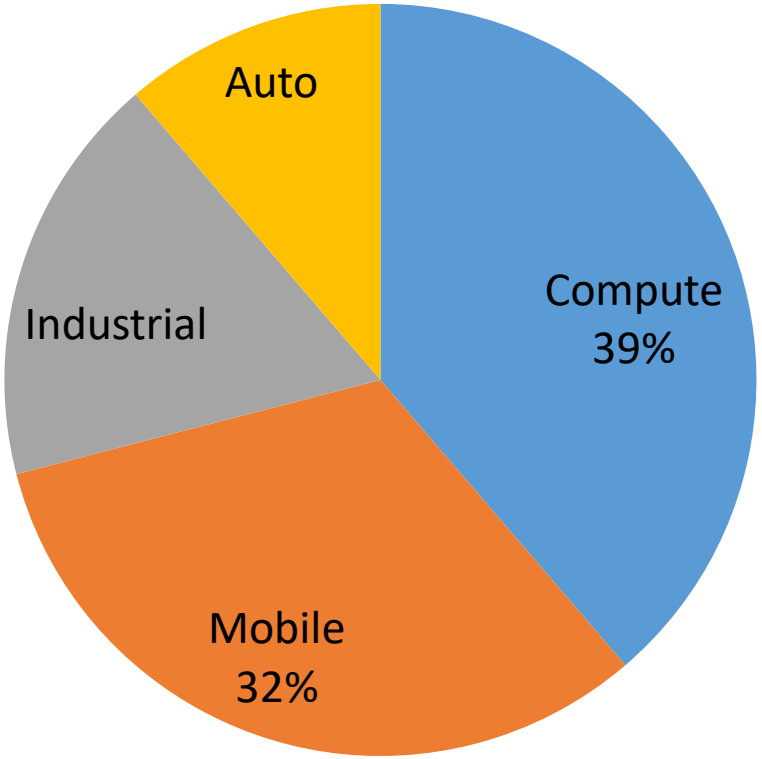
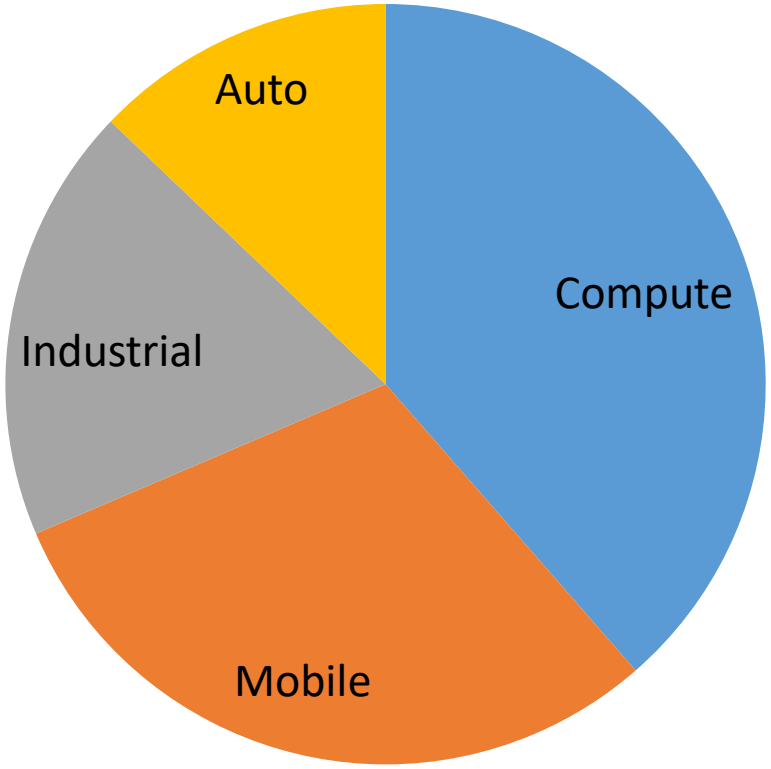
Global Silicon Wafer Demand Segmentation By End Application
硅片應用分類市場規模演進

2019 = 62 BSCM



2022 = 70 BSCM



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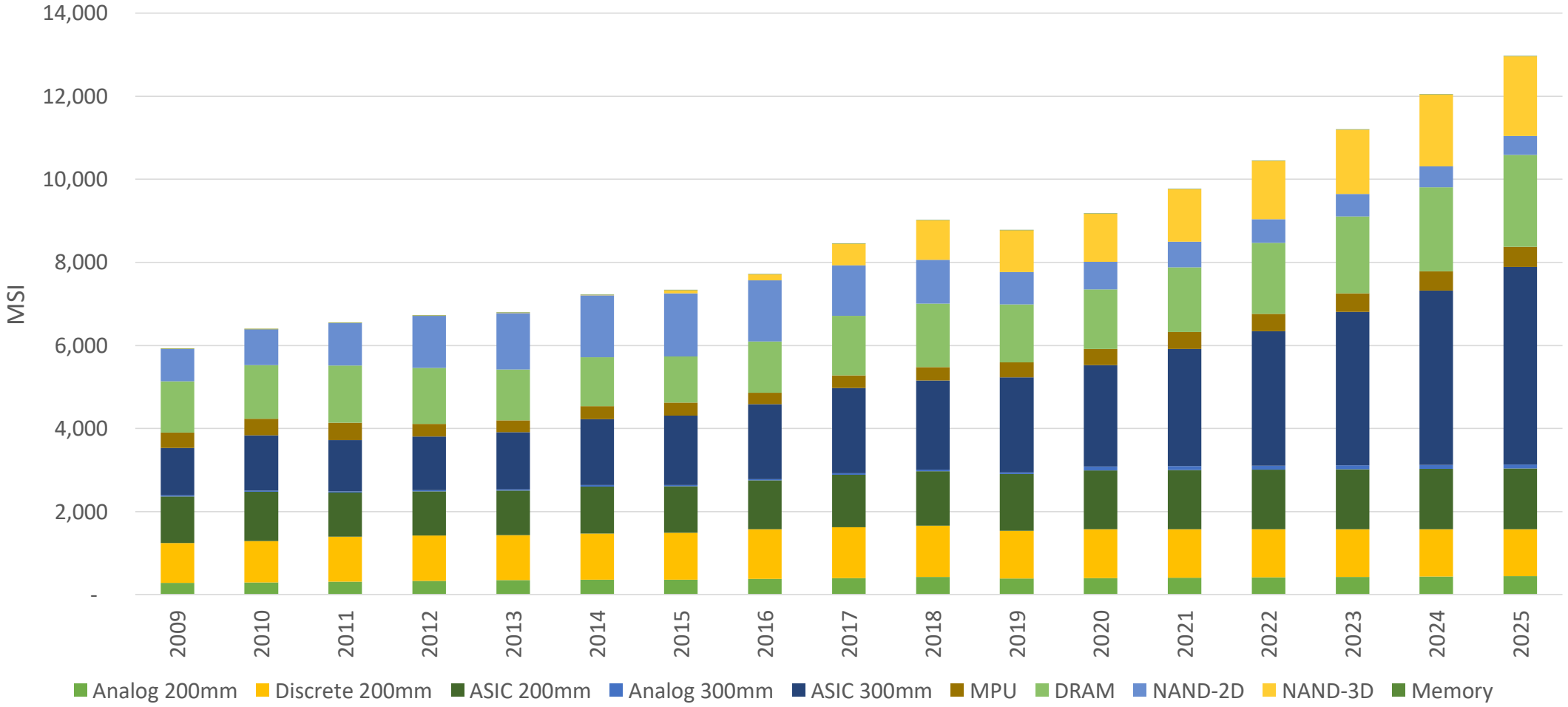
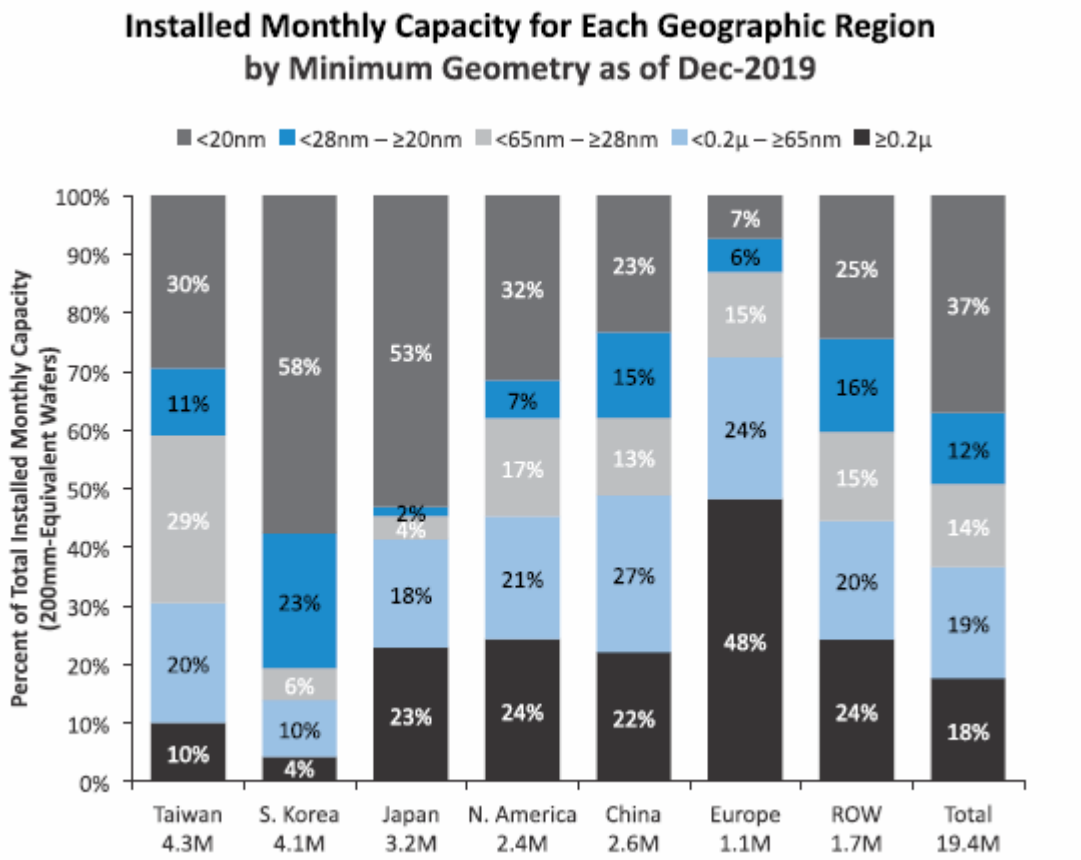
Silicon Demand Forecast By Device
依器件分類的硅片需求預測

