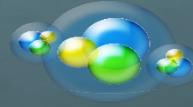




Electronics Materials Information



WW Materials Market Forecast & Roadmaps CMC Conference 2018

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April 2018
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Analyze, Prepare & Move Forward



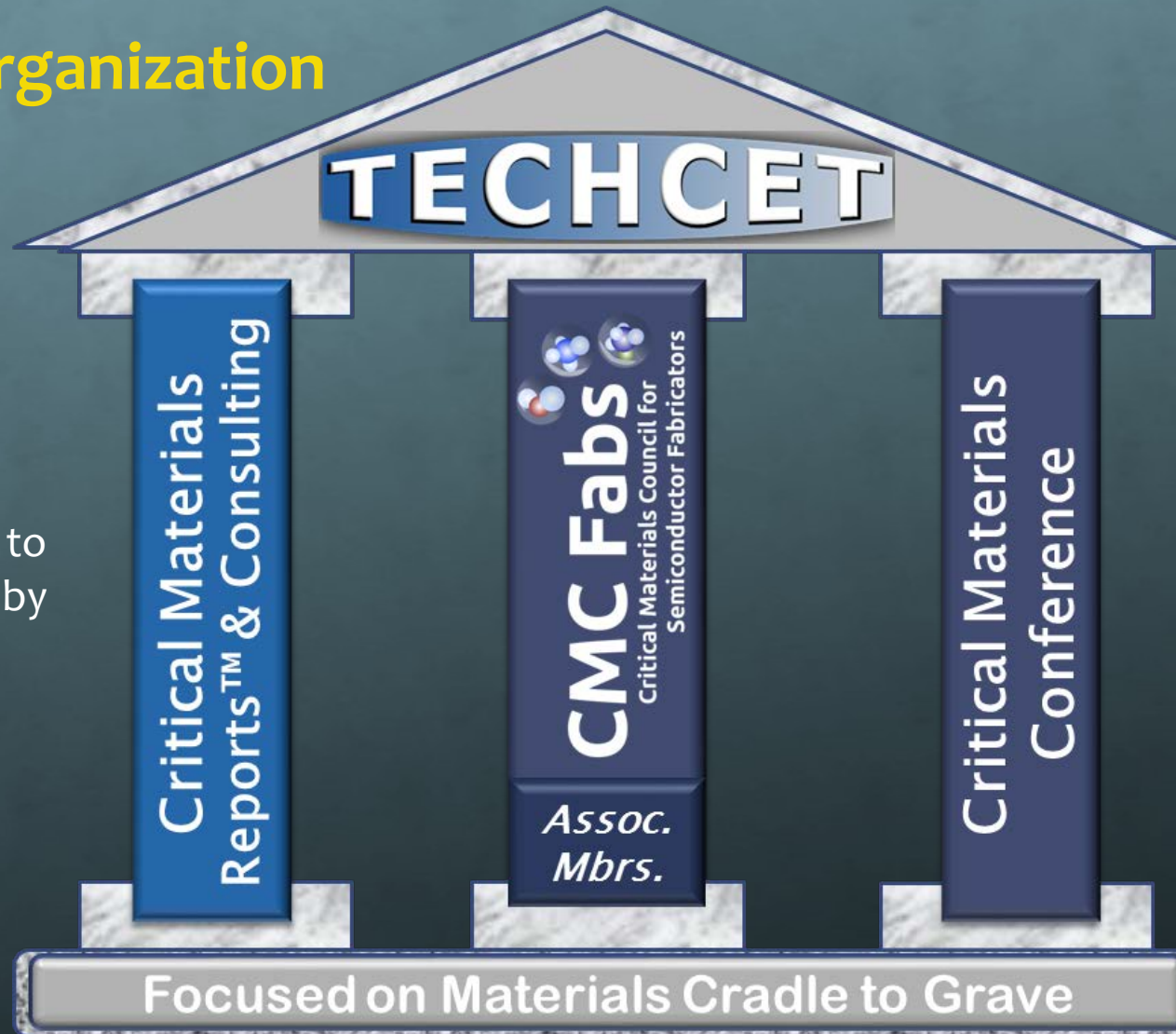
Disclaimer: This presentation represents the interpretation and analysis of information generally available to the public or released by responsible agencies or individuals. Data was obtained from sources considered reliable. However, accuracy or completeness is not guaranteed. This report contains information generated by Techcet by way of primary and secondary market research methods.

A Fab Centric Organization

A Semiconductor
Materials Markets &
Supply Chain
Advisory Firm

TEHCET 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 includes:

