January 2018
CMC Associate Member Monthly Meeting

- 2017 Wrap – Up
- 2018 Outlook
  - CMC F2F / Conference
    - April 24-27th Chandler Az
- Analyst Update
  - Mike Walden: Si Wafer Market Update
- Joint Session Updates

2017 Wrap-Up

- Successful Meetings + Conference and Seminar
  - Dallas and Taiwan - attendance ~19 in Dallas (vs. 7 in Hillsboro)
- New CMC A members and new CMC members
- Strengthened in-country support
  - Korea / Japan – HT Jeong
  - Taiwan / China – Kuang-Han Ke

2017 Highlights / Wrap-up (2)

BROADCOM
TPSCo TowerJazz Panasonic Semiconductor Co., Ltd.
qorvo
NXP
intel
SAMSUNG
SEMATECH SUNY POLYTECHNIC INSTITUTE
CYPRESS PERFORM
GLOBALFOUNDRIES
Texas Instruments
ST life.augmented
"Major-US-Memory Manufacturer"
infineon
nexperia

CRYOIN ENGINEERING
DOW
MATHESON ask. . .The Gas Professionals
ZINGSEMI
Heraeus
SK telesys
JM Johnson Matthey
MATERION
umicore
KFMI QUALITY CREATES THE FUTURE
WONIK MATERIALS
SACHEM
MOMENTIVE inventing possibilities
THE LINDE GROUP Linde
NOVA-KEM Precursor to Success
LCY
Fraunhofer
BRITECH A JUHUA COMPANY

2018 Outlook

- Membership renewals Ongoing (report section)
- Monthly Meetings with Analysts, see table
- PCN Joint Session Planning
- April 25th 2-4:30 CMC Joint Session with Fabs
- April 26th -27th CMC Conference and Not-so-usual-Roundtable Session
- Fall Seminar planning starting May
- Continue to grow CMC Fab and Associate Membership

PCN / Joint Session
April 25th 2pm, NXP, Chandler

- 1-2 Presentations from CMC Associate Members on PCN Challenges / Case Study
- 1 Presentation from CMC Fabs Member on PCN Challenges
- Discussion
- Actions to be Taken

Analyst Update: Mike Walden

Director of CMC / Business Development, and Sr. Technology Analyst of TECHCET—

- an expert in silicon covering the silicon wafer industry and related technologies.
- 20 years of experience in the silicon supply-chain for high volume manufacturing, including both consumption and supply sides
- 10+ years at BOTH IBM and SUMCO,
- Experience in in a variety of business development and senior / executive management roles and was an active leader in the National and International Technology Roadmap
- He holds a M.S. in electrical engineering from Virginia Tech, and a B.S. double major in physics and mathematics from Morehead State University.

TECHCET
Critical Materials Report:
Silicon Wafer Update

Mike Walden

January 2018

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Market Segment (1)

- Momentum from 16H2 continued into 2017 with 17H1 up sequentially by 20.8% to $190.5 B USD* and 17Q3 achieving a record of $107.9 B*, up 10.2% versus 17Q2
- Although unit shipments declined YoY in 2016 to 868.6B**, they are projected to reach 950 B in 2017 showcased by strong sensor growth and essential components for consumer electronics (logic – special purpose & app. spec., analog and flash memory)
- Silicon wafer unit shipments*** posted their 7th consecutive sequential growing reaching another record at 2,997 MSI in 17Q3 (up 0.6% and 9.8% QoQ, YoY respectively)

Source: * SIA Sep - Nov 2017, ** IC Insights Mar 2017, *** SEMI SMG Nov 2017

Market Segment (2)

- Semi revenue was bolstered by strong DRAM price appreciation, increasing from 16Q3 by approximately 40% for key categories and upwards of 75% full YoY, the largest increase since 1994
- After a slight aggregate decline in 2016, silicon wafer pricing rebounded in 2017, up for some 300 mm customers / products by estimates in the range of 20 – 30% through 4Q17, contributing to strong earnings reports and financial performances by suppliers
- Lagging 300 mm in price appreciation, 200 mm is now experiencing marked increases and in some instances, are exceeding the relative growth of the larger diameter wafer
- Market fears concerning shortages in this critical material have led major silicon wafer customers to negotiate extended / multi-year contracts with suppliers in addition to pre-payment of capex to bolster certain products (leading-edge) and general expansions as well