Stronger Growth in ASIC/Logic 300mm and 3D-NAND



Global Installed Wafer Capacity Analysis
全球各地區晶圓廠安裝產能的硅片需求分析



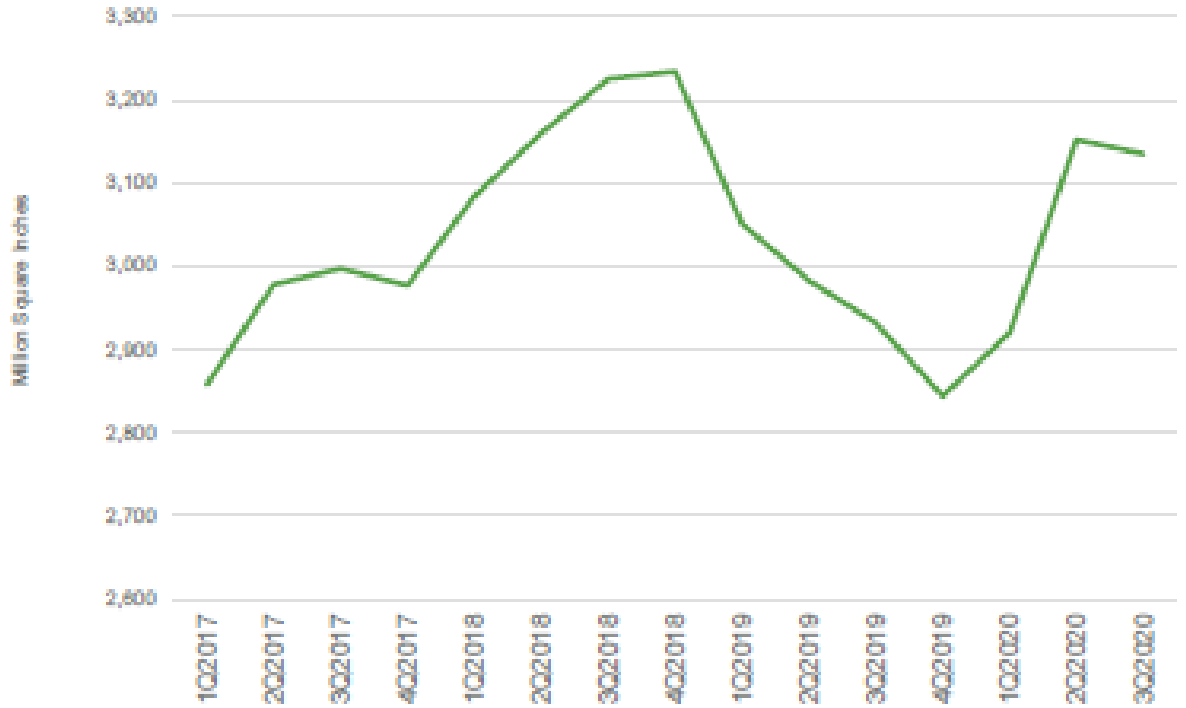
Taiwan has the largest installed wafer fab capacity

Regional Capacity by Wafer Size as of Dec-2019
(Installed Monthly Capacity in Millions of 200mm-Equiv. Wafers)

Product	Taiwan	S. Korea	Japan	N. America	China	Europe	ROW	Total
300mm	3.2	3.5	1.9	1.6	1.4	0.3	1.0	12.9
200mm	0.9	0.5	0.8	0.7	0.9	0.7	0.7	5.2
≤150mm	0.2	0.0	0.5	0.2	0.3	0.1	0.1	1.3
Total	4.2	4.1	3.2	2.5	2.6	1.2	1.8	19.4