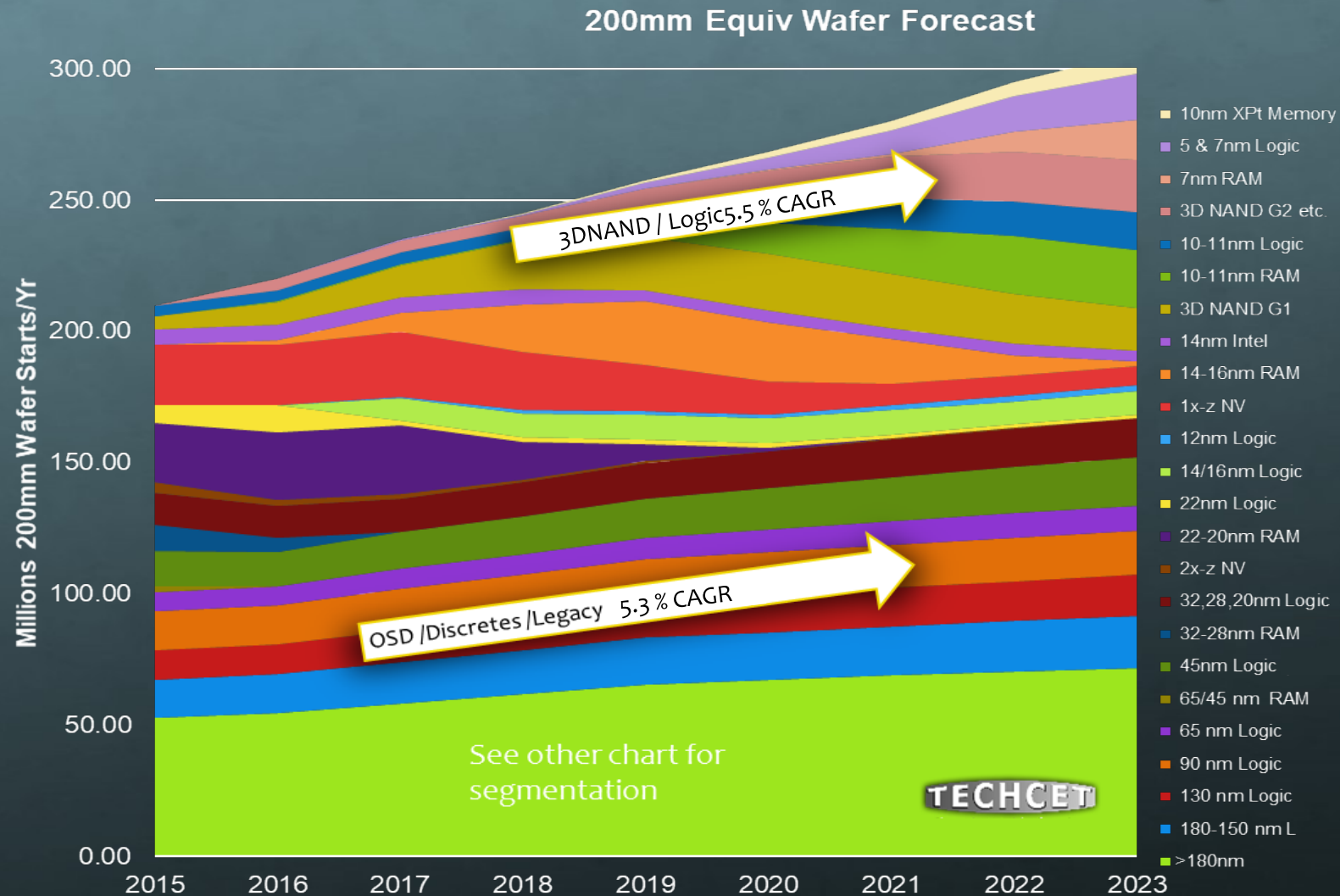
Broadcom
Cypress
Infineon
Intel
GlobalFoundries
Micron
NXP
Samsung
Sematech
ST Microelectronics
Texas Instruments
TowerJazzPanasonic
& Other tbd

For more info go to : www.cmcfabs.org

Outline

- 🌐 **TEHCET's MegaTrends & Drivers**
 - China
 - WW Economy
- 🌐 **WW Materials Trends – Wafers / Mix**
- 🌐 **Materials Roadmap**

WW Materials Trends Update



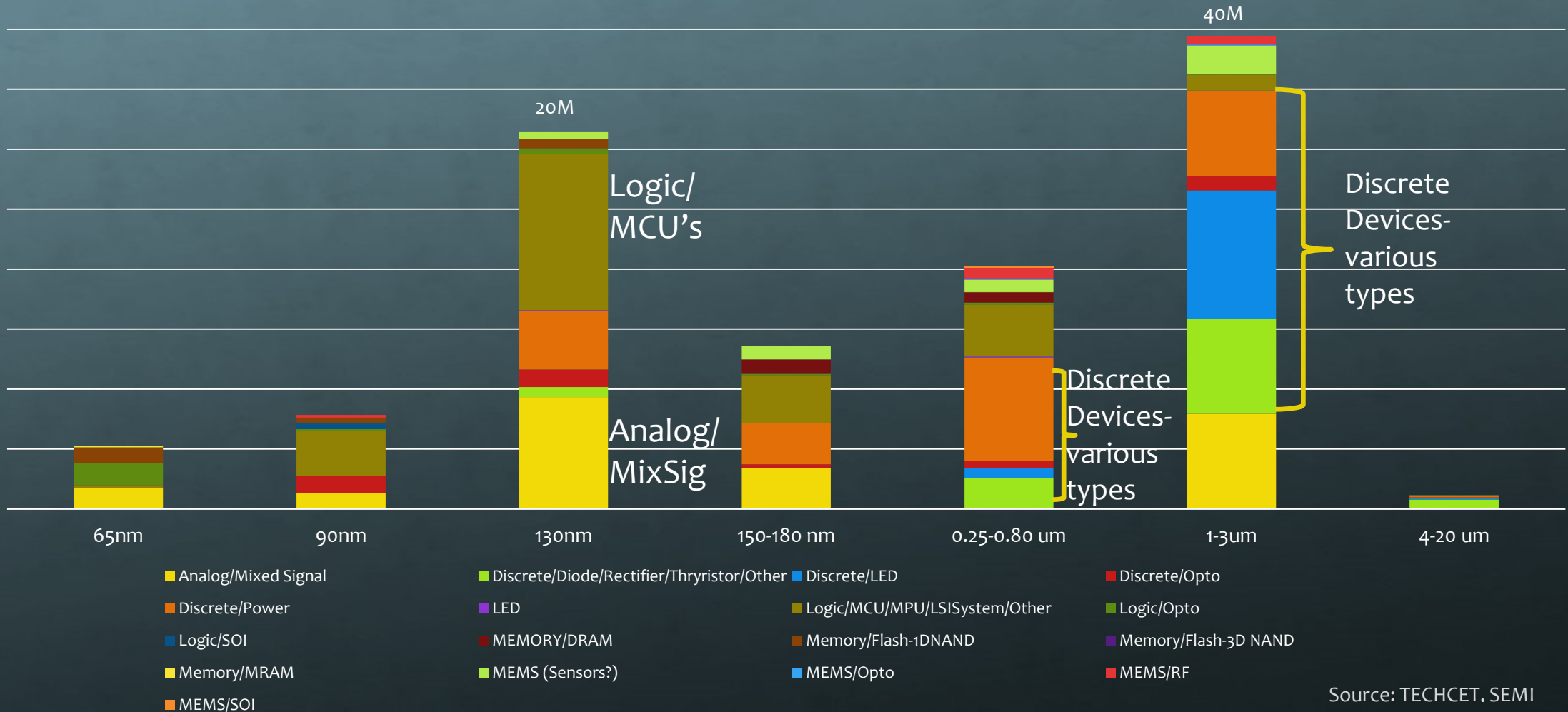
TECHCET MegaTrends

- 🌐 Two key drivers of materials Growth:
 - Legacy (> 65nm)
 - IoT / Consumer
 - Leading Edge
 - Big Data and AI
- 🌐 China a market disrupter / game changer
- 🌐 Economies - Huge influencing factor

