



Electronics Materials Information



“GLOBAL MATERIALS MARKETS & SUPPLY-CHAIN TRENDS & CHALLENGES”

TEHCET CMC SEMINAR 2019

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OUTLINE

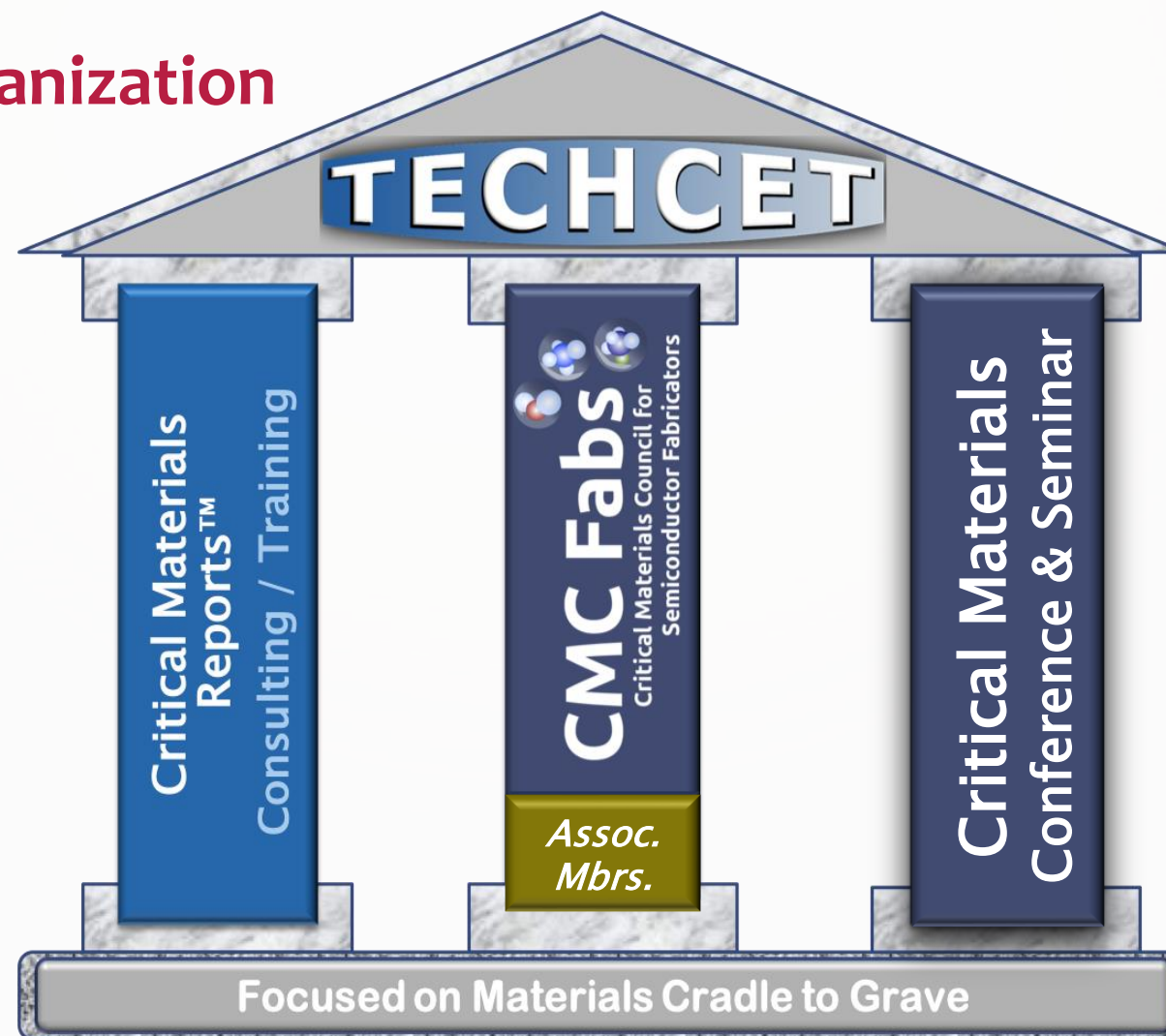
- TECHCET / CMC
- Semiconductor Industry Outlook
- Material Supply Chain Issues
- Material Opportunities and Challenges
- TECHCET Materials Outlook
- Summary

A Fab-Centric Organization

A Semiconductor Materials
Markets & Supply-Chain
Advisory Firm

TECHCET started in 2000 to
support the CMC hosted by
SEMATECH / ISMI and the
materials supply chain.