Source: IC Insights

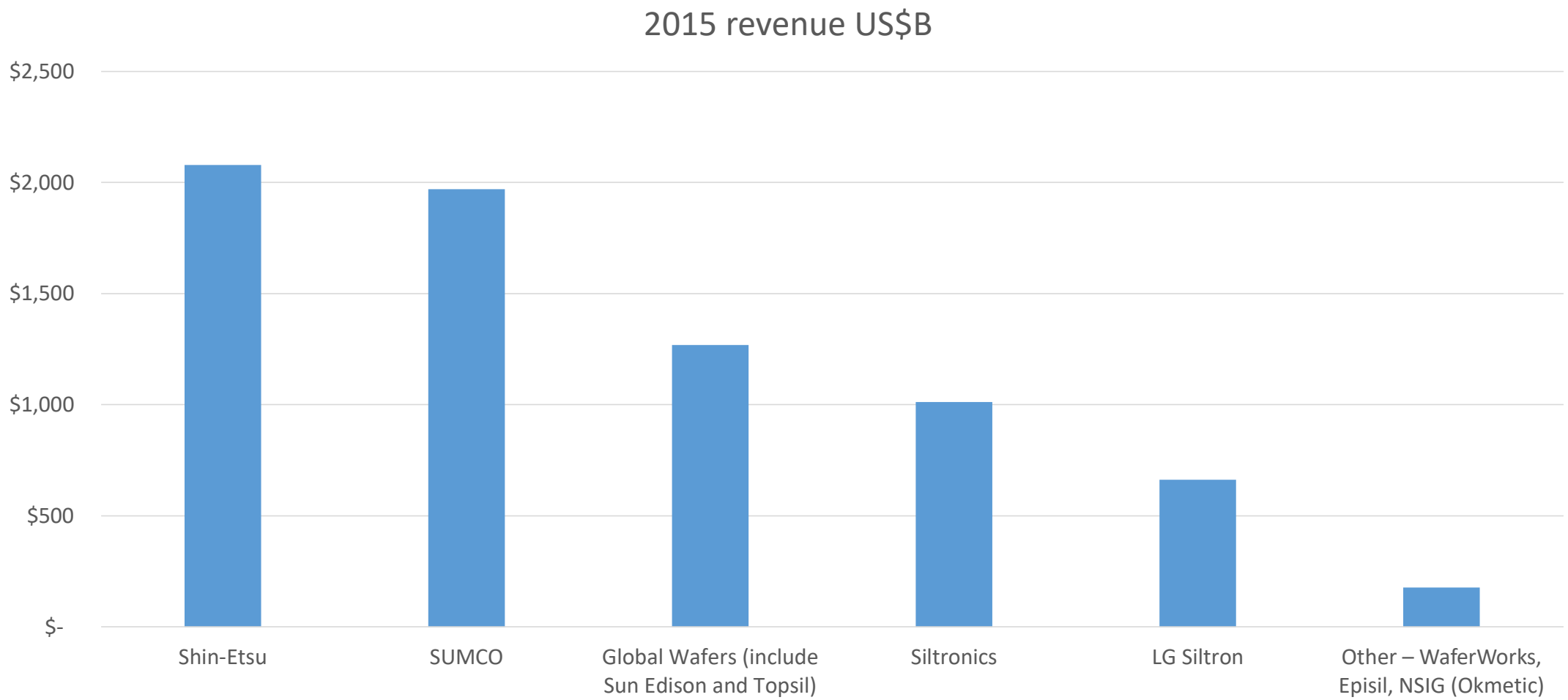
SEMI Silicon Wafer Report: Healthy 2020 Performance
2020硅片市場維持健康發展



Source: SEMI SMG, October 2020

- Year-to-date through 3Q20 wafer shipment increased 2.7% Year-over-Year
- 2Q 2020 shipment rebounded 8% QoQ, driven by various demands pick-up and partially for the safety stock build-up
- 3Q 2020 shipment declined 0.5% QoQ as demand for memory (polished wafer) was weaker than expected
- Overall pricing pressure could continue into early part of 2021 except for 300mm epi-wafers

Wafer Maker Financials in 2015
硅片生產商2015年營收分析



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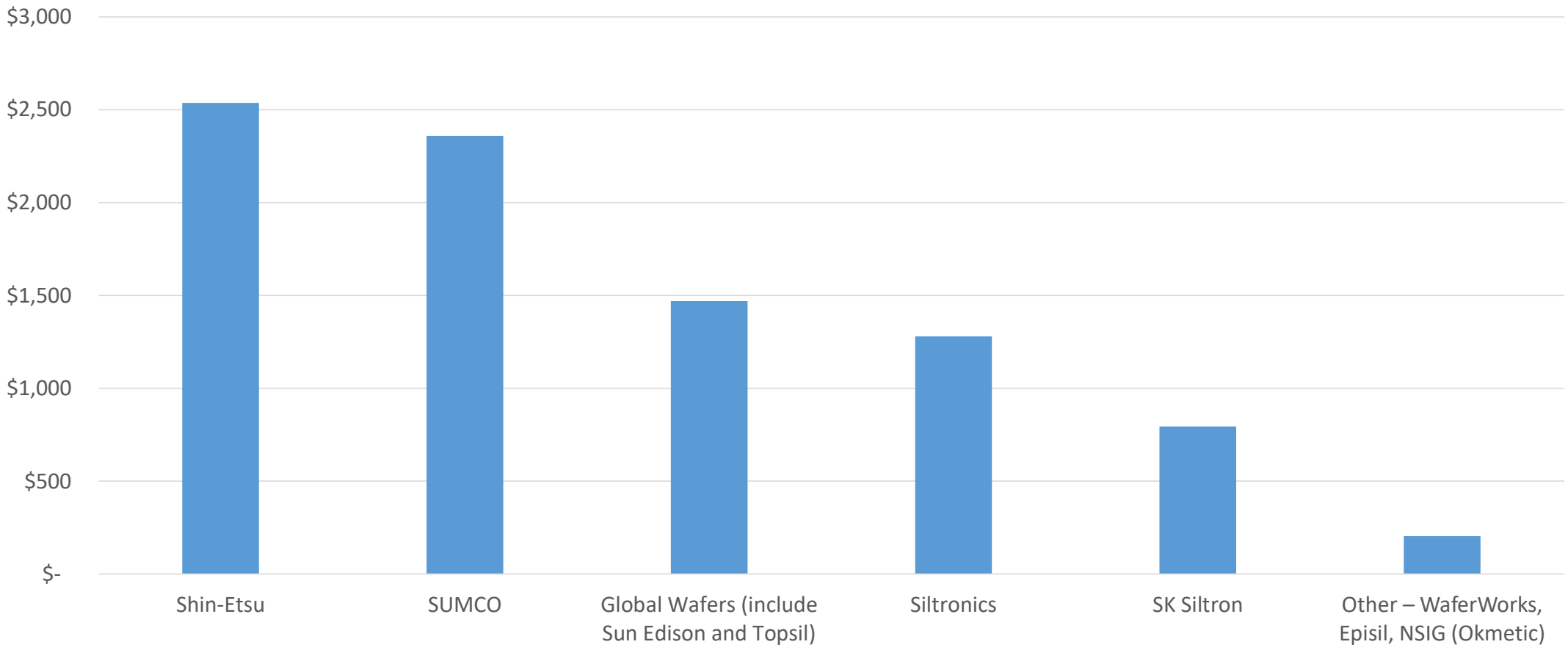
Wafer Maker Financials in 2017
硅片生產商2017年營收分析