Market Segment (3)

- While price appreciation of silicon wafers impacts cost of chip production, this bodes well for the semiconductor supply-chain
- Ongoing price erosion long impacted silicon wafer suppliers' ability to adequately reinvest and expand capacity
- This trend is slowly being reversed but changes in the demand can occur quickly and can derail the recovery

Financials (Jul 1– Sep 30)

Siltronic
- CY Q3 2017 - Net Sales 30.0% YoY, 8.8% QoQ
- CY Q3 2017 - EBITDA 188.6% YoY, 46.5% QoQ

Shin Etsu Handotai (S E H)
- FY Q2 2018 - Net Sales 23.9% YoY, 5.5% QoQ
- FY Q2 2018 - EBIT 76.6% YoY, QoQ 11.2%

SUMCO
- CY Q3 2017 - Net Sales 27.4% YoY, 4.2% QoQ
- CY Q3 2017 – EDITDA 108.2% YoY, 14.9% QoQ

GlobalWafers
- CY Q3 2017 - Net Sales 180.8% YoY*, 6.9% QoQ

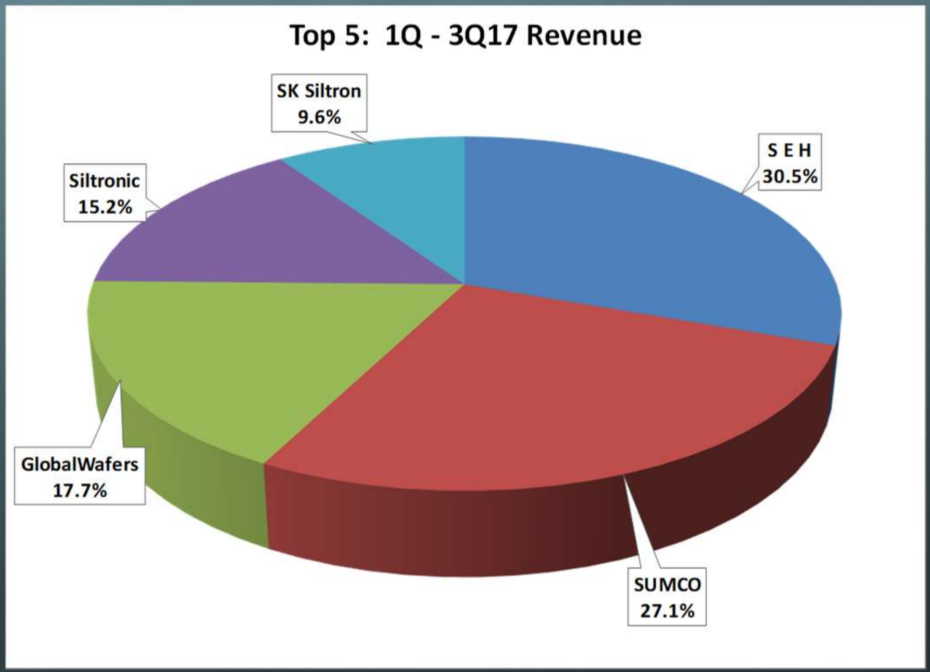
SK Siltron
- CY Q3 2017 – Net Sales 15.2% YoY, 6.0% QoQ**

As Reported
No Currency Conversion

Dramatic improvements in sales and profits are driven across the board by strong demand, tight supply and rising prices