MegaTrends Details

- 🌐 Legacy Fabs producing devices 150/200mm are at maximum capacity and continue to grow
 - LE150 mm wafers saw a huge growth in 2017/2016 of ~ 19%
 - 200mm healthy growth but constrained by availability ~15%
- 🌐 45% of all devices are 65nm and larger nodes

Legacy Device Mix growing 6-7%/yr (MSI)



Source: TECHCET, SEMI

China

- 🌐 **China is becoming a market disrupter - coming on strong**
 - Huge government & private investments driving new fab growth
 - Phase I: \$21B (65% to be allotted for IC mfg) Population of up and coming consumers the big carrot -> 1.4B people
 - 20 new 200 mm fabs being build 2017-2019
 - China makes ~16% of the chips they consume
 - Major share of raw materials markets
 - Chip trade balance will be impacted by these fabs looking to sell
- 🌐 **Tariffs on products imported from China and those exported from China will continue to be a concern.**
 - Tariffs - a concern for buyer and sellers

China's influence on the Metals & Minerals

- China's raw materials resources will be the limiting gate for metals/sputter target production as China's economy further expands

	China Supplies X % of WW Supply	Consume Y% of WW Supply	Major semi-raw material supply country
Aluminum	54%	63%	Various
Titanium	33%	63%	China
Tungsten	82%	48%	China
Rare Earths	82%	Nd	China

- China domestic raw materials sources of fluorspar, phosphor rock continuing concerns.
 - Anhydrous hydrofluoric acid price showed a sharp rise in the first half of 2017 in China. The average price increased from 6,366 yuan/ton at the beginning of the year to 11,090 yuan/ton at the end of June, up 74.19%.

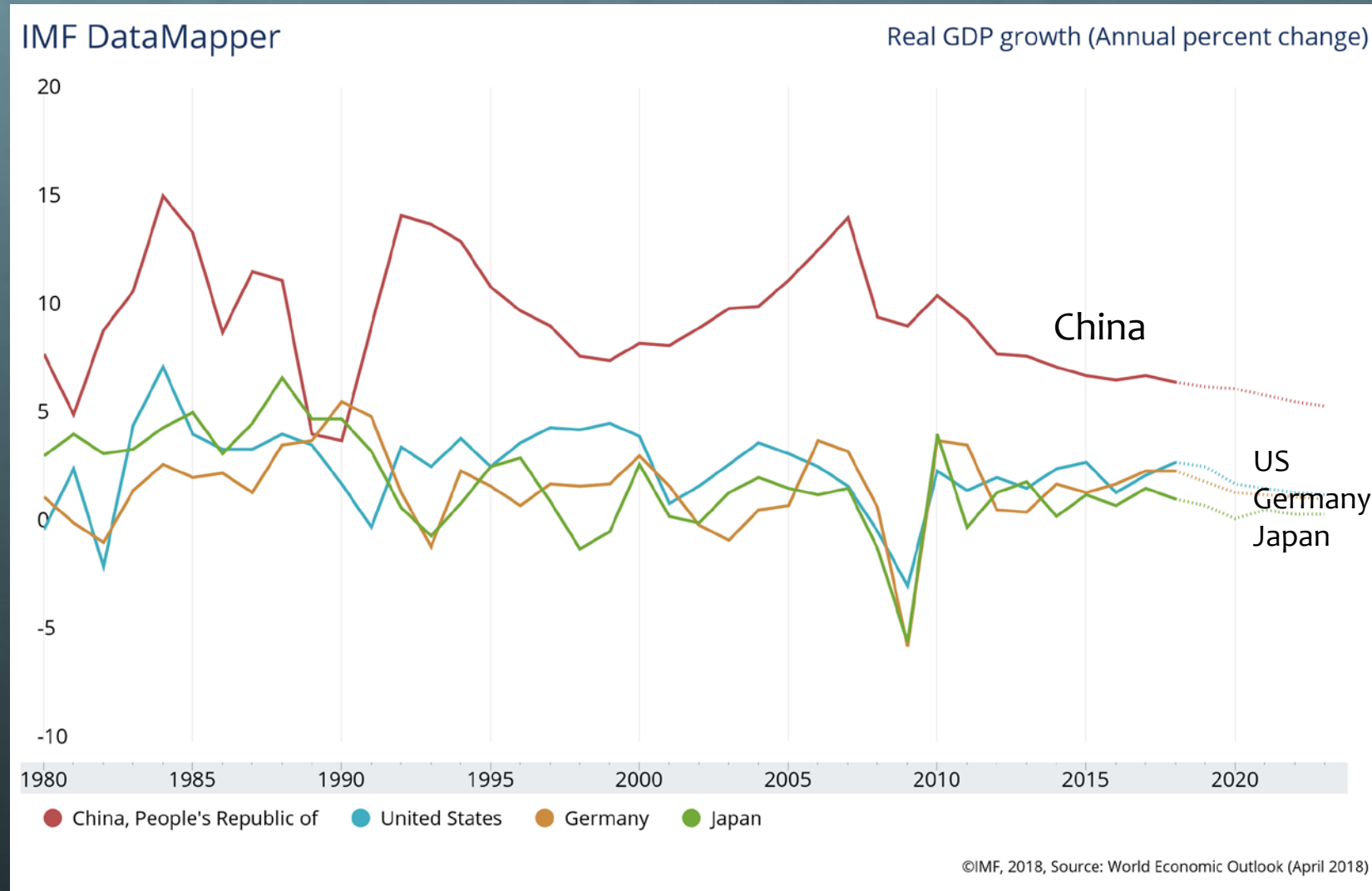
MegaTrends Details – Leading Edge ($\leq 45\text{nm}$)

