2016 JAN MONTHLY MEETING

Lita Shon-Roy, President / CEO
Jerry Yang, Ph.D., CMC Fabs Manager

www.cmcfabs.org
cmcinfo@Techcet.com

CMC Fabs
Critical Materials Council for Semiconductor Fabricators

TECHCET
Electronics Materials Information

Outline

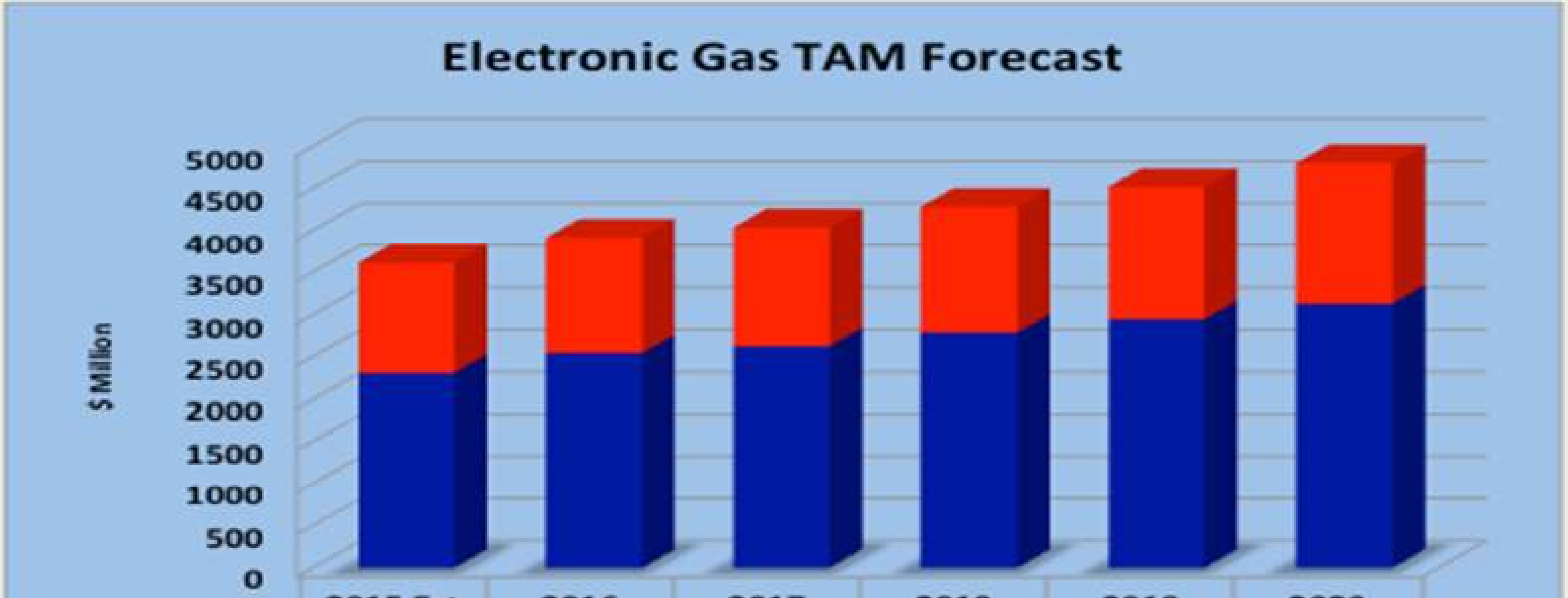
- CMC Market Report – Update
  - *Gases Update by Bruce Adams*
  - *CMP Update by Sue Davis*
- CMC Fabs Update
  - *Foundry Capacity Update*
  - *Current & Potential CMC Members*
- May Face to Face Meeting Planning - Focus / Objectives
  - *Survey Results Update*
- CMC Seminar Planning and Update
  - *Invited Speaker*
  - *Program Outline*
- Hot Topics, Q&A