Supporting the CMC /
SEMATECH for > 15 years



CMCFabs now include:

Broadcom
Cypress
Infineon
Intel
GlobalFoundries
Micron
Nexperia
ON Semiconductor
Samsung
ST Microelectronics
Texas Instruments
TowerJazzPanasonic
& Other tbd

Associate Members: (suppliers) Linde, GAM, SACHEM, Ereztech, Niacet, Wonik, Grikin, Britech, Dow, KFMI, Matheson / TNSC, Eastman, 3M, Silfex/LAM, Heraeus, Morgan Ceramics, ATI Metal Chemicals, Fraunhofer, Feilihua, LCY, Umicore, Momenive, Cryoin, Sinyang, Veeco, Ereztech, EpiWorld

DISCLAIMER

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GLOBAL ECONOMY

- For 2019, IMF expects slower growth in nearly 90% of the world
- Softening economic activity in the US, Japan, and Euro area
- Trade disputes have created uncertainty
 - Could lead to “broken supply chains” & “siloed trade sectors”
- Positives: Unemployment at historic lows in the US and Germany; consumer spending

	2018	2019f	2020f
US	2.9	2.4 (2.5)	1.7 (1.7)
Euro Area	1.9	1.2 (1.6)	1.4 (1.5)
Japan	0.8	0.9 (0.9)	0.5 (0.5)
Emerging Market	4.5	3.9 (4.3)	4.6 (4.6)
China	6.6	6.1 (6.2)	6.0 (6.2)
World	3.6	3.0 (3.2)	3.4 (3.5)

Source: IMF (April forecast in parentheses)

SEMICONDUCTOR INDUSTRY OUTLOOK

Spring 2019 - Q2 Update	Amounts in US\$M			Year on Year Growth in %		
	2018	2019	2020	2018	2019	2020
Americas	102,997	74,894	78,933	16.4	-27.3	5.4
Europe	42,957	40,344	41,587	12.1	-6.1	3.1
Japan	39,961	36,098	37,557	9.2	-9.7	4.0
Asia Pacific	282,863	255,251	267,998	13.7	-9.8	5.0
Total World - \$M	468,778	406,587	426,075	13.7	-13.3	4.8
Discrete Semiconductors	24,102	24,138	25,264	11.3	0.1	4.7
Optoelectronics	38,032	39,840	43,112	9.2	4.8	8.2
Sensors	13,356	13,430	14,081	6.2	0.6	4.8
Integrated Circuits	393,288	329,180	343,619	14.6	-16.3	4.4
Analog	58,785	53,617	55,604	10.8	-8.8	3.7
Micro	67,233	63,492	64,928	5.2	-5.6	2.3
Logic	109,303	103,017	108,027	6.9	-5.8	4.9
Memory	157,967	109,054	115,060	27.4	-31.0	5.5
Total Products - \$M	468,778	406,587	426,075	13.7	-13.3	4.8