* Includes SunEdison gains ** TECHCET estimate

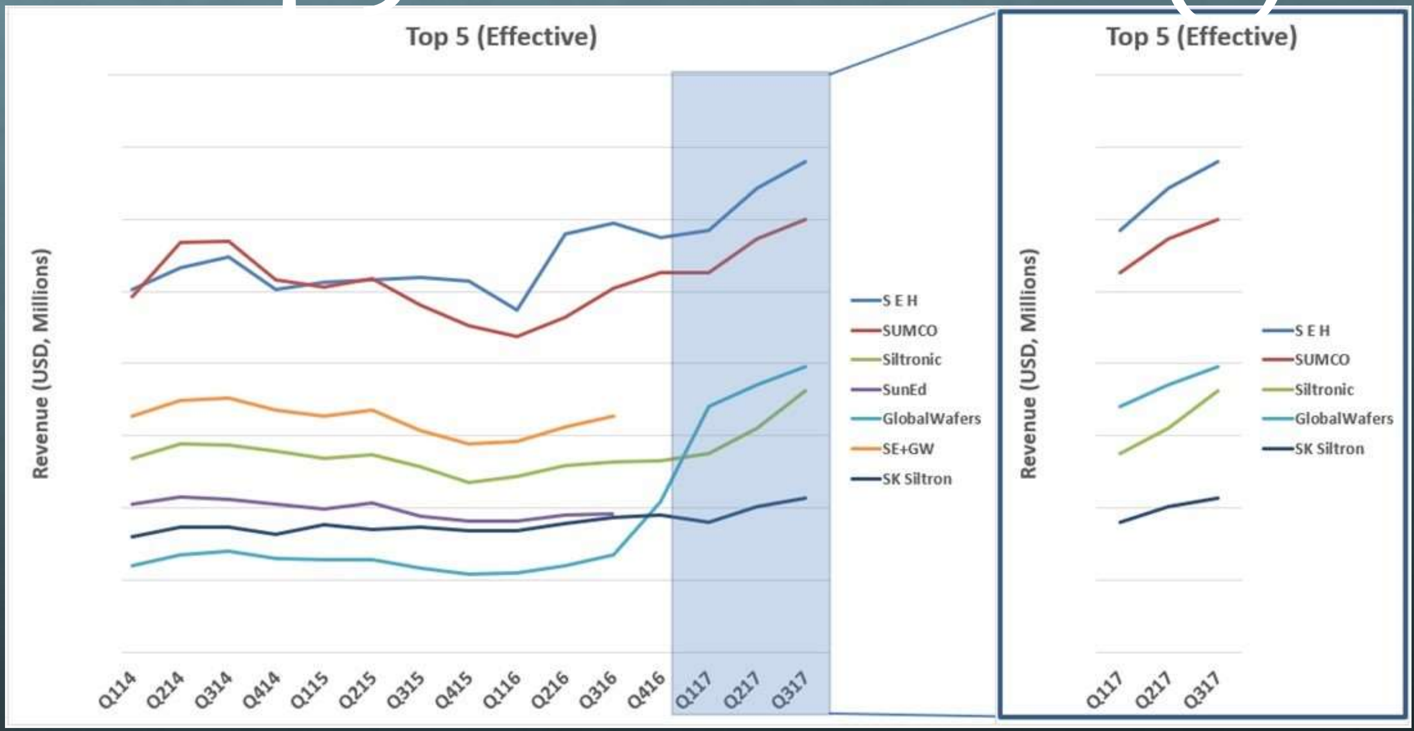
Top 5 Market Leaders (1)



- S E H continues to lead the top 5 who account for more than 97% of total wafer revenue
- The top 2, who had for a protracted time accounted for more than 60% of the total, have now fallen to below 58%
- Siltronic has made the strongest improvement in revenue share based upon a very strong 17Q3, capturing ground mainly from the top 2

Source: Company reports, TECHCET

Top 5 Market Leaders (2)



The evolution of the top 5 – 2 still clearly lead the pack but their lead continues to shrink

Source: Company reports, TECHCET

Mergers & Acquisitions

- No significant M&A activities for the quarter

Expansions (1)

- As forecasted demand continues to climb, there are increasing concerns regarding the availability of silicon with some allocations already being made public
- Initially a 300 mm issue, this has now spread to 200 mm, bolstered by automotive, industrial and IoT growth, and is even beginning to trickle down to 150 mm
- SUMCO became the first top 5 supplier to publicly disclose expansion (300 mm) sighting that previous reticence has been overcome largely due to substantially appreciating prices

Expansions (2)