Electronics Materials Information

CMC Jan Update - Gases

- Report by Bruce M. Adams

Updated Gas TAM Forecasts



	2015 Est	2016	2017	2018	2019	2020
Bulk Gas	1298	1372	1413	1493	1572	1668
Spec Gas	2314	2545	2626	2789	2949	3134

NOX Plant Incident

- At 9:20 AM on Monday, October 12th, an explosion and fire incident occurred at Leeden National Oxygen Ltd in Singapore.
- A fatality occurred to one staff member and another three sustained injuries. Additionally four members of Leeden NOX's self defense fire brigade were injured while fighting the fire.
- Cause of the incident is under investigation
- Leeden NOX is majority owned by Taiyo Nippon Sanso Singapore, a subsidiary of Taiyo Nippon Sanso of Japan and supplies high purity atmospheric gases

Dow Chemical Incident

- Explosion at North Andover, MA plant on Jan 7, 2016
  - *Five people injured, some damage to plant*
- Trimethylaluminum reacted with water
- Second explosion in this plant, first in 2013, killing one person due to TMA

Air Products Spin Off

- Air Products Board announced its intent to spin off the Materials Technology business on Sept 16, 2015 on a tax-free basis. Targeted completion is Sept 2016. New company name is Versum Materials
- Seifi Ghasemi will be the non-executive Chairman and Guillermo Novo will serve as the CEO. Mr. Novo currently serves as an Executive VP at Air Products.
- The Materials Technology segment includes the Electronics specialty gas and chemicals business as well as the performance chemicals business, which includes Epoxy curing agents, polyurethane and specialty additives..

AP Spin Off Cont'd

- The new Materials Technology company will be focused on technology driven offerings.
- Initial revenue for the new company will be around $2.2 billion.
- The Electronics business segment will represent approximately 45% of the new entity. (~$990 million)
  - *Advanced Materials ~ 15% $330 million*
  - *Process Materials ~ 20% $440 million*
  - *Delivery Systems ~ 10% $220 million*

AP Spin Off Comments

- There have been several rumors in the past couple of years related to the Electronics business being sold off. This may be the initial step as a separate company will be much easier to sell to another gas supplier or investment firm in the future.
- The new entity will not include the high purity bulk gases being supplied to Electronic customers. This will still be supplied by Air Products.
- The new company will have two complications from my perspective outlined in the next two slides.

Customer Interaction

- **End use customers will now have to deal with two different companies and sales personnel to acquire their gas requirements.**
  - ***They will deal with Air Products for their high purity bulk gas needs, e.g. Nitrogen, Hydrogen, Oxygen, Argon, and Helium***
  - ***Their specialty gas and equipment requirements will be procured through the new company.***
- **This will complicate supplier interaction and supply chain management from the end user customer perspective.**