Average 25% sales growth from 2015 to 2017

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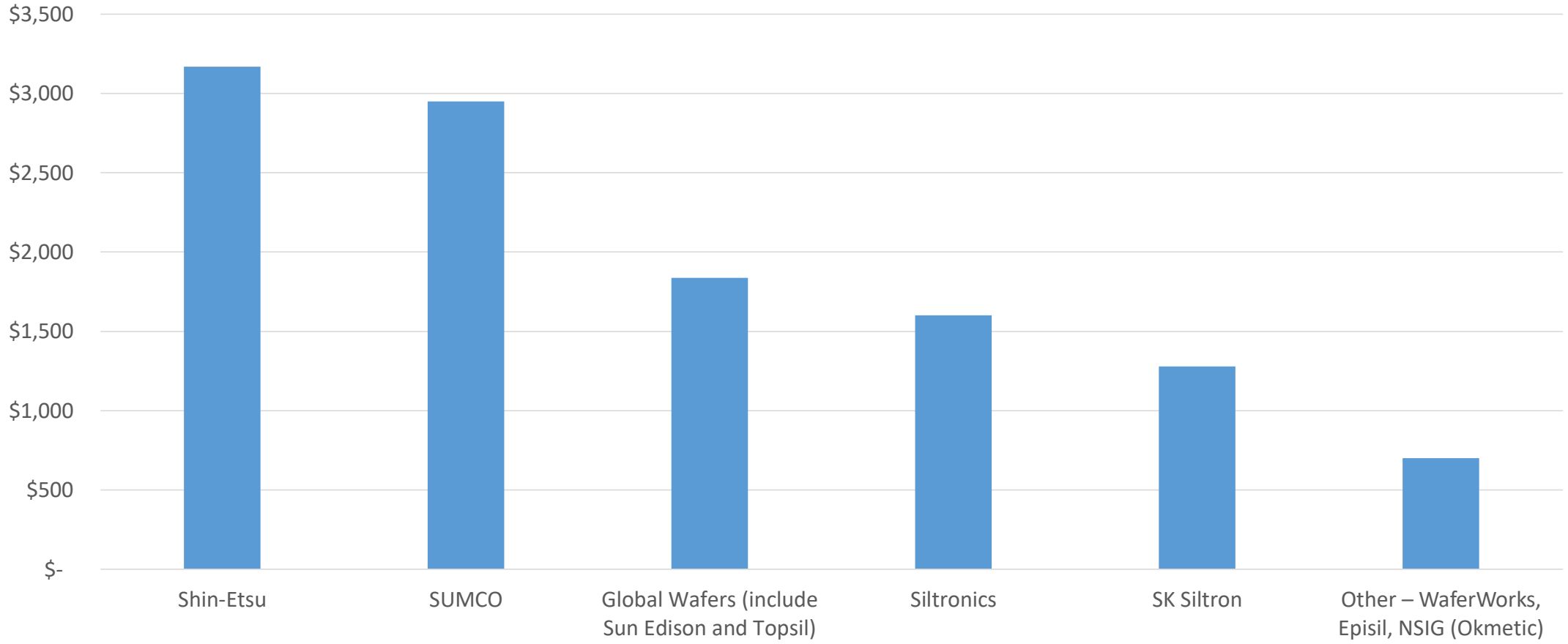
Wafer Maker Financials in 2019
硅片生產商2019年營收分析



Average >20% sales growth from 2017 to 2019

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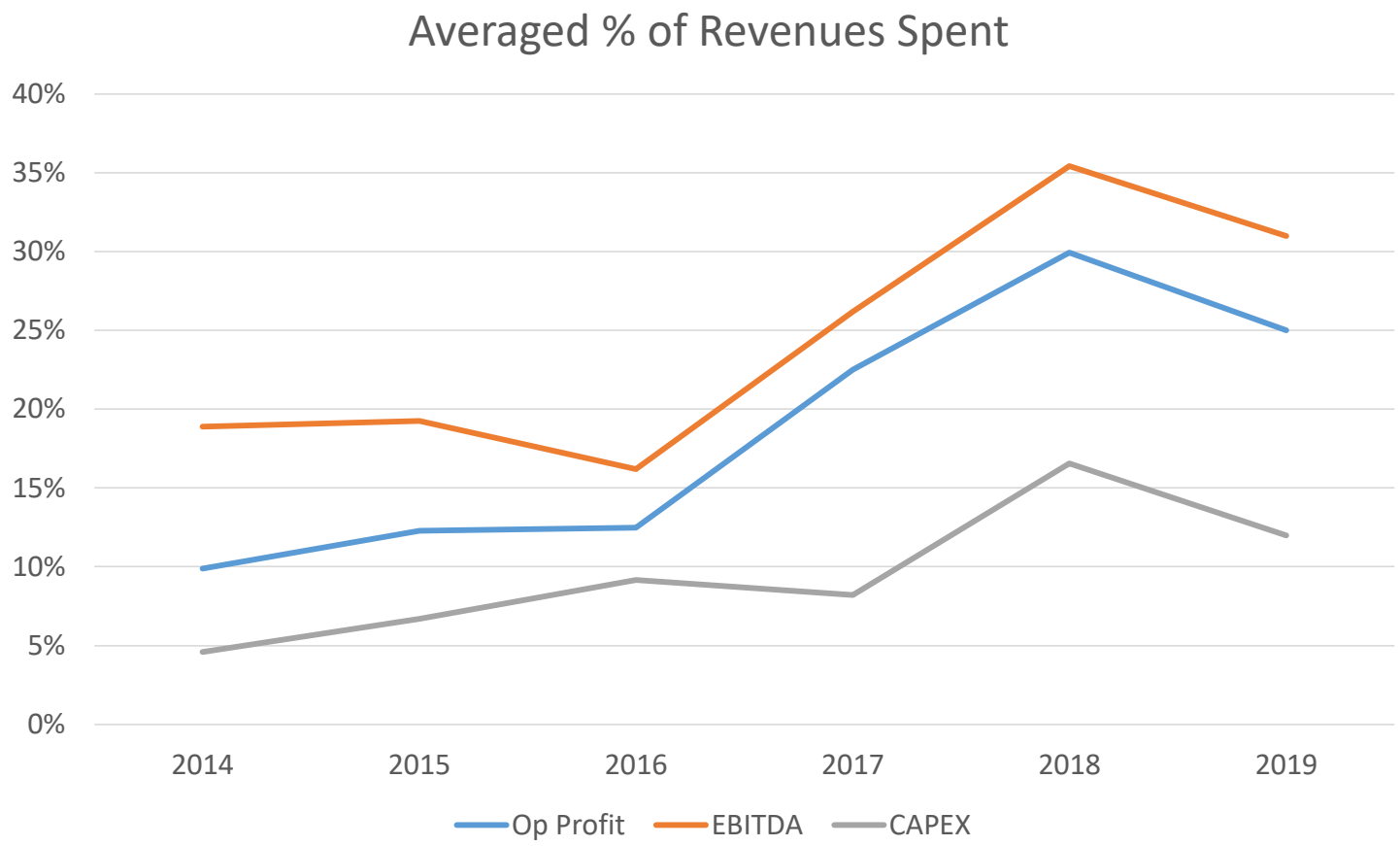
Wafer Producer Financial Trends
硅片生產商財務結構分析



Market recovery has improved operating profits and sparked some reinvestment from 2016, peaked in 2018

CAPEX is focused primarily on sustaining and facilitization of brownfield capacity.