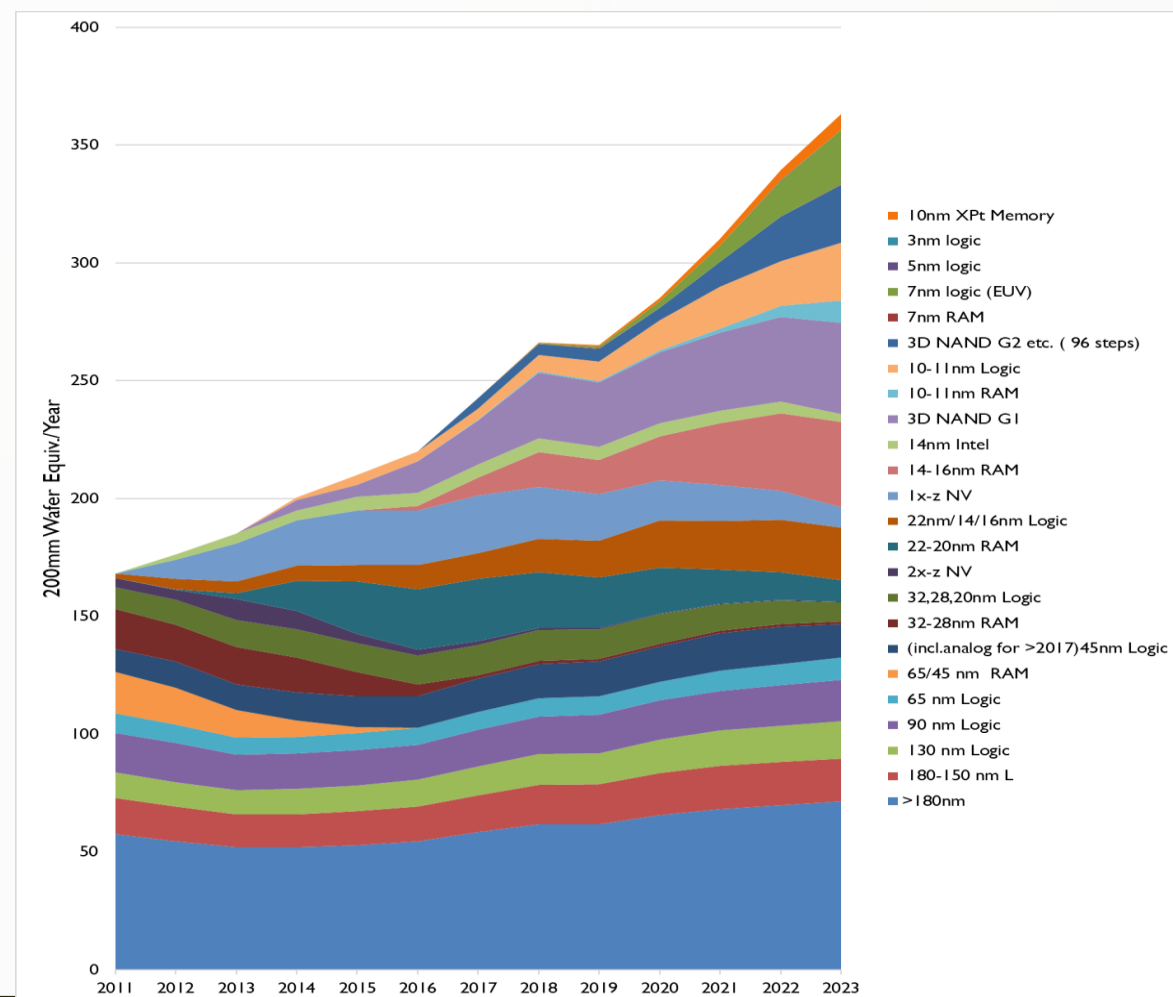
Note: Numbers in the table are rounded to whole millions of dollars, which may cause totals by region and totals by product group to differ slightly.

- WSTS now forecasting a -13.3% decline in 2019 semiconductor revenues
 - June forecast was -12.1%
- Non-memory sales forecasted to decline by -4.3%
- Forecasting 4.8% growth in 2020, with growth anticipated for all device segments and in all market regions

TEHCET WAFER START FORECAST

- Declining wafer starts in 2019:
 - DRAM -7%
 - NAND -3%
- TEHCET forecasts total wafer starts 2018-2023 to grow approaching 5.6% CAGR.
- Forecasted growth rates vary depending on technology node and device type.
 - 16/14nm & below logic approaching +20% CAGR
 - 3D NAND approaching 14% CAGR

TEHCET Wafer Start Forecast



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MATERIAL SUPPLY CONCERNS

- Trade/Tariffs issues impact on raw material and finished materials
 - Trade conflicts between US-China and Korea-Japan
- Korea & Japan have de-Whitelisted each other, thus increasing requirements for exporting each country
 - Korea has qualified non-Japan sources of HF gas (for wet chemicals): Befar (China) and Ram Technology
- Environmental issues and the processing of rare earth metals, Se, Te, Sc, and other metals.
- Non-African sources of metals reduce concerns of conflict minerals being consumed in the electronics supply chain