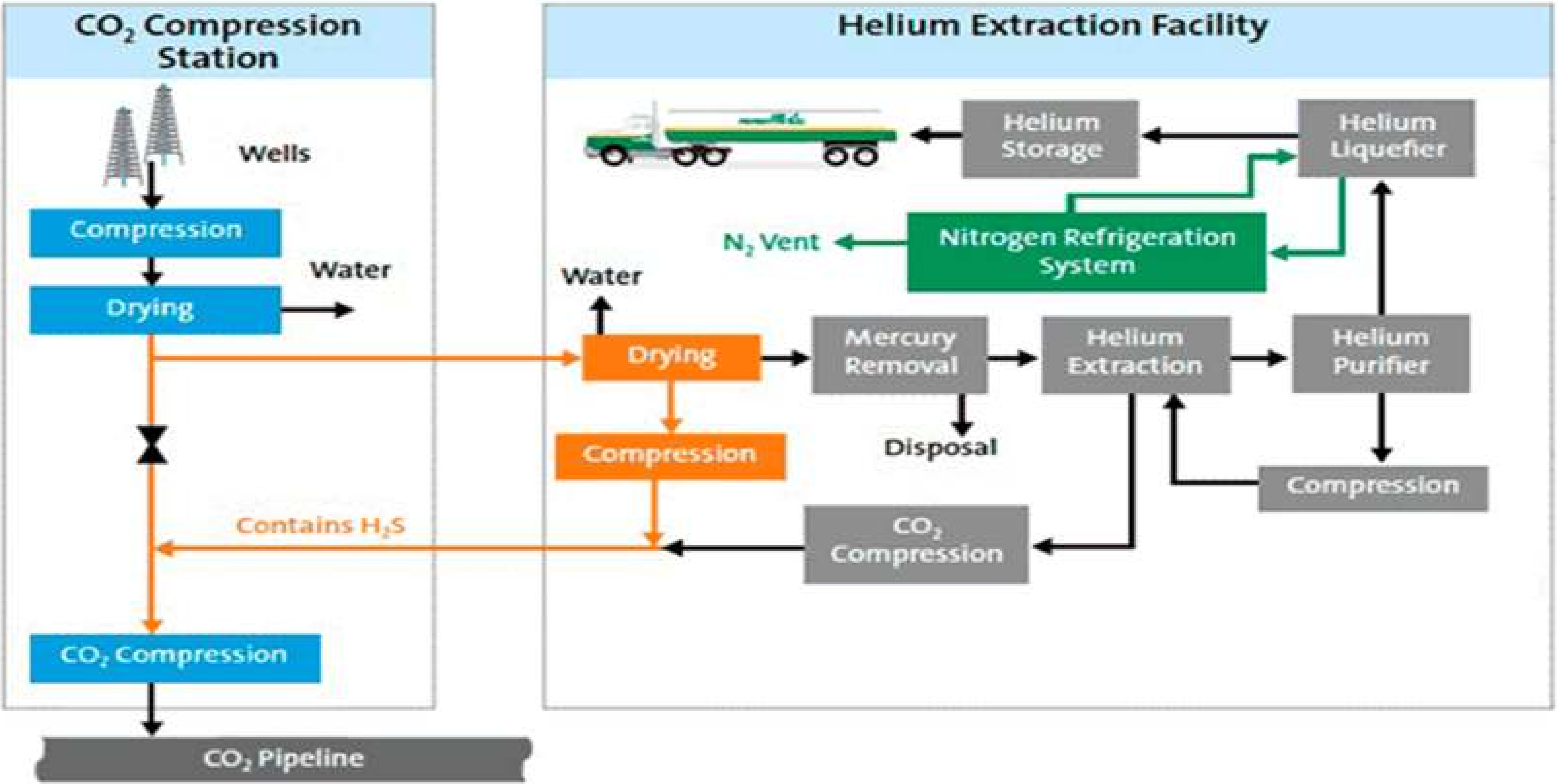
Supplier Complications

- Major gas suppliers have always leveraged their bulk and specialty gas sales to large customers to mitigate cost pressures. With this spin off, both companies have lost this tactic and must let its products stand on its on two feet, so to speak. This may result in higher prices for some products. It is too soon to say for sure as one benefit to the new company will be the advantage of less overhead to account for with the loss of the capital intensive bulk gas business. This may be enough to keep pricing in check for awhile.

New Air Products Helium Plant

- Air Products had a grand opening ceremony for its new Doe Canyon Helium production facility in Colorado in August. This is the only plant that extracts helium from a gas stream composed primarily of CO_2. Most of the current helium comes from the Bureau of Land Mgt, whose reserves are dwindling, requiring suppliers to look for other sources. The new plant will provide 230 million SCF of helium per year, replacing more than 15% of the current BLM reserve supply.

Doe Canyon He Process



Source: Air Products 2015

Neon Update

- Situation is starting to ease. Ukraine situation has calmed down a bit but still remains a factor (see below). Some tightness will remain in the market through mid 2016 but should start to ease further as new sources and purification come on line. Force Majeure has stopped.
- The Ukraine situation continues to be unsettled as Russia takes on a more aggressive role in international politics. Its intervention in Syria only heightens potential further action in the Ukraine as Putin wants to enhance his global presence via use of military force.