- 🌐 Logic devices MSI growing at 6% CAGR (2017-2022)
- 🌐 Memory growth (DRAM/NAND) – 3D device ramps will continue to accelerate materials growth at 6.5% CAGR
- 🌐 EUV materials challenges and opportunities
- 🌐 Novel materials not expected until 5nm or later
- 🌐 China – 13 new 300mm fabs coming on by 2019

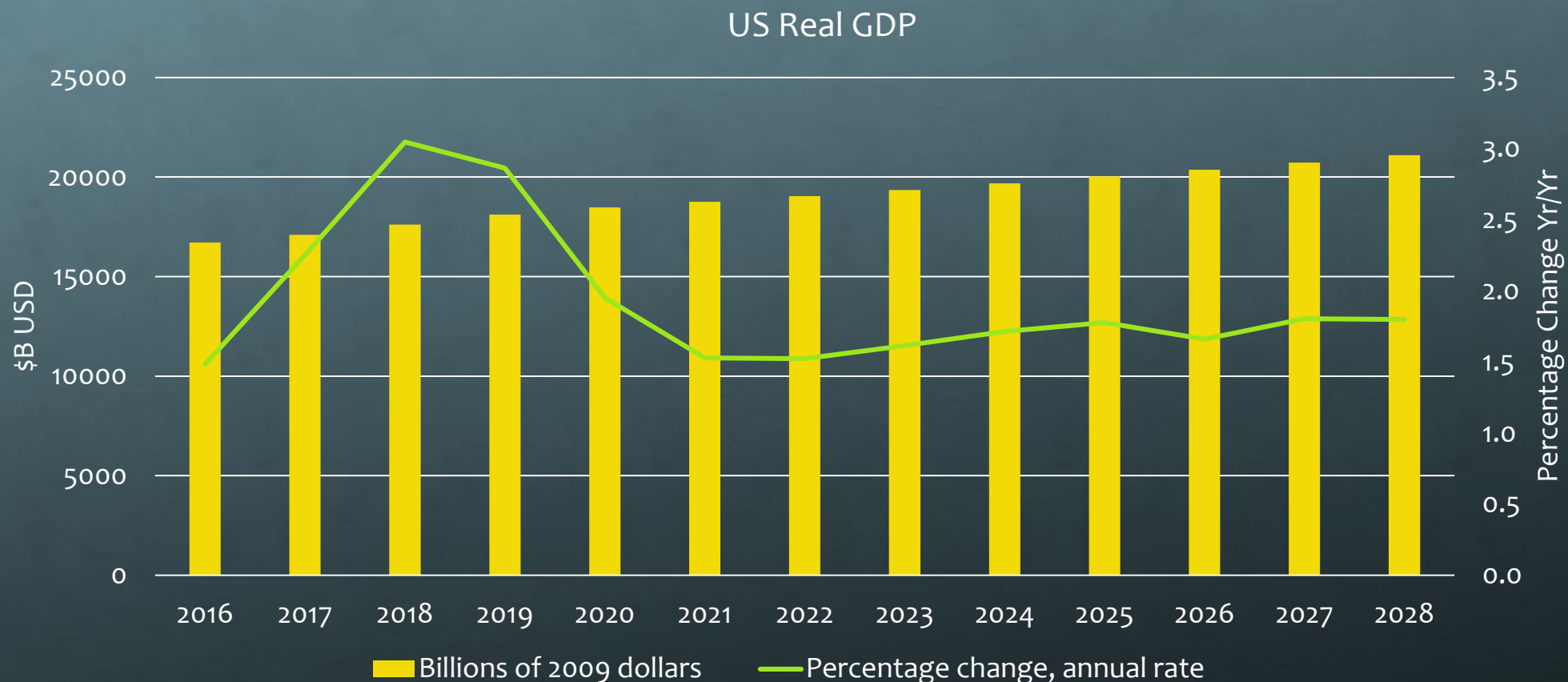
How long can I ride this wave?



GDP Growth Expected to Moderate



The Market is hot but will it last?