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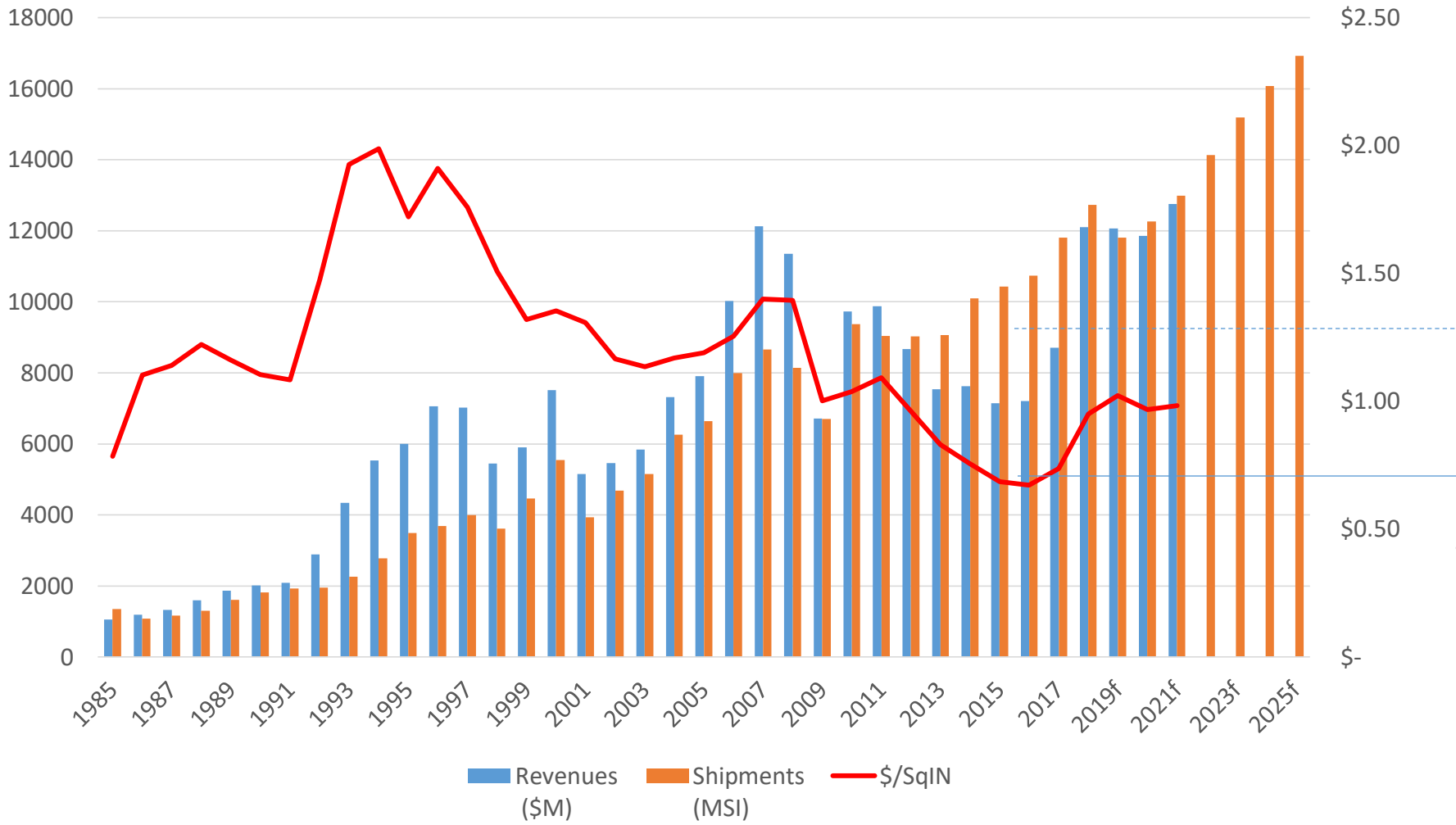
Silicon Wafer Makers Capacity Investment Decision
硅片生產商產能投資決策



Greenfield Investment

Brownfield Investment

Supply tightness in 2017-2018 has reversed value trend, and promoted brownfield build out.

Greenfield investment level (>$ 1.3/sqIN) has not been reached.

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Implications for China Semiconductor Wafer Industry Development

對中国半导体硅片产业發展的影响分析

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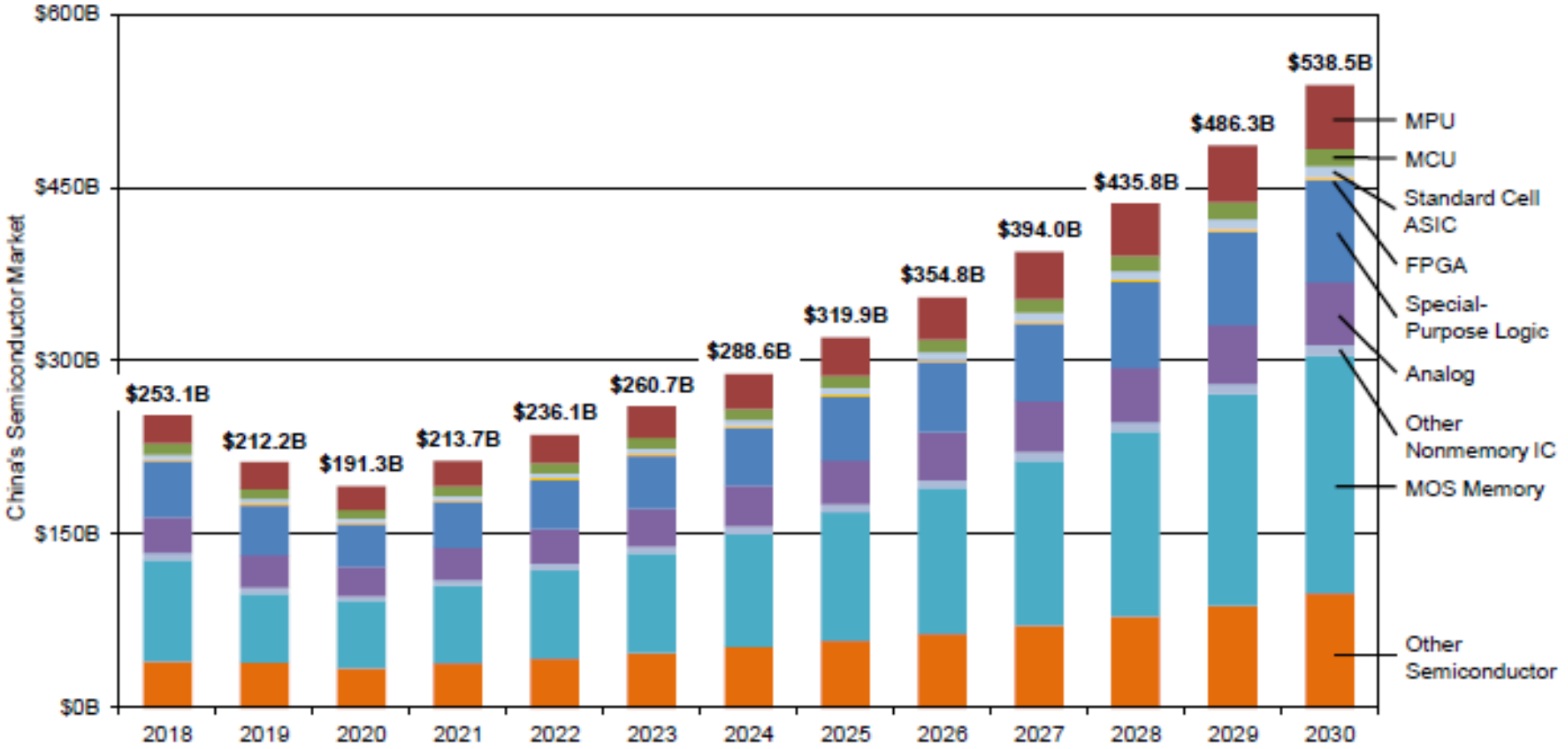
Topics 議題