Neon Update Cont'd

- An additional cause of the shortage was due to a couple of large companies purchasing large volumes of Neon initially due to projected shortages. This led to other companies buying up additional material exasperating the situation.
- Industrial slow down in both China and Russia also may further impact Neon supply. Neon is typically sourced from very large Oxygen plants tied to steel production. As the economies of both countries shrink, steel production is down, reducing the amount of Neon that can be extracted from the stream.
- Pricing remains high although they have dropped a bit. Pricing will further decline in 2016 but is not expected to return to pre-shortage levels any time soon.

Fluorocarbon Update

- Some impact was seen in the market with the spin off of the fluorocarbon business of Dupont to Chemours. Chemours stopped manufacturing H116 (Hexafluoroethane) and H23 (Trifluoromethane). Other suppliers stepped up to fill the void and the situation was quickly resolved.
- C_4F_6 is showing tightness in the market. Only two major suppliers supply the majority of this product, Solvay in Italy, and Kanto Denka in Japan. One supplier is looking for take or pay contracts to justify further expansion.

TECHCET

Electronics Materials Information

CMC Jan Update – CMP Consumables

- Market Trends
- CMP M&A Activity
- CMP Update

Report by Sue Davis

Industry Update- ISS 2016 Highlights

- ***Gartner:*** *weak short-term outlook, improves by EOY*
  - 2017: high single digit growth (10nm in HVM, 3D NAND ramps)
  - 2017-2019 China will boost spending
- ***Hilltop Economics***
  - Millions of Square Inches (MSI) :
    - *forecasts for 2015 and 2016 are both up about 2.8 percent*
    - *2017 is anticipated to be higher at 6.4 percent*
- ***IC Insights***
  - WW semiconductor market forecast to grow 4 percent to $367 billion in 2016
  - Capital spending expected to increase ~ 1 percent to $66 billion
  - Semiconductor materials revenues will increase 4 percent to $48 billion in
- ***McKinsey & Co, Techcet***
  - Globally the world is ~y 10 years into a dramatic transition as a result of four disruptive trends:
    - *Growth and urbanization in emerging markets*
    - *Rapid technological changes*
    - *Increasing connectivity*
    - *Changing demographics (i.e.a aging population, decrease in populations of EDC)*

Market Trends

Connectivity Demands Grow

- *# wireless devices & operating frequencies → RF growth*

Demand continues for 200mm equipment (refurb & new)

- *Many devices for IoT & mobile do not require 300mm capability*
- *Multi-functional devices for IoT*
- *Process & cost improvements for older nodes*

Improved process control, reduced cost as key technologies & process continue to move to HVM

- *Multi patterning*
- *Planar to 3D (3D NAND, FinFET)*

Small Form Factor, Multi-Die and SiP applications are driving Advance Packaging

- *2.5/3D stacking, InFO, TSV to integrate multiple chips into single device (CoWoS), W PoP*

Source: SEMI, SST, semim

CMP M&A Activity

Cabot Microelectronics/NexPlanar (completed 10/22/15)

- *NexPlanar's pad IP and knowledge base enables more extensive pad portfolio to complement slurry platform*
- *CMC/NexPlanar integration continues*
- *NexPlanar 2015 sales~ $22-25M*
- *CMC continues to bear the bulk of R&D burden, with more companies turning to them for process development*
- *Supply chain, device mfr collaboration exists, not broad based due to competitive concerns*
- *Next CMC earnings call 1/28/16*

CMP M&A Activity

Dow Electronic Materials/DuPont (DowDuPont)

- ***DowDuPont will be 2nd largest chemical company , behind BASF***
- ***Each will have 50% ownership***
- ***Post merger, DowDuPont will split into three companies***
    - **Materials Science (CMP consumables will be organized)**
    - **Specialty Products**
    - **Agricultural Chemical**
- ***Prior to merger, Dow will assume full ownership of Dow Corning***