- Slated for Imari to be available in 1H19, this brownfield expansion is scheduled to add 110 k wpm which accounts only for approximately 2% of the current installed base
- Ferrotec is pursuing addressable markets for semiconductor wafers (primarily in China) and has brought 200 mm crystal growth to Yinchuan China earlier in 2017, coupled with expanded wafering at the Shanghai facility, targeting 100 K wpm overall (in addition to the installed capacity of 350 k wpm of 150 mm and smaller)
- GlobalWafers and Ferrotec Shanghai (FTS) formed a joint venture sales company to market the 200 mm wafer output identified above (Shanghai GROWFAST Semiconductor Technology Co., LTD.)

Expansions (3)

- In addition to 200 mm expansion, Ferrotec has also reportedly been considering a 300 mm silicon production operation in China
- WaferWorks is also expected to bring their new 200 mm facility on line in Zhengzhou, China this quarter, a plant which will ultimately reach 200 k wpm, and additionally announced expansion of their Longtan, Taiwan facility from 200 k to 250 k wpm in 2H17

Expansions (4) - Update

- **Siltronic is the latest to officially announce a small expansion in 300mm capacity**
- **Slated for 2019, brownfield expansion will tally approximately 70 k wpm, accounting for less than 1.5% of the total installed WW base**
- **This expansion is funded through customer pre-payments and extended contracts (LTA's)**

Plant Closures / Discontinued Operations (1)

- **Wacker Chemie AG's Charleston, Tennessee polysilicon plant operations remain suspended**
- **The most recent update came during late October wherein AG's executive board offered the following statement**

"We are working hard toward restarting production. We will start up the facilities again as soon as an inspection has confirmed they are safe."

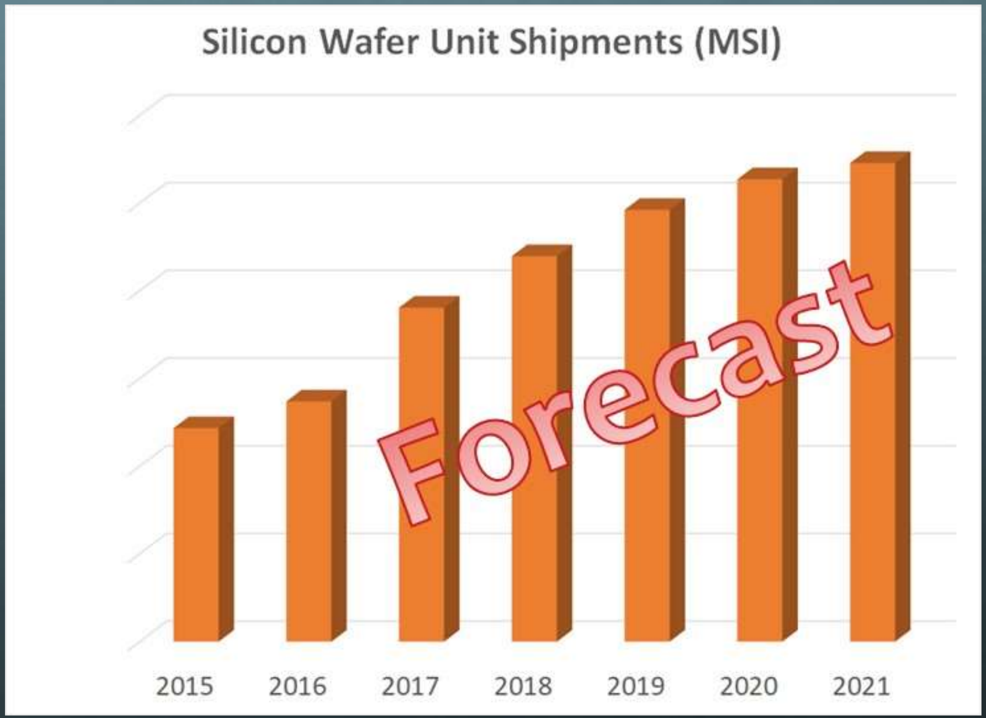
- **Capacity at its two German facilities has been sufficient to cover contracts and 3Q17 represented a record polysilicon output for the company**

Plant Closures / Discontinued Operations (2)

- **Hemlock Semiconductor (HSC), in October 2017, announced a layoff of 100 employees from its Michigan polysilicon plant**
- **Strongly focused on PV polysilicon production, trade disputes (China-imposed import tariffs and competition) have led to this move**
- **According to a company spokesperson, the output will shift to more strongly embrace semiconductor-grade polysilicon output**

"…HSC is simplifying and streamlining its organization to meet the new market realities."