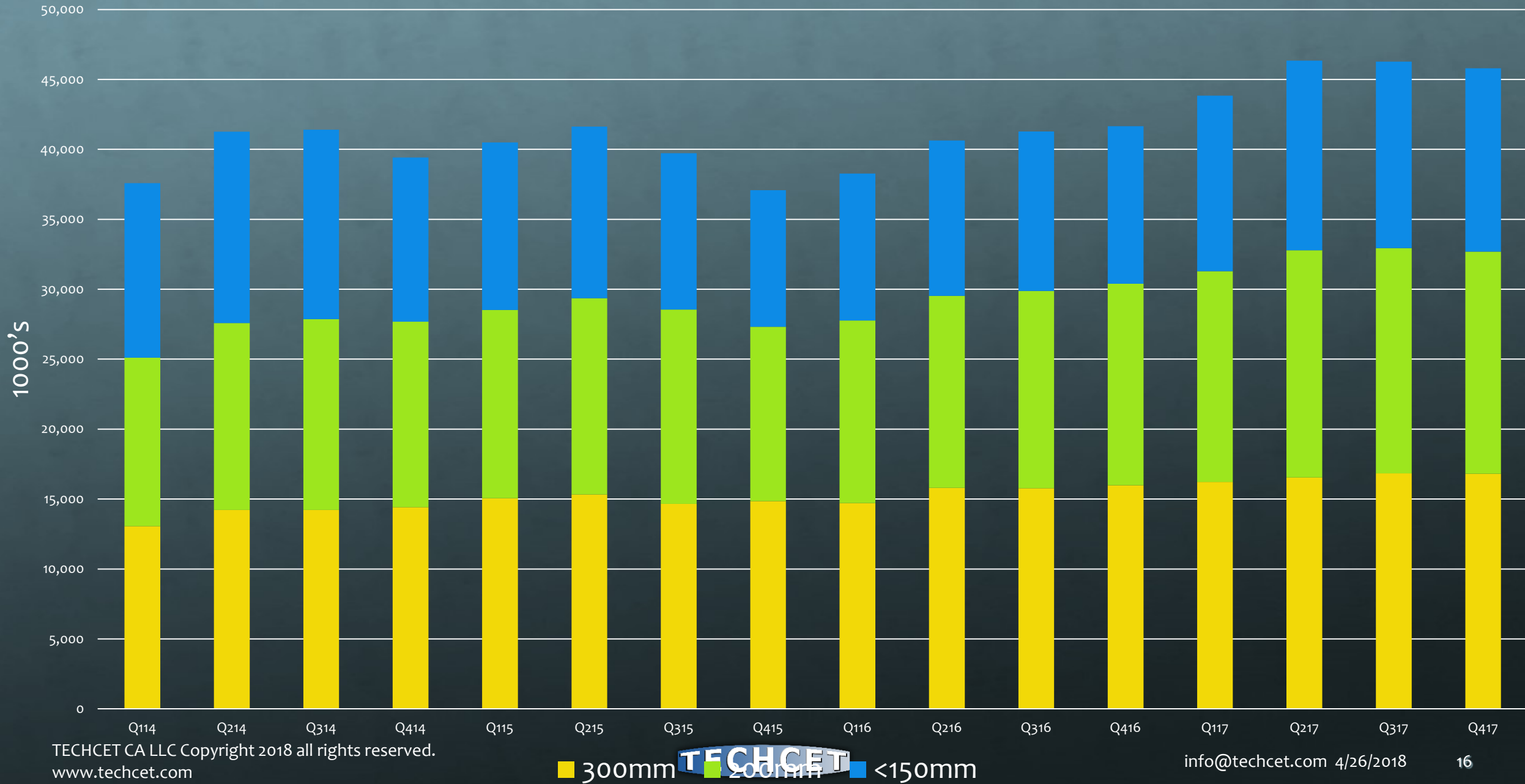


Source: US Congressional Budget Office's June 2017 report, *An Update to the Budget and Economic Outlook: 2017 to 2027*. www.cbo.gov/publication/52801 and TECHCET

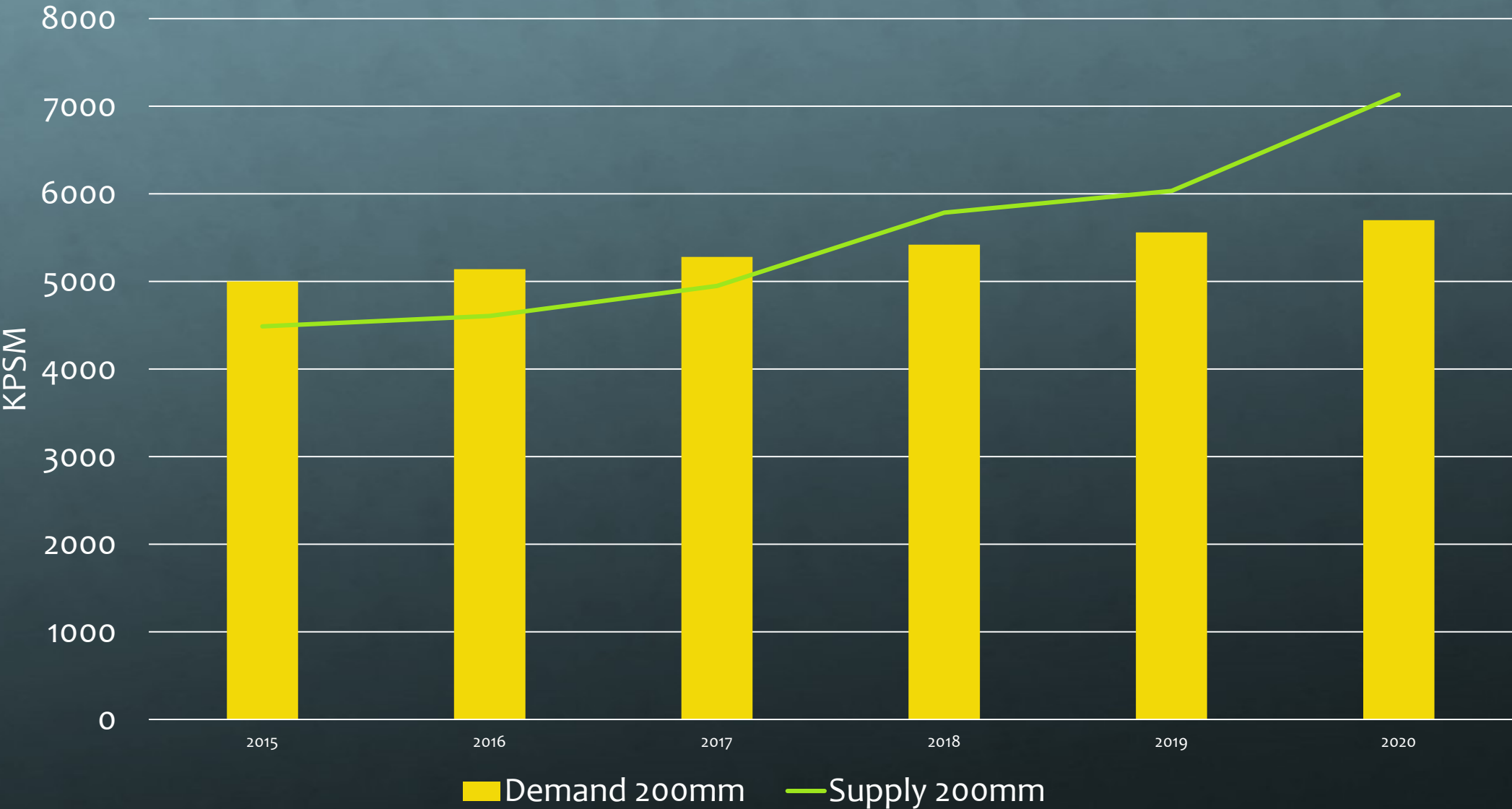
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Wafer Shipments by Diameter