CMP Update -1

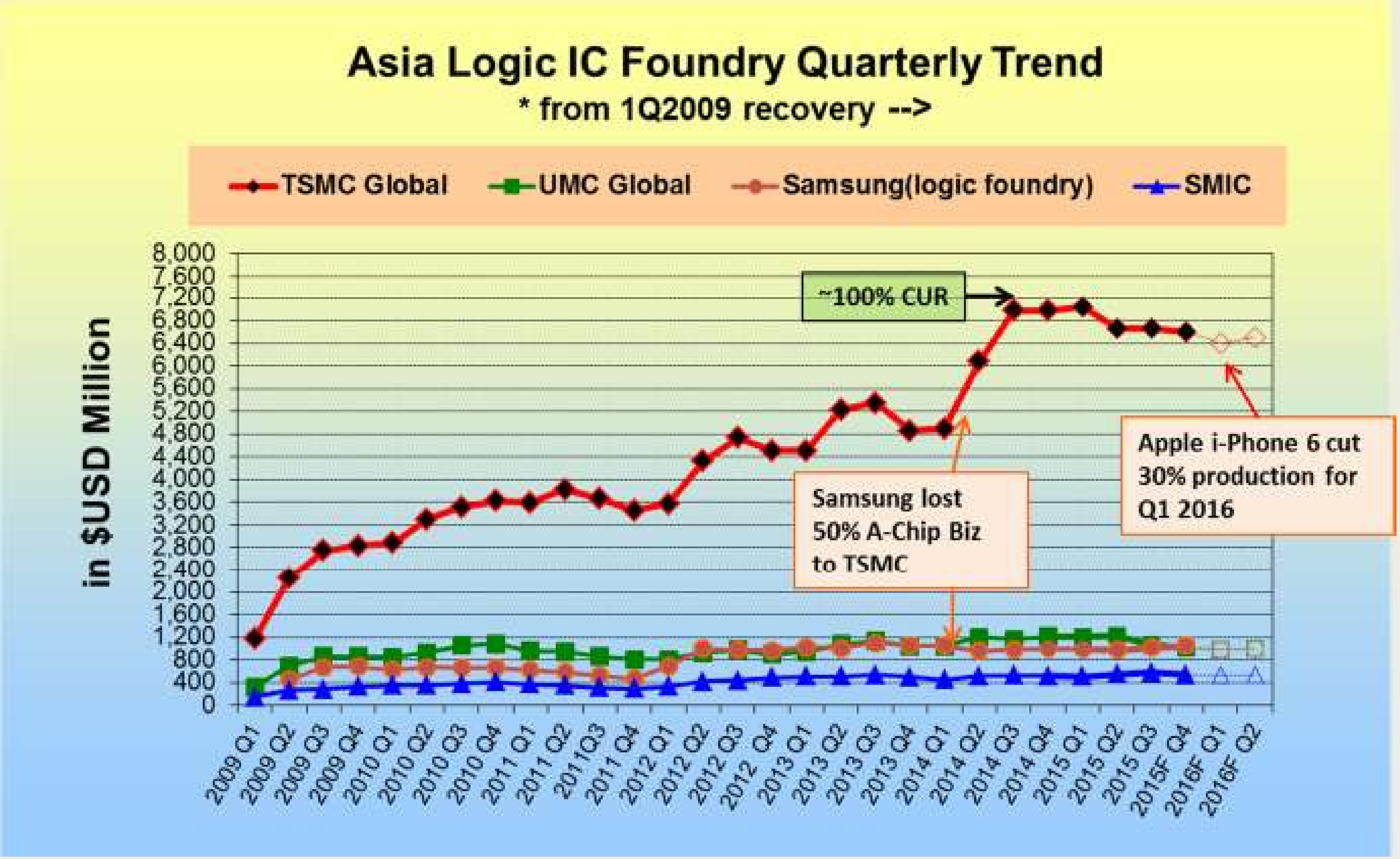
- **Ceria**
  - *Expanded usage of ceria slurries for new layers/new materials*
  - *Global supply currently not a critical hot button*
  - *Suppliers have or in process of qualifying second/multiple sources*
- **Real-time slurry monitoring enabling improved understanding of subtle filter-filter differences:**
  - *Initial capture performance*
  - *Pressure shock response*
  - *End-of-life behavior*
- **Defect reduction advances require partnership with metrology suppliers and analytics to understand relationship of wafer defects and slurry particle data**
- **CMP migrating toward extremely slow and careful removal of material with extreme selectivity requirements**