Forecasts – Revised

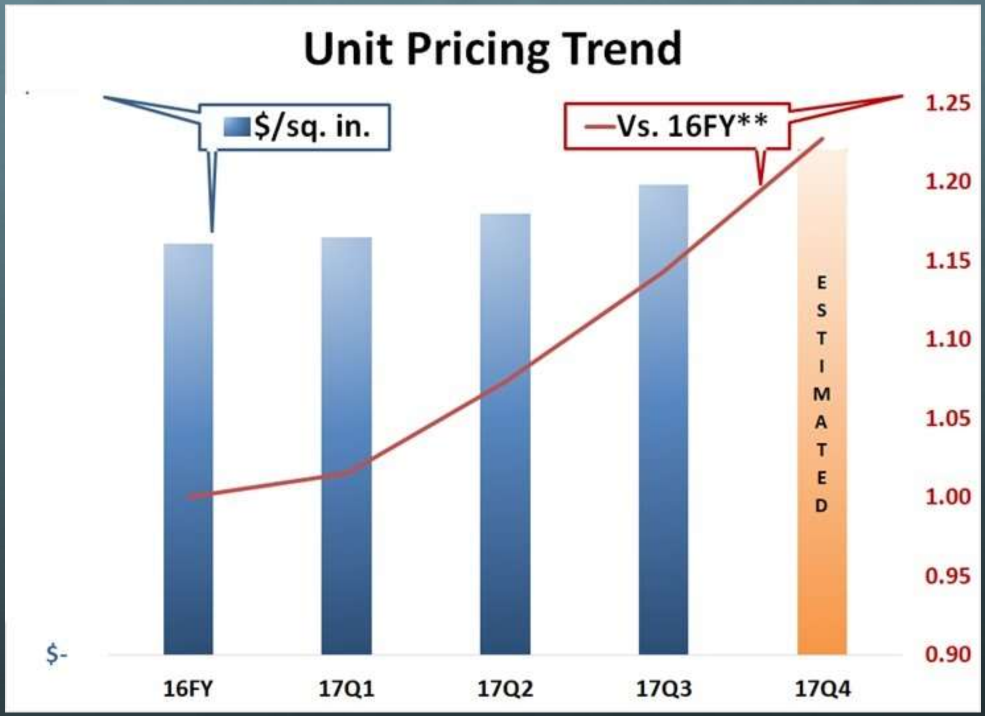


- TECHCET evised its silicon wafer forecast for 2017 from 10,976 to 11,807 MSI
- Steady growth is expected through 2021 at CAGR of 3.3 % from 2017
- Current installed capacity (which is heavily product mix dependent) will struggle to meet anticipated demand beyond 2017, even with stated expansions

Source: 2015 - 2016 SEMI SMG; 2017 – 2021 TECHCET

TECHCET Electronics Materials Information

Strongly Appreciating Pricing



- After stabilizing unit pricing ($ / sq. in.) in 16Q2, this metric began to increase in 17Q1
- Concerns over shortages, coupled with continuing strong demand, has accelerated price increases throughout 2017
- If demand continues on pace with the current outlooks, increases in 2018 could be similar in magnitude

Source: TECHCET, SEMI SMG; ** Multiplier, normalized versus full year 2016

Thank You!