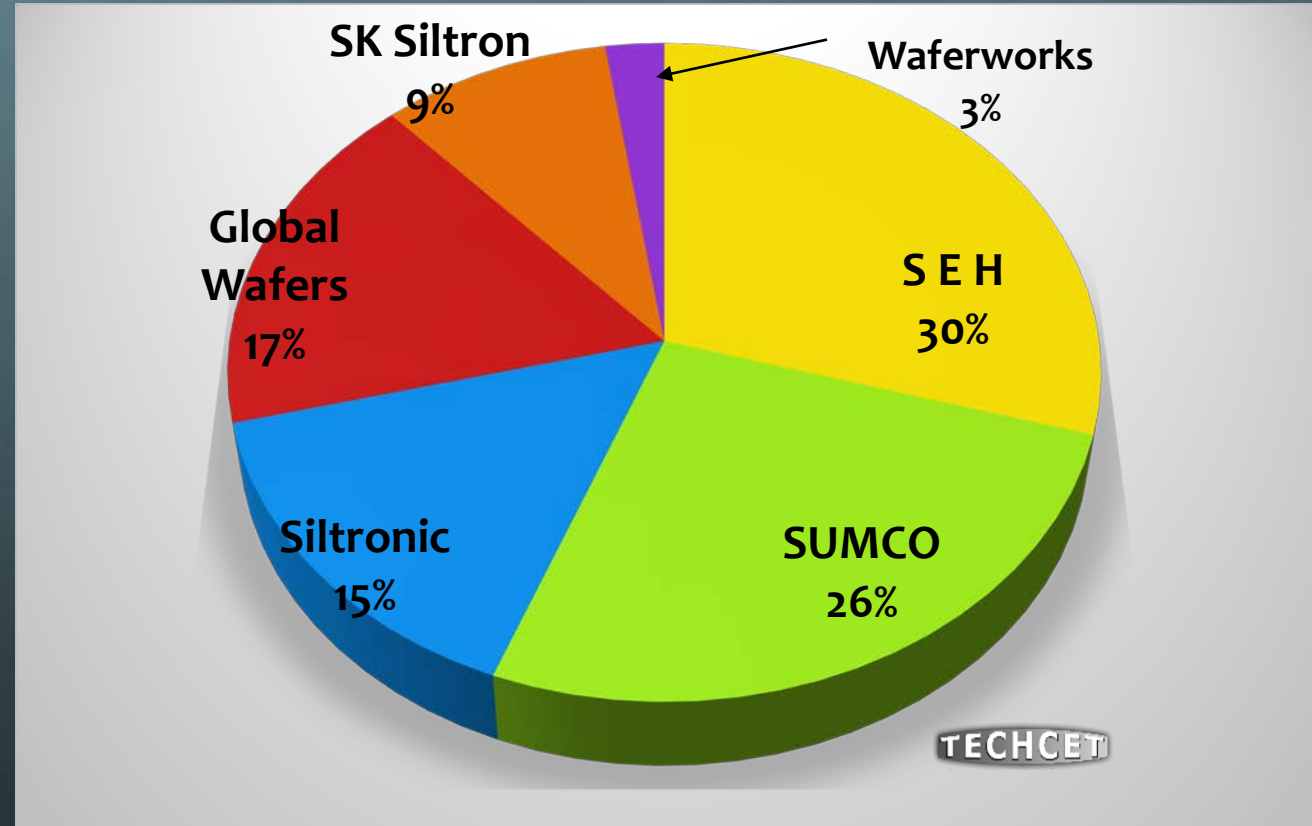


200mm Supply Demand




The Silicon Wafer Market: \$8.7B

- SEH and SUMCO still remain dominant
- Supply running close to supply causing leadtimes and tightness