CMP Update -2
New CMP Supplier Entrants

- New entrant surge halted
- Korea highly successful supporting growth of regional/national slurry suppliers
- Taiwan supports local CMP suppliers as well as global CMP firms to localized in Taiwan

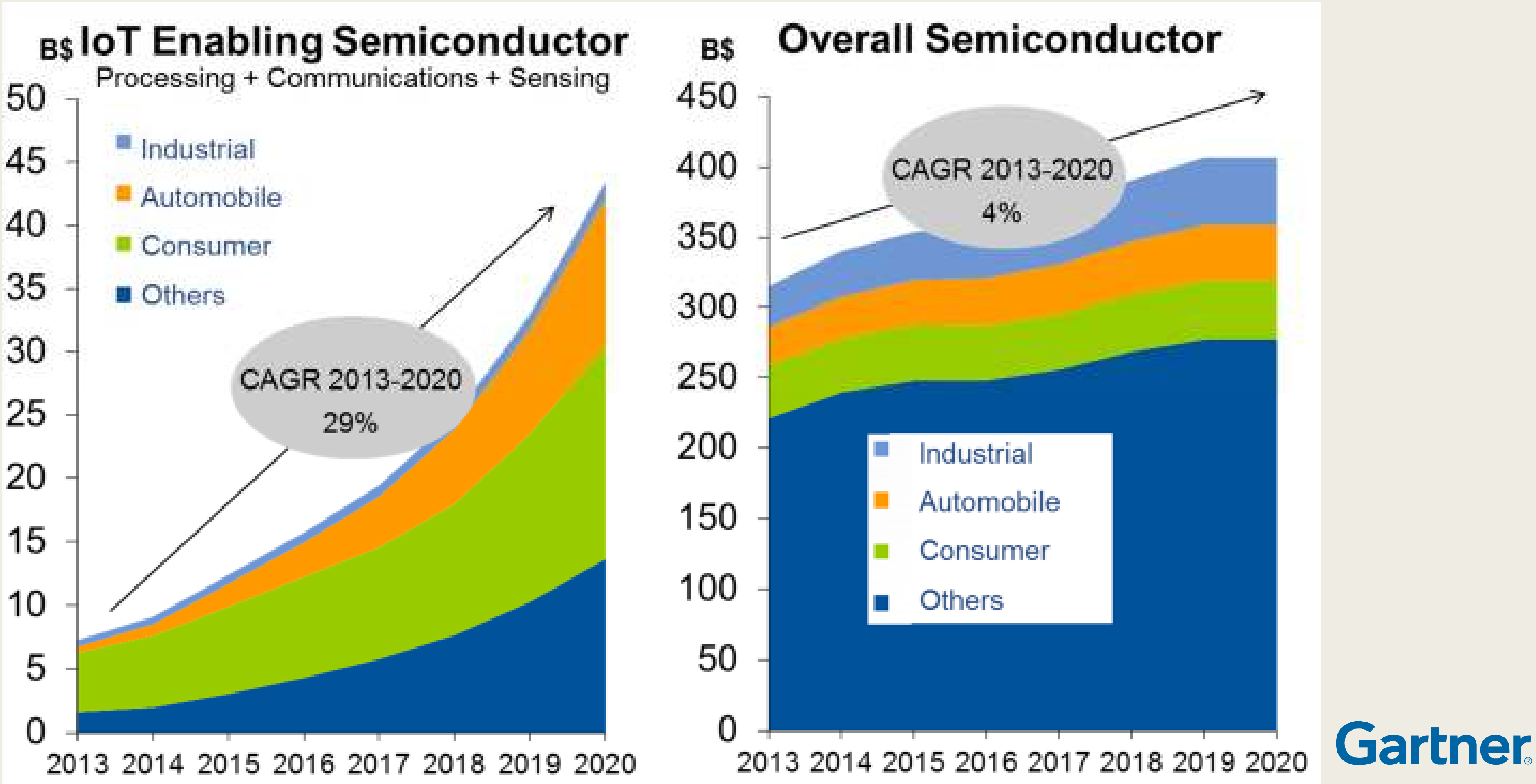
CMC Fabs Update

Foundry Capacity Update



- Apple i-Phone 6 cut 30% production for Q1 2016, i.e. 50% A-Chip reduction at TSMC and Samsung each.
- Foundry capacity utilization rate (CUR) declined from ~100% at Q1 2015 to ~85% in Q3/Q4 2015 and may further decline in Q1 2016 due to weak demand from i-Phone, PC & IoT devices.