MATERIAL SUPPLY CONCERNS

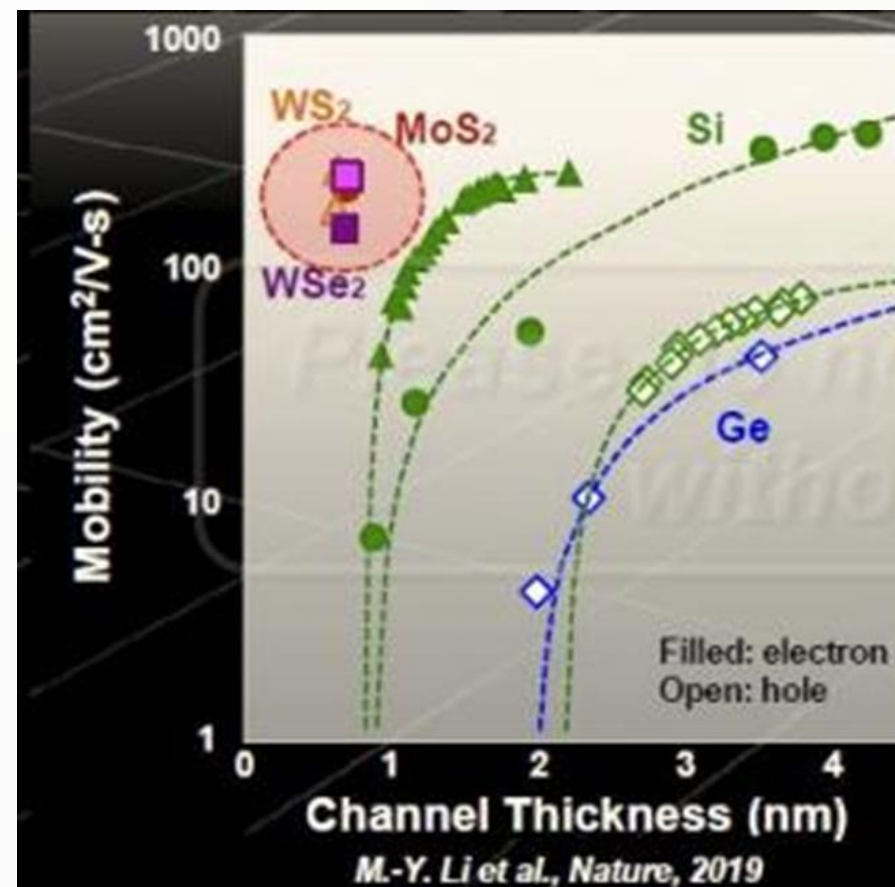
Material Segment	Comments
Fluorspar	<ul style="list-style-type: none">• No shortage though China has become a <u>Net Importer</u>• Mexico increasing production
HF	<ul style="list-style-type: none">• Korea is aggressively securing supply of HF from non-Japan sources due to Japan-Korea trade restrictions.
Helium	<ul style="list-style-type: none">• Currently no shortages are being reported in the semiconductor sector, and gas suppliers are careful in not filling volumes much beyond previous years sales to prevent hoarding by customers.• The tight situation will continue this year and most likely into 2020 until new capacity comes on-line in late 2020 or early 2021.
Neon	<ul style="list-style-type: none">• Neon supply situation has improved significantly with new Neon supply coming on-line and reduced Neon usage by laser manufacturers
Phosphoric Acid	<ul style="list-style-type: none">• Price of Phosphor Rock has been volatile.• China provides 65% of the global phosphor rock supply.
Precious Metals	<ul style="list-style-type: none">• Ru and Ir demand > than current supply

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ALD/CVD PRECURSORS

- US\$1.1 Billion, total of metal & dielectric, and forecasted to have 7.9% CAGR from 2018 to 2023
- There is currently a high demand of ALD Ruthenium test wafers for Metrology and CMP development
- Area-selective deposition is currently in production for capping of Cu with Co, ALD processes have yet to be implemented for selective processing in high volume manufacturing.
- R&D activities in materials research for future nodes – e.g., Ge nanowire/nanoslab device channels, 2D semiconductor materials (ZrSe₂, MoSe₂)