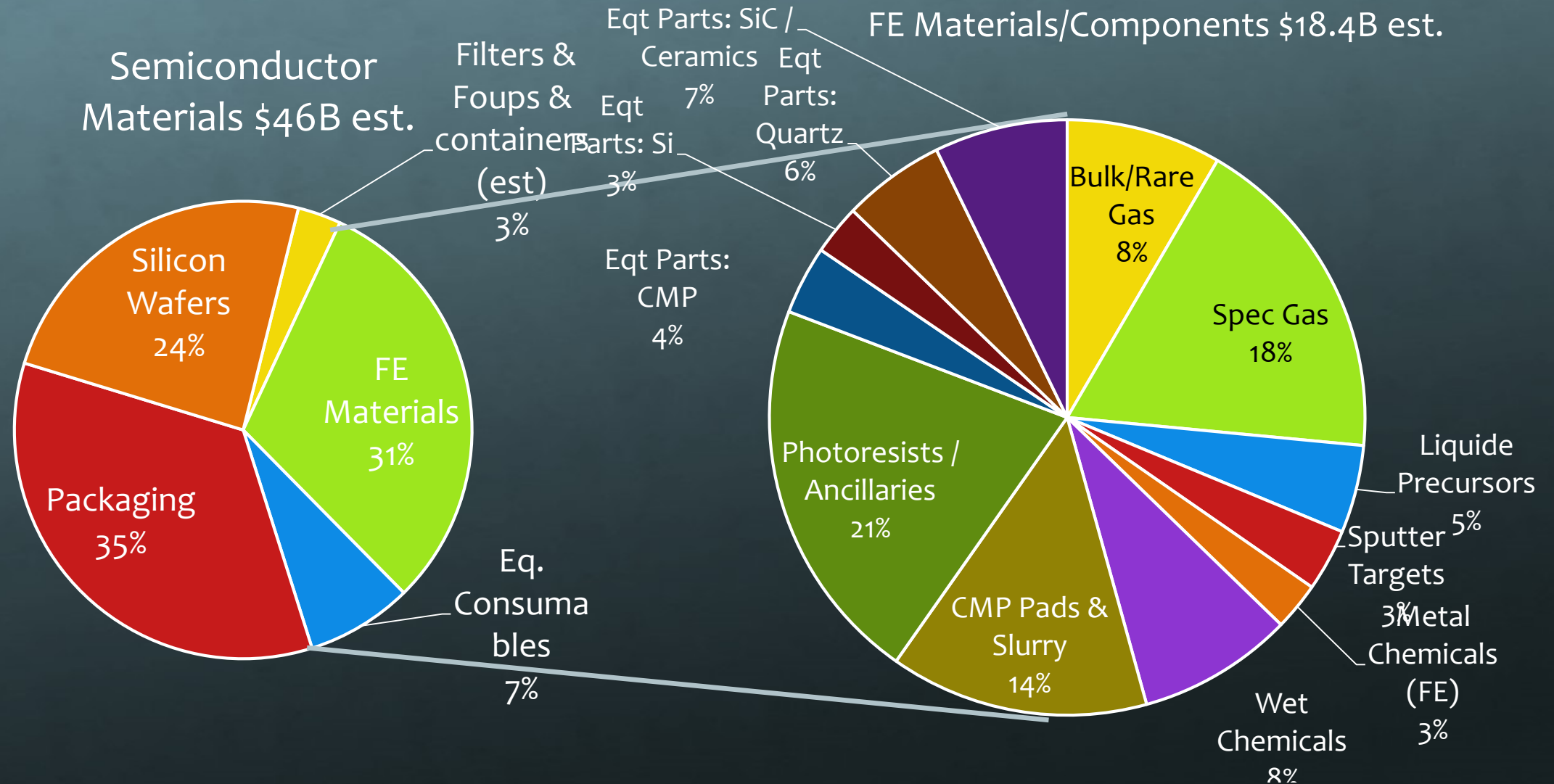


Semiconductor Materials Market Forecast

All revenue data from TECHCET with the exception of packaging materials, which is Courtesy of TechSearch International

TECHCET Forecast	2016	2017	2018 est	2018/17	
Bulk/Rare Gases	\$1,359	\$1,450	\$1,505	3.8%	\$14,883M
Spec Gas	\$2,919	\$3,115	\$3,330	5.9%	
Liquide Precursors	\$730	\$820	\$920	12.2%	
Sputter Targets	\$540	\$583	\$621	6.5%	
Metal Chemicals (FE)	\$407	\$448	\$491	9.6%	
Wet Chemicals	\$1,360	\$1,455	\$1,550	6.5%	
CMP Pads & Slurry	\$2,220	\$2,418	\$2,626	8.6%	
Photoresists / Ancillaries	\$3,387	\$3,625	\$3,840	5.9%	\$3,634M
Eqt Parts: CMP	\$572	\$641	\$714	11.4%	
Eqt Parts: Si	\$380	\$467	\$550	17.8%	
Eqt Parts: Quartz	\$803	\$956	\$1,023	7.0%	
Eqt Parts: SiC / Ceramics	\$1,154	\$1,245	\$1,347	8.2%	\$16,709M
Packaging Materials*	\$15,493	\$16,252	\$16,709	2.8%	
Silicon Wafers	\$7,201	\$8,710	\$10,701	23.0%	\$10,701M
 Total	\$37,789	\$41,357	\$45,927	11.3%	

Materials Markets



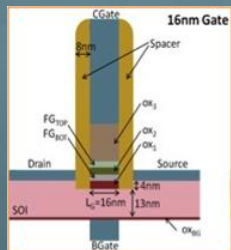
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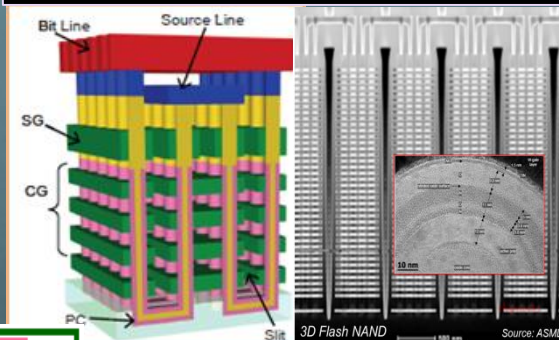
IC Technology Roadmap Evolutions/Revolutions

Note "Node" is "nm" performance, physical is GLph

Non-Volatile 1X & 1Z nm Shrink Planar NAND



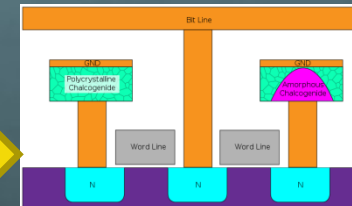
Non-Volatile 80-30nm features 3D NAND (BiCS, TCAT, etc.)



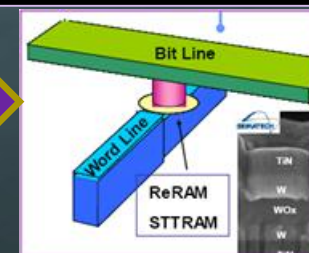
Charge Trap Flash in Vertical Plane also called 3D or V-NAND

3D/V-NAND Extend >5 yrs
(longer than first expected)
16 to 512? Layers

Non-Volatile <10nm CNT? PCM



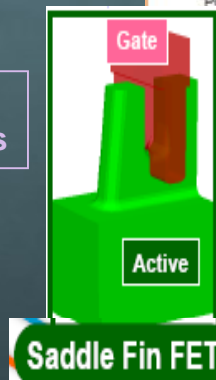
3D Cross Point ReRAM & maybe others?