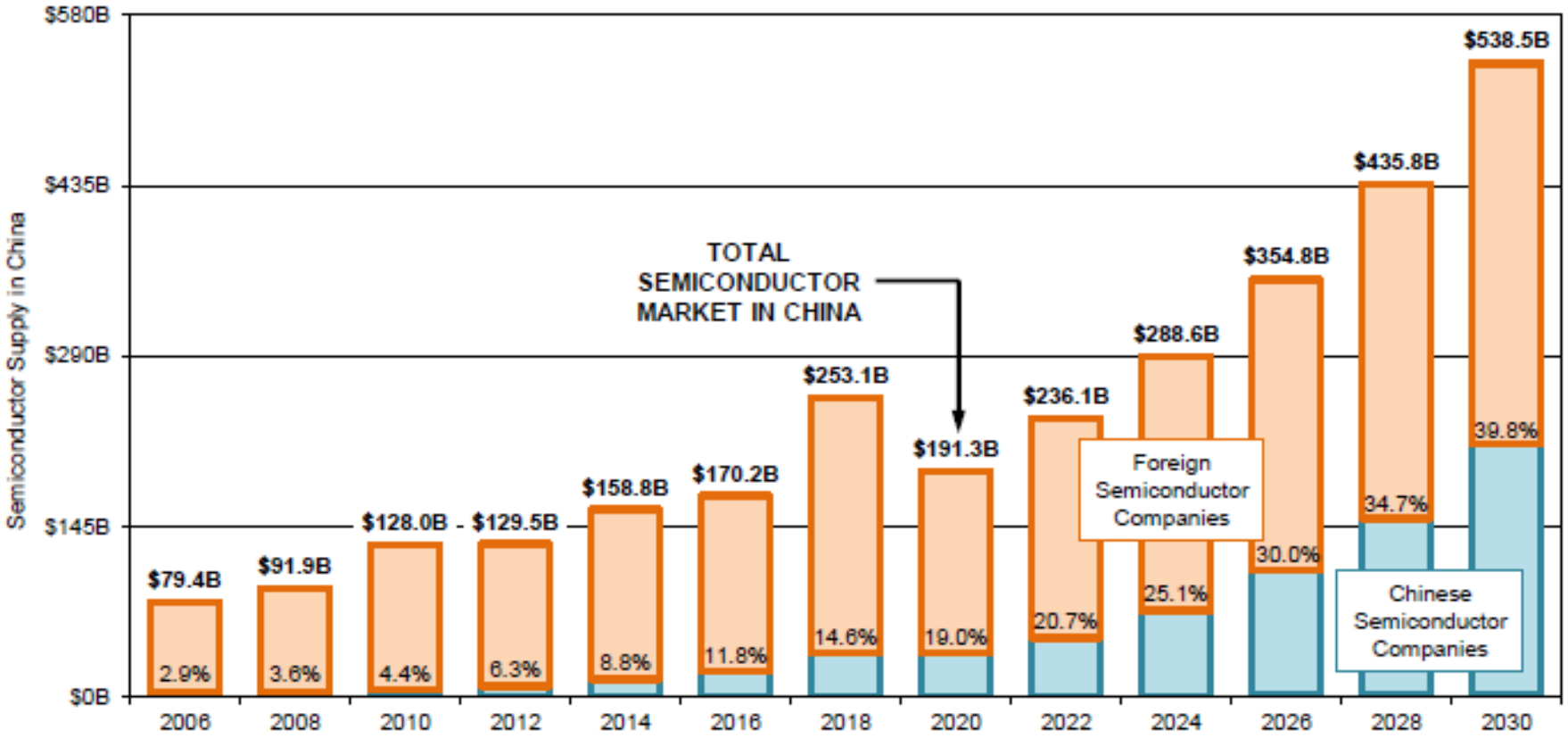
- Strong Growth Potential in China
- Participation of China in Global Landscape with Support of Government Funds
- Impact of China-USA Technology Cold War
- Local Demand vs. Local Supply
- Supply Landscape Analysis

China Semiconductor Market Demand Growth Trend
中國半導體市場需求的強勁成長



HIGHER GROWTH THAN TOTAL SEMICONDUCTOR MARKET

Increasing Local Supply of China Semiconductor Market
中國半導體市場需求的本地供應率提升



CHINA IS PROJECTED TO BUY 81.0% OF SEMICONDUCTORS FROM NON-CHINESE VENDORS IN 2020 AND 60.2% IN 2030

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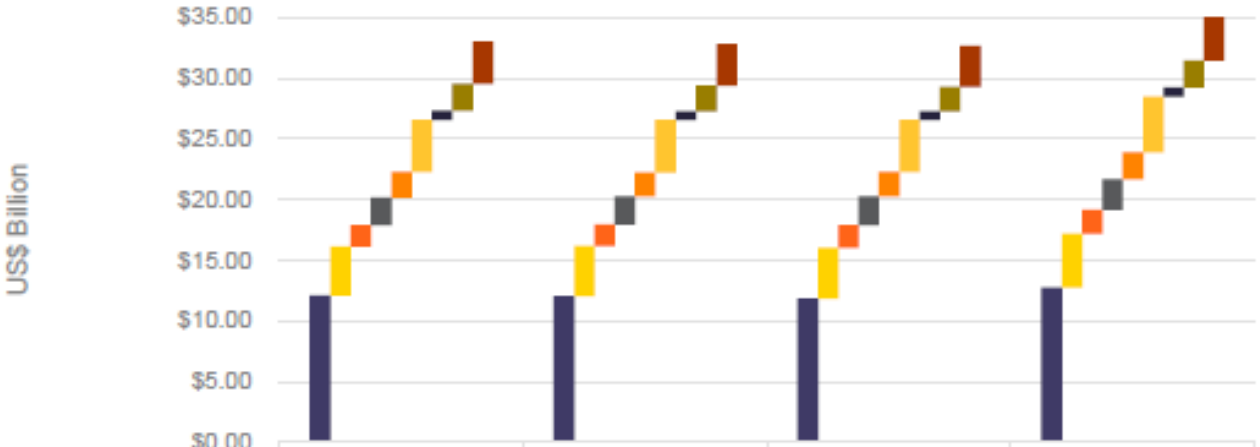
China Semiconductor Materials Market Growth
中國半導體材料市場的成長趨勢

- China has the highest overall semiconductor materials (and packaging materials) market growth at CAGR of 9.1%
  - Wafer fab materials:10%
  - Packaging materials: 7.9%

US$ Billion	2019	2020F	2021F
North America	5.64	5.30	5.58
Europe	3.93	3.71	3.90
Japan	7.74	7.69	7.97
Taiwan	11.48	11.83	12.56
Korea CAGR@9.1%	8.90	8.54	9.04
China	8.76	9.34	10.42
ROW	6.42	6.54	6.89
Total	52.88	52.94	56.36

Source: SEMI Materials Market Data Subscription, September 2020

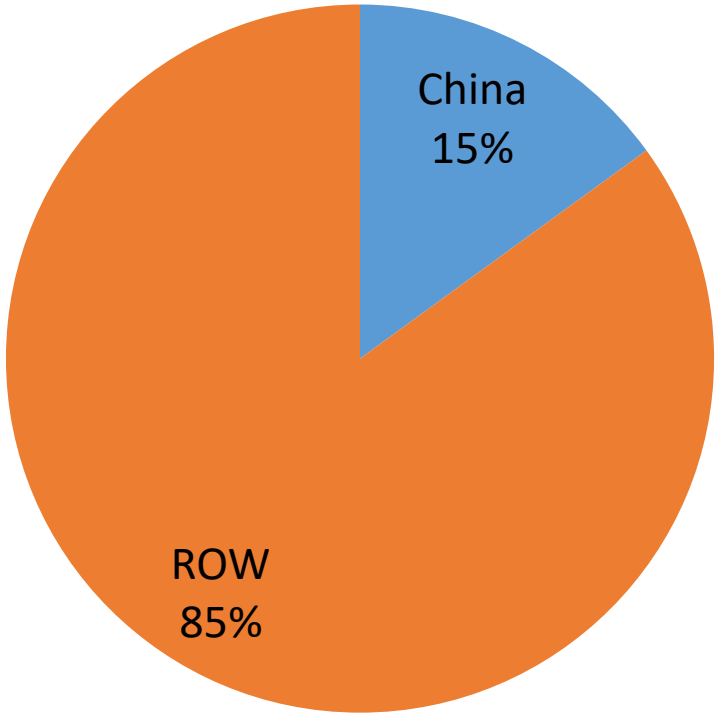


	2018	2019	2020F	2021F
Other/New Materials	3.5	3.48	3.39	3.61
CMP Slurry & Pads	2.18	2.06	2.01	2.18
Sputter Targets	0.78	0.73	0.71	0.78
Gases	4.27	4.3	4.29	4.58
Wet Chemicals	2.14	2	2.02	2.19
Photoresist Ancillaries	2.28	2.32	2.37	2.52
Photoresist	1.73	1.77	1.85	1.98
Photomasks	4.04	4.1	4.16	4.42
Silicon Wafers	$12.10	$12.07	$11.86	$12.76