EMERGING PRECURSOR MARKETS

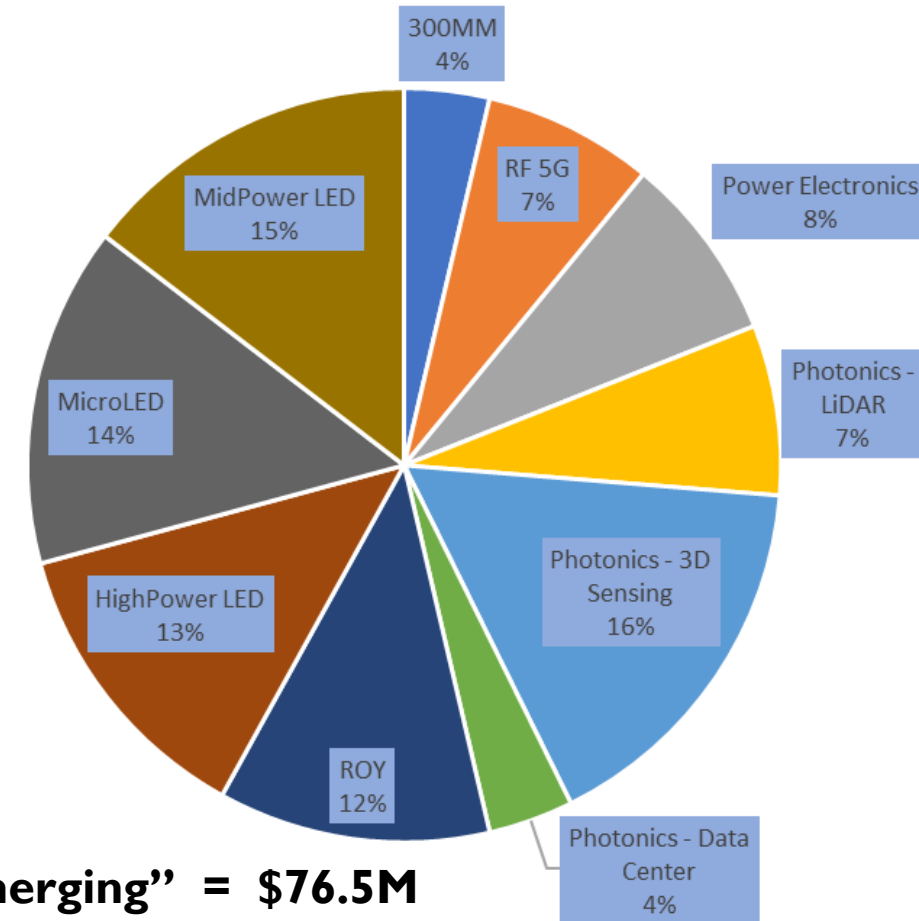
- Niche & emerging memory technologies like :
 - Spin-transfer torque MRAM (STT-MRAM)
 - Resistive RAM (ReRAM)
 - Ferroelectric FET (FeFET) and RAM (FRAM)
 - Cross-Point memory

- New emerging markets:

- Photovoltaic
- Display
- MEMS
- Power Electronics
- LED/ μ LED, Optical
- Lithium Battery (EVs, Mobile)
- Parts and powder coating
- Medical / Healthcare