Semi Revenues



2016 CMC Membership and Plans

& Others

F-2-F Meeting Planning for May, 2016

2016 CMC F-2-F Meeting Plans

Meeting date	Location	Event Content	Supplier presentations for day 1 -2 closed session & day 3-4 seminar
May 3-4	Intel Hillsboro Site	CMC Meeting •Member Share Topics & Round Table Discussion •Supplier Presentation (3-4/material) •1:1 supplier meetings	Supplier and Experts (choose 2). Will do survey ahead of meeting. • Wafers • Photoresists and Ancillaries • Gases • Target and Quartz • Wet Chemicals • CMP • ALD Precursors
May 5-6	Hillsboro Oregon	CMC Seminar	"Materials Requirements for the Future of Semiconductor Devices"
Nov 10-12 in Korea w/ i-SEDEX2016 Or Oct 15-17 in China w/ ICPT 2016 Or Oct in US	Seoul, Korea Or Beijing, China Or US	• Asia & 2nd source Supply Chain ○ Global sourcing, forecast and demand, transportation, quality, and ship-to-control etc.. • Other New Topics..	•Supplier and Experts • Wafers • Target and Quartz • Wet Chemicals • CMP • Others ....

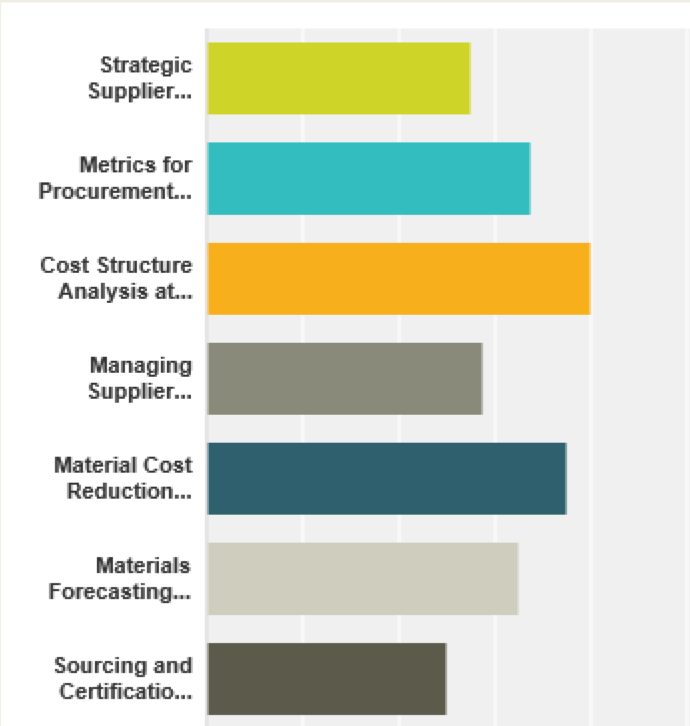
Day 1 & 2– CMC Member Share Focus

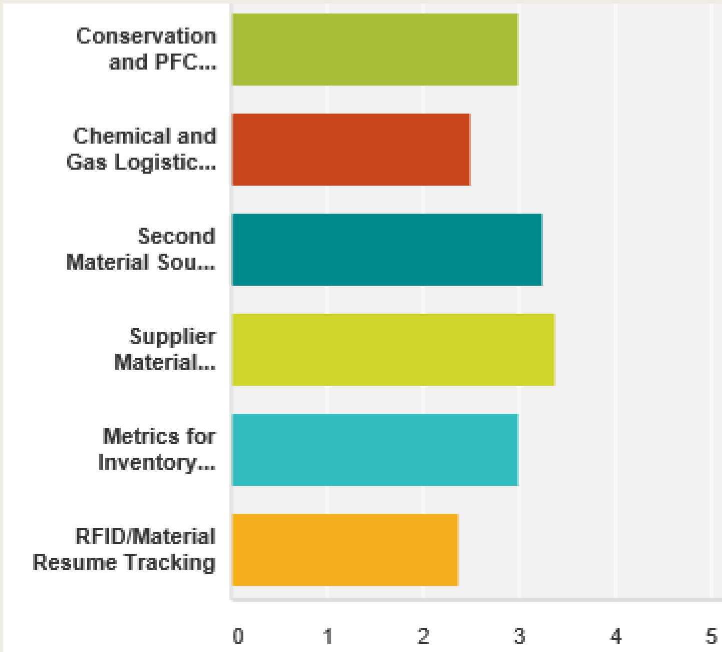