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2018 Meeting Calendar w/ Analysts

YEAR	MONTH	DAY	Meeting Type	Subject/Analyst	Analyst
2018	January	17	CMC ASSOCIATES	Silicon Wafers	Mike
2018	February	14	CMC ASSOCIATES	Wet Chem	Yu
2018	March	21	CMC ASSOCIATES	Ceramics	Tim
2018	April	25,26,27	CMC Meeting & Conference	Gases/Metals	Various
2018	May	16	CMC ASSOCIATES	Photoresist	Ed
2018	June	20	CMC ASSOCIATES	CMP	Diane
2018	July	25	CMC ASSOCIATES	Precursors	Jonas
2018	August	15	CMC ASSOCIATES	Silicon Wafers	Mike
2018	September	19	CMC ASSOCIATES	Metals	Terry
2018	October	?	CMC Seminar & meeting		Various
2018	November	7	CMC ASSOCIATES	Wet Chem	Yu
2018	December	5	CMC ASSOCIATES	Gases	Bruce

CMC Associate Member/FAB F2F and Conference Update

- CMC Associate and CMC FAB F2F
  - Joint Session April 25, 2-4:30pm
    - At NXP
    - Need to RSVP to get security badges
    - Networking Reception to Follow
    - Contact Meena for hotel reservations for block room rate: msher@techcet.com
- CMC Conference at Hilton Hotel, Chandler, AZ
  - April 26-27
  - April 26th – not so usual round table
- http://cmcfabs.org/cmc-events/

PCN Joint Session Topic

- Problems:
  - PCN notification period may be prohibitively long limiting the degree to which a supplier may be able to cost reduce or introduce improvements. In the meantime, constant price pressure is being applied.
  - PCN terms and definitions are not always clear up front causing confusion, cost and loss of time.
  - Automotive industry is requiring excessive term for PCN notification.
- Actions:
  - Work Team to configure Joint Session – F. McNeil, K. McLaughlin
  - Need 2-3 Fab Members to participate with Suppliers

CMC F2F and Conference Update

		Presenter	Presentation Subject/Title	AR's / notes
April 25th Evening Reception	**5:30 - 7:30 pm**	**All CMC Members**	**Welcome Reception**	**ALL**
April 26th Conference Starts	8:30	Ed Korczynski, TECHCET	OPENING REMARKS	COMMITTED
KEYNOTE	8:45	KEYNOTE: David Bloss (VP/Director) Intel	**Critical Materials for Device Driven Scaling**	COMMITTED
1. Global Issues	9:30	Lita Shon-Roy, TECHCET	**Critical Materials market forecast & roadmap**	COMMITTED
	9:45	coffee break		
	10:00	James Votaw (partner) Keller & Heckman	**Regulatory Challenges for Novel Engineered Materials**	COMMITTED
	10:30	US EPA	**Update on US TSCA**	TBD
	11:00	Keith Long (Director) USGS	**Tantalum metal sources and supply-chain**	COMMITTED
	11:30	KPMG - Scott Jones	**Global Macroeconomics and Impact of new US Tax Laws**	COMMITTED
	12:00	LUNCH		
2. Immediate Challenges of Materials and Manufacturing	1:30	Hutcheson (CEO)/Puhakka (Pres) VLSI Research	**OEM Markets and Materials Trends**	COMMITTED
	2:00	Ken Unfried (Technologist) Linde	**Neon and Xenon recycling**	COMMITTED
	2:30	Samsung	**Topic t.b.d.**	waiting for confirmation
	3:00	coffee break		
	3:15	Speaker being confirmed	**Peroxide replacement of SPM**	Lita to ask.
	3:45	Praxair/Versum	**Ion Implant critical materials**	COMMITTED
	4:15	Texas Instruments	**Reduce/Reuse/Recycle of chemicals**	Chad to ask.
	4:45	There may be one other talk inserted into this spot - we are expecting 1-2 additional submissions		
April 27th, Conf. Day 2	0.34375	Jonas Sundqvist, TECHCET	OPENING REMARKS	
3. Emerging Materials	8:30 AM	Micron	**PVD targets for chalcogenides**	waiting for confirmation
	9:00	Nick Blasco, Air Liquide	**Ru precursors, & Co precursors issues**	

Thank-you!

- Next Meeting is
  - Wednesday February 14th -
    - Details on Joint Session
    - Analyst Update – Wet Chemicals, by Yu Bibby, Ph.D.