Non-semi applications with numerous opportunities for ALD/CVD processing

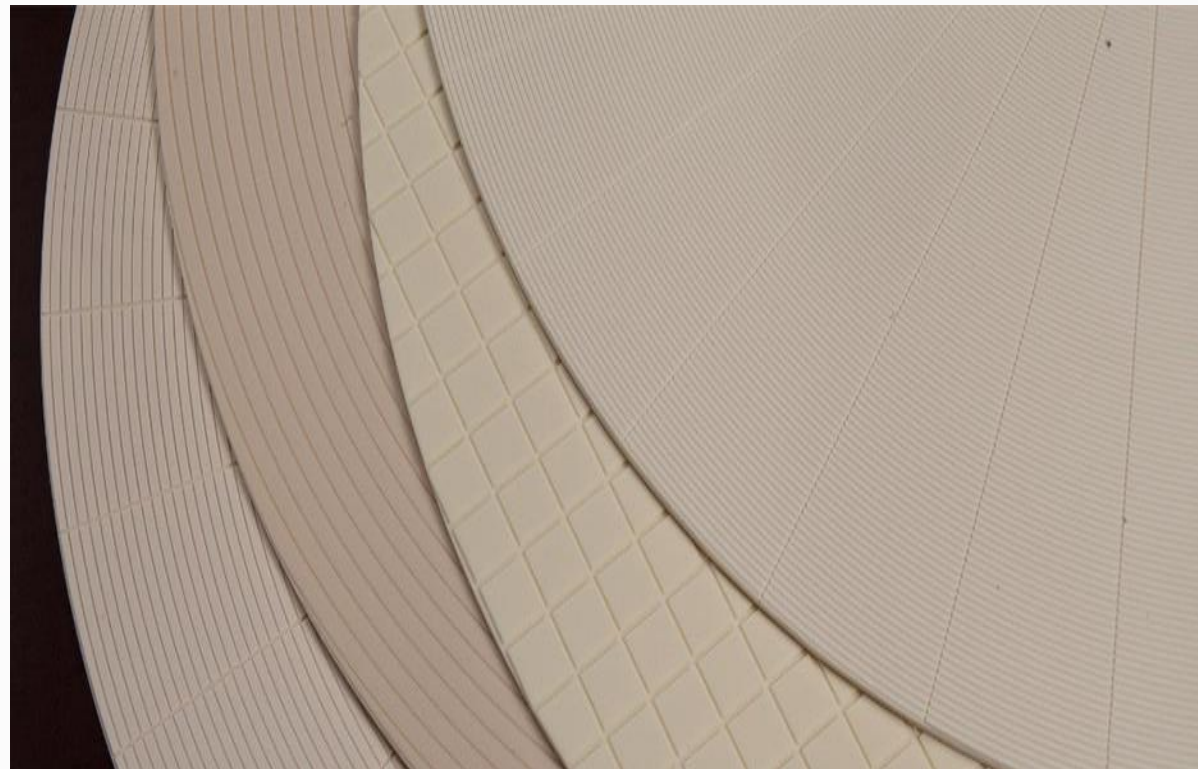
Precursors Market Applications



Total “Emerging” = \$76.5M

CMP CONSUMABLES

- Slurries, pads, & disks are a US\$2.7 Billion market growing at 5.4% CAGR from 2018 to 2023
- Slurry customization and rapid prototyping are more common in the market
- Soft pad technology for defect critical process steps. 3D printed pads starting to be evaluated.
- CVD diamond disk is a growing technology for advanced nodes. Structured CVD diamond conditioning disks improves soft poromeric pad performance