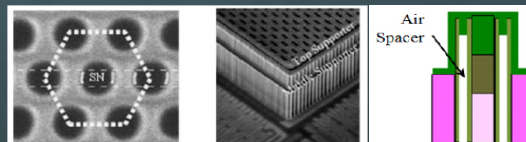
DRAM 32-28nm Vertical Capacitors



20nm Planar SOI Hk/MG

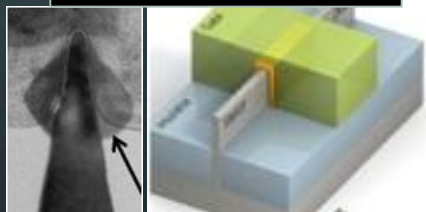


DRAM 26-16nm HkMG + Si Fin

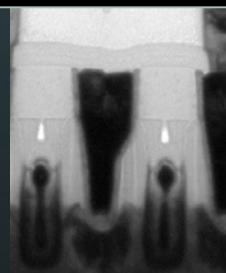


Continue DRAM Shrink w/ MPU
Honey comb cell + Air-gap spacer

14nm TriGate 14/16nm FinFET-STI



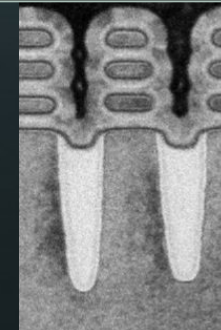
10nm transistor FinFET w/ Co



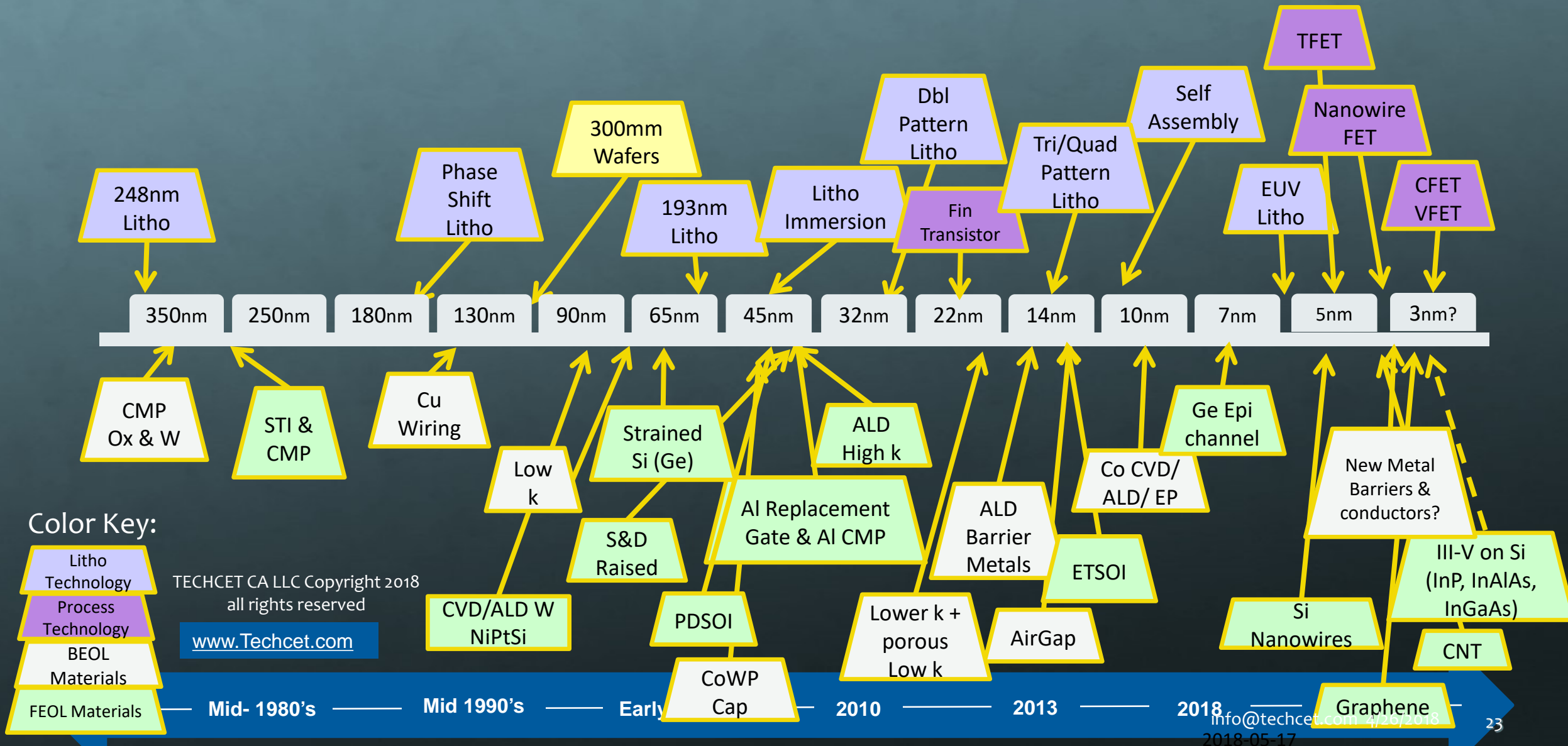
7nm transistor FinFET



5nm Gate all Around



Rapidly Increasing Changes Required to Shrink Logic & RAM



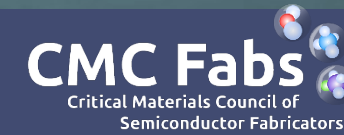
Summary & Assessment

- 🌐 China growing semiconductor competency disrupting the market landscape
- 🌐 Geopolitics will continue to cause strain between US and China resulting in higher tariffs on both sides
- 🌐 2018 expected to be a good year although 4Q2018 growth may start to moderate – caution recommended to prevent excessive inventory build
- 🌐 Legacy Materials growth in parallel to Leading edge
- 🌐 ‘New’ Materials will continue to enable advanced devices
 - novel materials <5nm
 - cobalt at 7nm
 - EUV materials opportunities
- 🌐 The market landscape is changing!

TECHCET's Critical Materials Reports™ & Services

Critical Materials Reports 2017-18

1	CMP Consumables (Pads/Slurry)
2	CMP Equip Consumables (filters, conditioners, etc.)
3	CVD /ALD Hi K Precursors
4	CVD DIELECTRIC Precursors
5	Device Trends & Materials Requirements
6	Equip Components –Quartz*
7	Equip Components -Ceramics & SiC*
8	Gases - Electronic Specialty & Bulk
9	Gases - Neon / Xenon
10	Metal Plating Chemicals
11	Photoresist, Ancillaries & Extension Materials
12	Targets
13	Silicon Wafers
14	Wet Chem & Specialty Cleans (incl. CMP)
15	China Market Brief: Electronics Market Trends*



Critical Materials Council (CMC)

- ✓ CMC Fabs Membership
- ✓ CMC Associate Membership

TECHCET's Services

- ✓ Training: Materials Markets & Technology
- ✓ Custom Consulting Projects



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- MegaFluid Systems, FEI, NexPlanar, IPEC, Motorola, IBM

► Ed Korczynski – Director, Marketing / Sr. Analyst

- Solid State Technology, Intermolecular, Nanomarkets, Applied Materials

► Diane Scott, Ph.D. – Manager, Technical Accounts, Sr. Technology Analyst

- NexPlanar, CMP Solutions, Rohm & Haas / Dow, 3M

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