Source: SEMI Materials Market Data Subscription, September 2020

China Silicon Wafer Market Size
中國硅片市場需求的全球占比

Wafer Fab Materials (US$ M)	2019 Global	2019 China	China/Global Ratio
Silicon Wafers	$12,070	$1,810	15%



Policies to Support Local Materials Supply Chain
支持中國本地材料供應鏈發展的政策

- Mission to establish China's own integrated circuits manufacturing supply chain:
  - A long-term mechanism has been established between the central and local governments to coordinate their supporting policies;
  - The related industries can resort to capital market and the governments will carry out policies to introduce more social funds in innovation
  - Joint-venture cooperation is highly encouraged with policies designed to guarantee cooperation quality.
  - Investments throughout the supply chain: design, manufacturing, packaging, equipment, materials….etc.

- Continued National 02 Project initiative

- Announced $160 Billion of “National Big Fund” over 10 Years

- Financial loans to supply-chain participants to become global top 5 in their segment.

- Created the China NASDAQ: Shanghai Sci-Tech Innovation Board

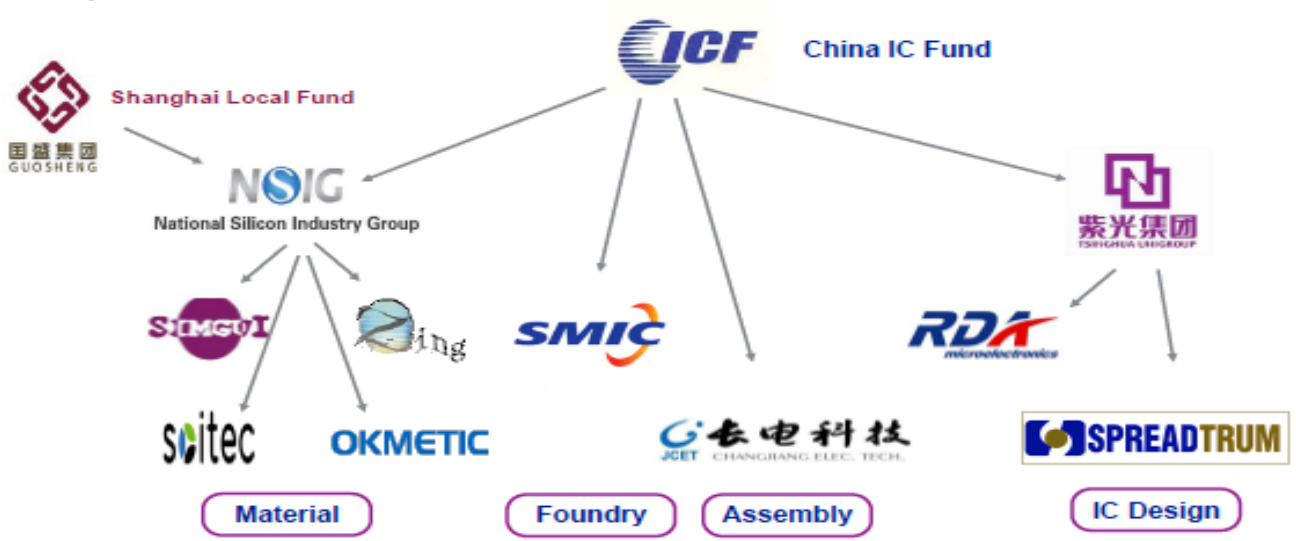
- Formed ICMtia Alliance to focus on local materials supply chain development

China Influence on Market Landscape
政策對中國本地硅片供應鏈的影響

Introduction of NSIG

- Established in Dec 2015 with focus on silicon wafers
- Sources of funding: Sino IC Capital (CICF “Big Fund”), Guosheng Capital…etc.
- M&A and strategic investment coverage: Okmetic (<=200mm), Zing Semi (300mm), Simgui (SOI), and Soitec (SOI)
- Plan to expand 300mm capacity to 1m wafers/month

Structure of “CICF” (Big Fund)



- To promote China IC industry, China IC Fund (CICF) was formed in 2014 with fund size of $20B.
- CICF directly invests into strategically important company in the IC supply chain in China.
- CICF also works with local government to form local IC fund to support IC industry.
- It is expected to invest total of US$ 150 billion (RMB 1 trillion) into IC industry from 2016 to 2020.

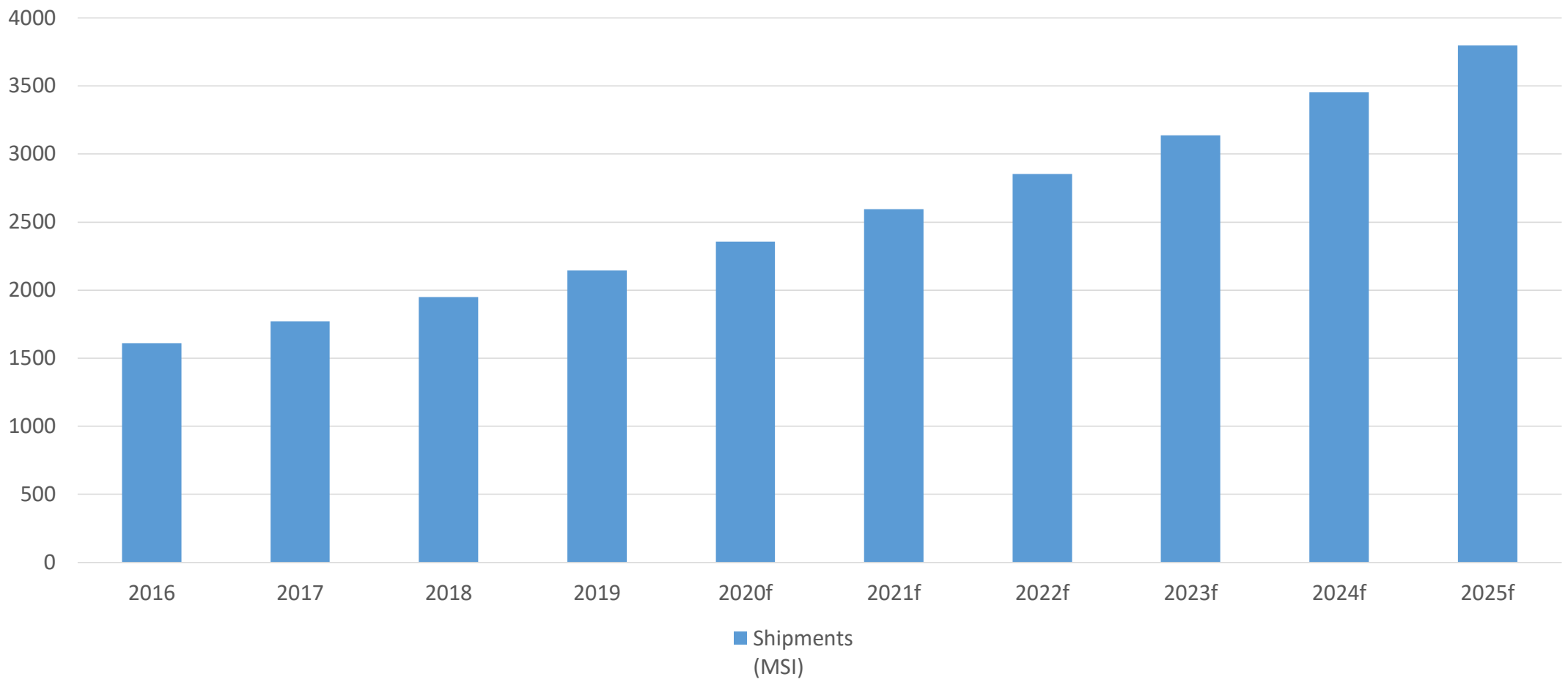
IC Mtia Alliance
政府政策支持的集成電路材料聯盟

- IC Mtia stands for “IC Materials Technology Innovative Alliance”
- Founded in Beijing as a non-profit governmental organization in June 2012
- Operating in a loosely coordinated manner to enable closer communications among government, academies, suppliers and customers in he IC materials value chain in order to achieve objectives of technology advancement and business success
- List of members
  - local semiconductor material companies (44)
  - front-end and back-end semiconductor fabs (9)
  - universities/research institutes (10)
  - governmental funding provider (1)