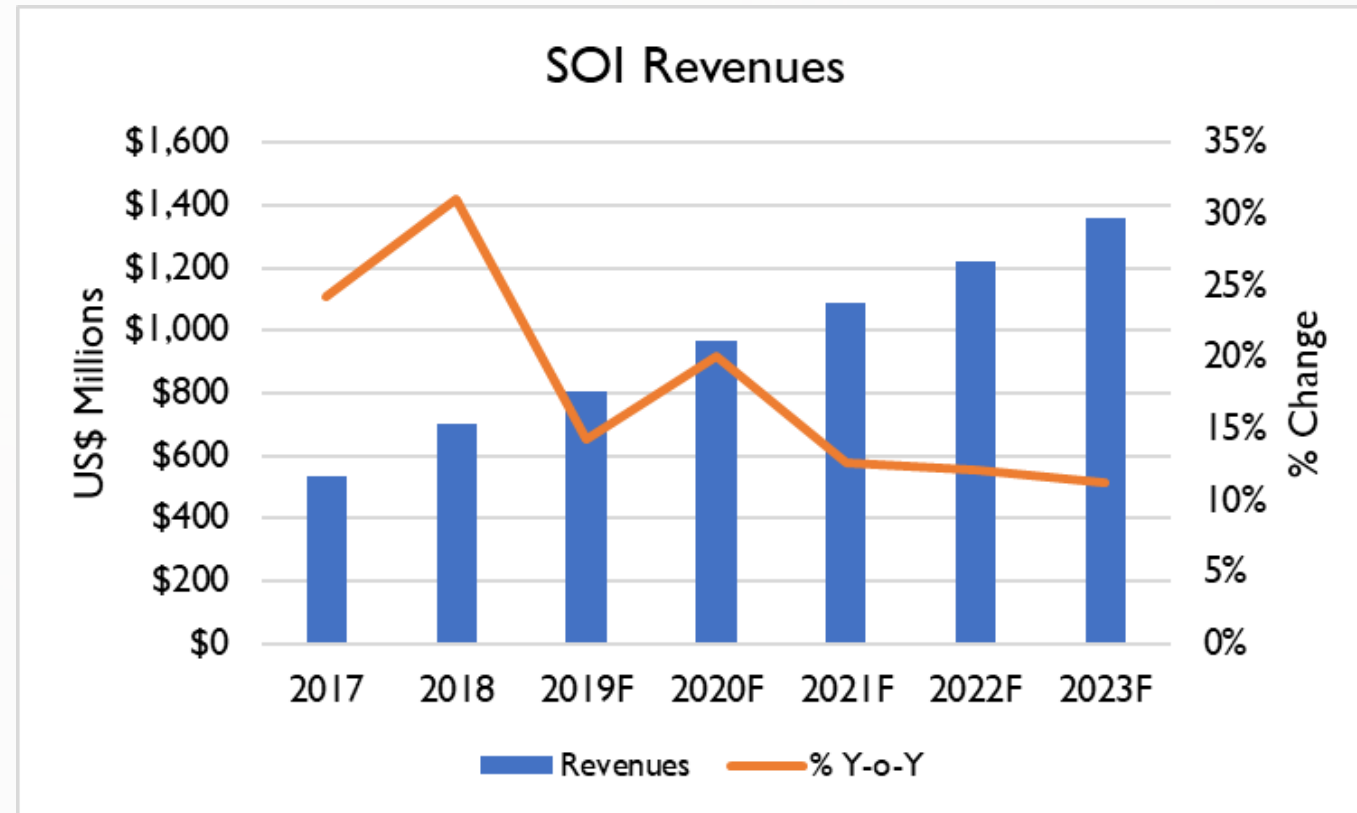
Source: DuPont

SPECIALTY GASES

- The US\$3.9 Billion specialty gases will grow at a CAGR of 6.2% through 2023.
- The specialty gas growth is being driven by 3D NAND with the need for additional etchant and cleaning gases as well as some deposition gases to create the 3D structures.
- NF3 demand continues to increase in double digits and will continue to grow at a CAGR of around 16% through 2023 due to the significant growth in OLED and 3D NAND devices.
- WF6 continues to grow at a respectable annual rate and demand will grow at a 16.3% CAGR through 2023.
 - 3D structures used in NAND drive the multiple depositions required to interconnect the interlayers

SOI WAFERS

- 14% CAGR from 2018 to 2023
- RF and 5G: FD-SOI, SiGe-SOI
- Cavity SOI (CSOI) for higher end sensor market for automotive applications.
- Use as base platform for photonic devices

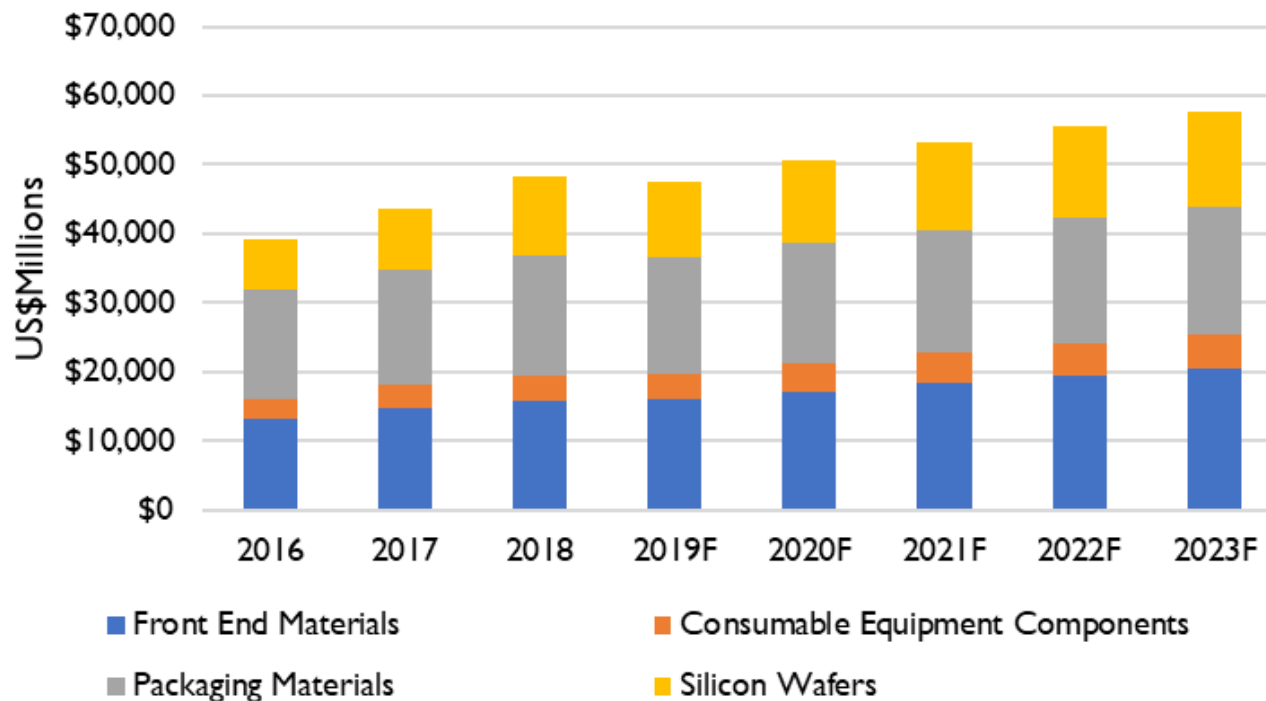


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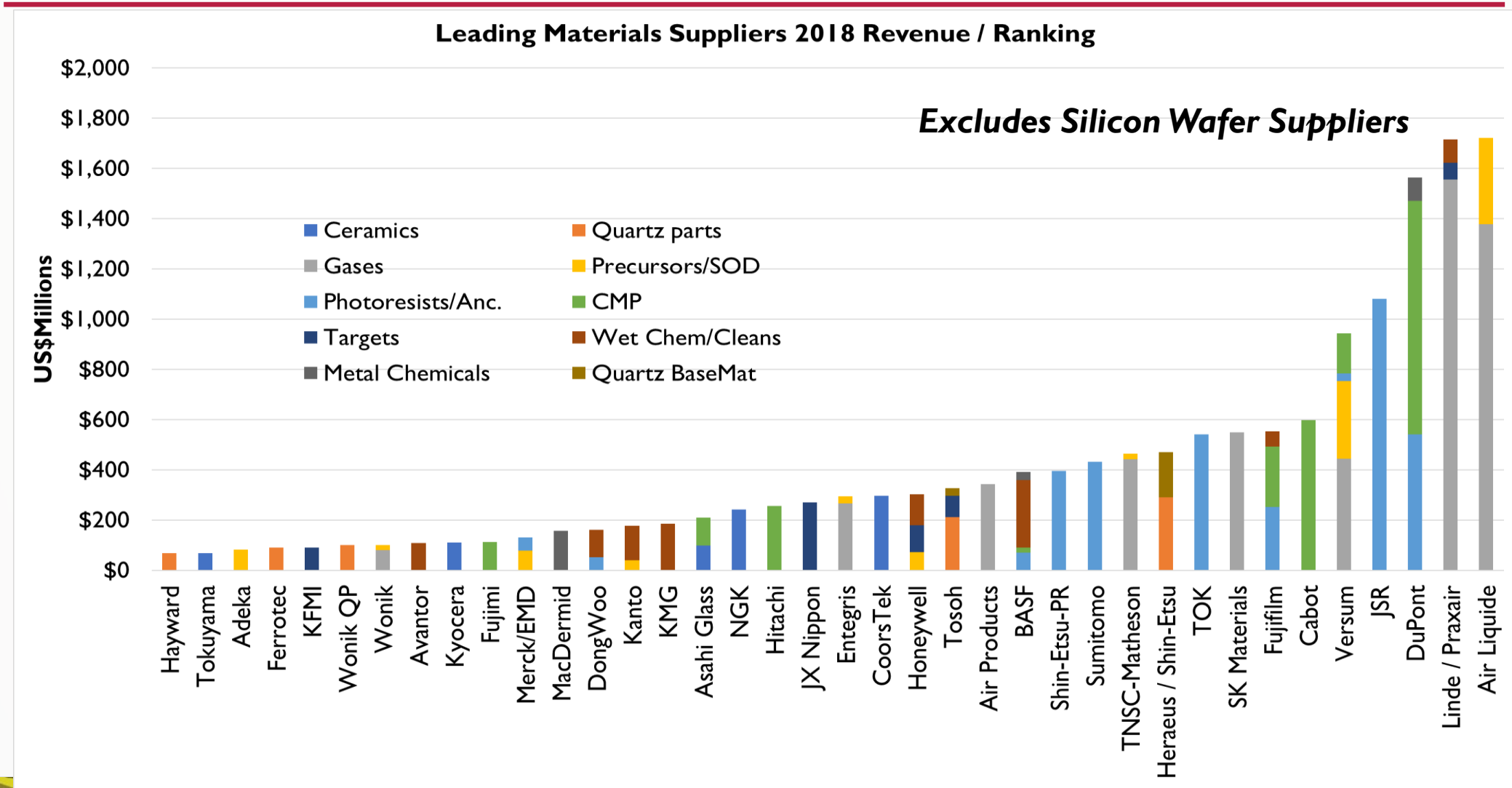
SEMICONDUCTOR MATERIALS OUTLOOK

Global Semiconductor Materials Outlook



- \$47.6 Billion market in 2019, a -1.4% decline from 2018
- Strongest growth over the forecast period for precursors, CMP consumables, precursors, advanced photoresists, SOI wafers, specialty cleans, and specialty gases.
- Overall materials 3.6% CAGR growth from 2018 to 2023.
- Front-end materials to grow at 5.4% CAGR

ESTIMATED 2018 SUPPLIER RANKINGS



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SUMMARY

- Trade issues and slower global economic outlook dampening semiconductor industry outlook, though industry recovery currently expected for 2020
- Raw and key material dependencies impacted by geopolitical factors with supply chains to adapt to changes
- Decline in overall materials revenue in 2019 with some “sweet spots” in FE materials
 - 3.6% CAGR through 2023 for overall semiconductor materials
 - >5% CAGR for Front-end Materials
- New 3D device structures for both logic and memory driving materials growth
 - Highest materials growth areas include precursors, etch gases, specialty cleans, and CMP in 3D NAND and in 10nm & below logic
- For more strategic information on materials contact TECHCET

THANK YOU!

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