Implications of USA-China Technology Cold War
中美科技冷戰的影響評估

- Continued trade conflicts and relocation of manufacturing sites out of China
- Increasing technology export restrictions from USA to China
- Delay of “Made in China 2025” initiative
- Decoupling of USA – China semiconductor supply chain: China-centric vs. Non-China
- Strengthen the determination of China government’s support to build up fully localized semiconductor ecosystem including design, manufacturing, packaging, testing, and supporting industries like EDA, equipment and materials/
- Silicon wafer industry is a strategic segment supported by various government policies

China Local Silicon Wafer Demand Forecast
中國硅片市場需求預測



China Supply Chain Capabilities
中國硅片市場本地供應能力分析

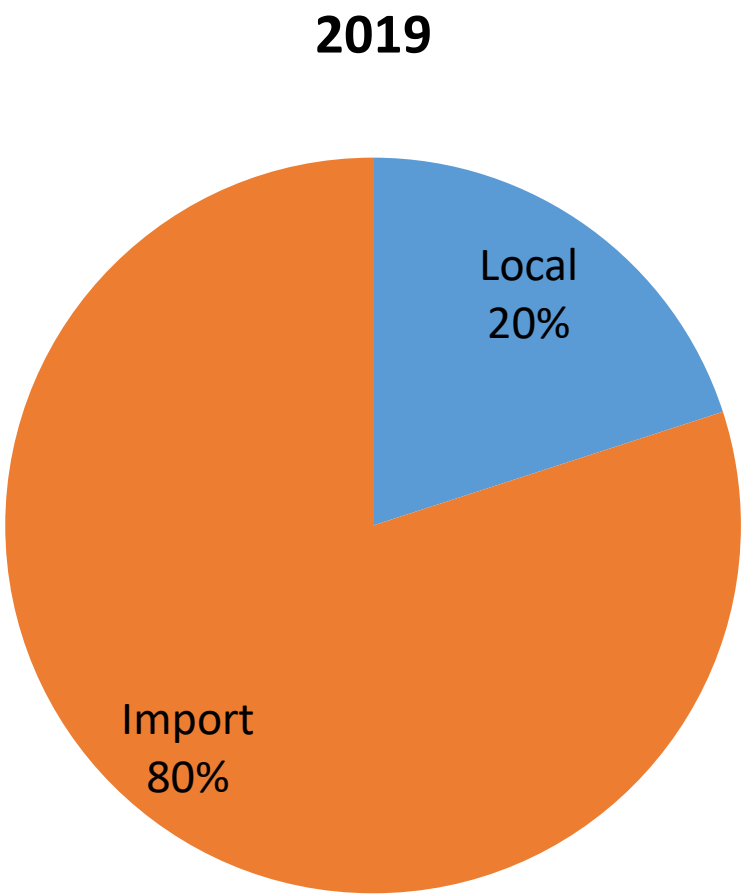
Sector	Capability
6” polished	
6” epi	
6” test	
8” polished (standard/advanced)	
8” epi (standard/advanced)	
8” test (standard/advanced)	
12” polished (standard/advanced)	
12” epi (standard/advanced)	
12” test (standard/advanced)	

Qualified

Evaluation

Not ready

Local Supply % vs. Import Supply %
中國硅片市場本地供應比率



Porter's 5 Forces Analysis on China Wafer Industry Structure
中國硅片產業結構五力分析

Increasing number of new players

Threat of new entrants

Bargaining power of suppliers

Intensity of competitive rivalry

High unless consolidation taking place

Bargaining power of buyers

Strong raw material and supply infrastructure

Threat of substitute

Government incentive and trade tension motivate buyers to evaluate local suppliers

No substitute for production- use wafer

Local existing and emerging players need to fight hard to replace foreign players to survive

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Key Local Suppliers
中國本地主要硅片供應商

Company	Category	Key Products	Website
JRH (QL)	Local	6” polished/epi, 8” polished/ epi (12” future)	http://www.zjjrh.com/
Gritek	Local	6” polished, 8” polished	http://www.gritek.com/en/dashiji.htm
SIMGUI	Local	6” & 8” epi/SOI	www.simgui.com.cn
Zing Semi	Local	12” polished	https://www.zingsemi.com/en/
Huan Ou	Local	6” polished, 8” polished	http://www.hosemicon.com/about.aspx
MCL Electronic Materials	Local	6” polished	http://www.ly-si.com/en/
AST	Local	8” polished (12” future)	www.ast.com.cn
Waferwork	Taiwan	6” polished/epi, 8” polished/epi (12” future)	http://www.waferworks.com/
Ferrotec	Japan	8” polished (12” future)	www.ferrotec-global.com/tech_1_2.php
Guosheng	Local	6” epi, 8” epi	http://gs-epi.com/EN/shebei.aspx?CateId=96
Puxing	Local	6” epi, 8” epi	http://www.poshing.cn

Summary总结

2020 Silicon Wafer Market Outlook
2020年硅片市場展望

- Overall:
  - Semiconductor industry is relatively immune to Covid-19 in 1H 2020
  - Wafer demand rises >10% in 1H 2020
  - Wafer demand is expected to be flat in 2H 2020
  - Overall 2020 wafer demand is expected to flat or slight growth (-1% to 3%) vs. 2019

- Headwinds:
  - The resurgence of Covid-19 cases will slow down the reopening of economies
  - The ongoing trade and geopolitical tensions between USA and China
  - Policy uncertainty of USA presidential election
  - Concern of inventory over-build driven by work-from-home and pull-in of Huawei rush orders may suppress demand in 2H 2020, especially memory segment

- Tailwinds:
  - Cloud/datacenter and 5G are still the key industry drivers
  - Laptop/server demand strength is expected to continue into Q3
  - 5G adoption is quickly happening in 2020, especially China
  - Massive government stimulus packages will continue to support the demand for hi-tech products which require more silicon content.

Summary总结

- Next wave of new AIoT applications are expected to drive the continued growth of semiconductor demand going forward.
- More materials like silicon wafer being the largest sector in the entire semiconductor materials supply chain will be consumed in semiconductor fabs to enable the strong growth in super cycle.
- Consolidation in global silicon wafer industry helps tier 1 players to achieve healthy financial performance and sustainable growth.
- Strong wafer demand growth in China semiconductor can’t be solely fulfilled by import and a more localized supply silicon wafer supply chain is necessary.
- The current China silicon wafer industry is highly competitive. Only those companies can meet higher quality requirements will be able to achieve differentiated growth.
- Policy and financial support from China government will continue to help build up solid infrastructure to enable a more localized silicon wafer supply chain.
- Ongoing China-USA technology cold war is de-coupling the global semiconductor supply chain and strengthening the determination of China government to accelerate the localization of China silicon wafer industry.

Q & A 交流討論