- Below are some key member share topic that we have included in the survey that send out in early Jan, so far we have 8 feedbacks from the survey. More result summary will be included before mid-Feb.

- Strategic Supplier Management and Award
- Metrics for Procurement Effectiveness
- Cost Structure Analysis at Supplier
- Managing Supplier Performance
- Material Cost Reduction Strategy
- Materials Forecasting Methods
- Sourcing and certification of Conflict Materials
- Conservation and PFC Reduction
- Chemical and Gas Logistics Concepts
- Second Material Source Qualification
- Supplier Material Sourcing Strategy
- Metrics for Inventory Performance
- Other New Topics (Global Logistics, Product Resume, etc..)

Survey Results to identify Shared Focus Topics-

level of interest but ranking from 1 (least) to 5 (most)





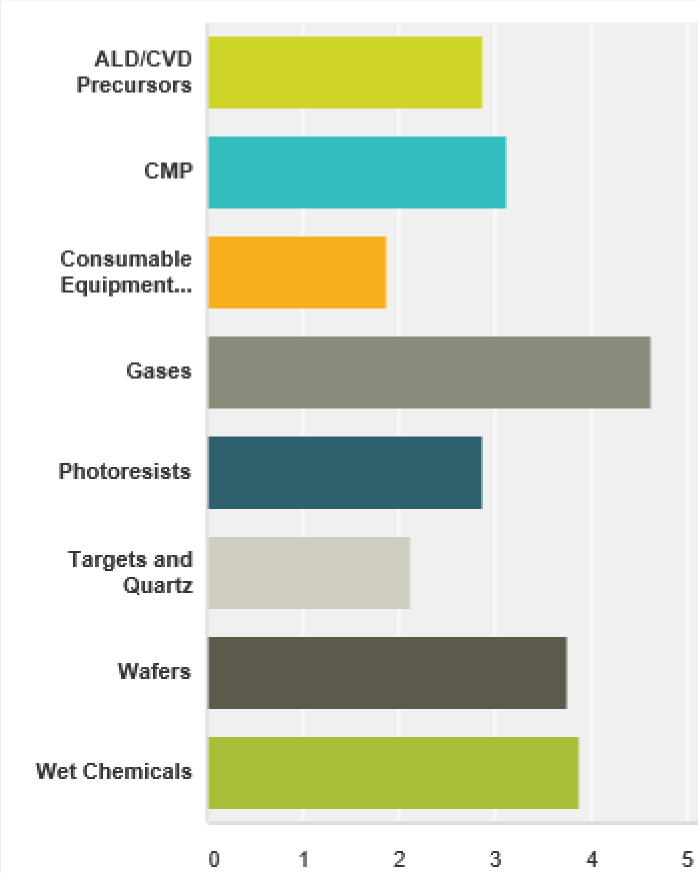
- Cost Structure Analysis at Supplier
- Materials Forecasting Methods
- Metrics for Procurement Effectivenes
- Second Material Source Qualificatio

Others:

- Custom Blend and Niche supplier options and manageme
- Regulation Outlook (PFOA, Pthalates, GHG's, RoHS, etc)

Survey Results to identify Suppliers to Invite

level of interest but ranking from 1 (least) to 5 (most), 2 out of 8 area are selected



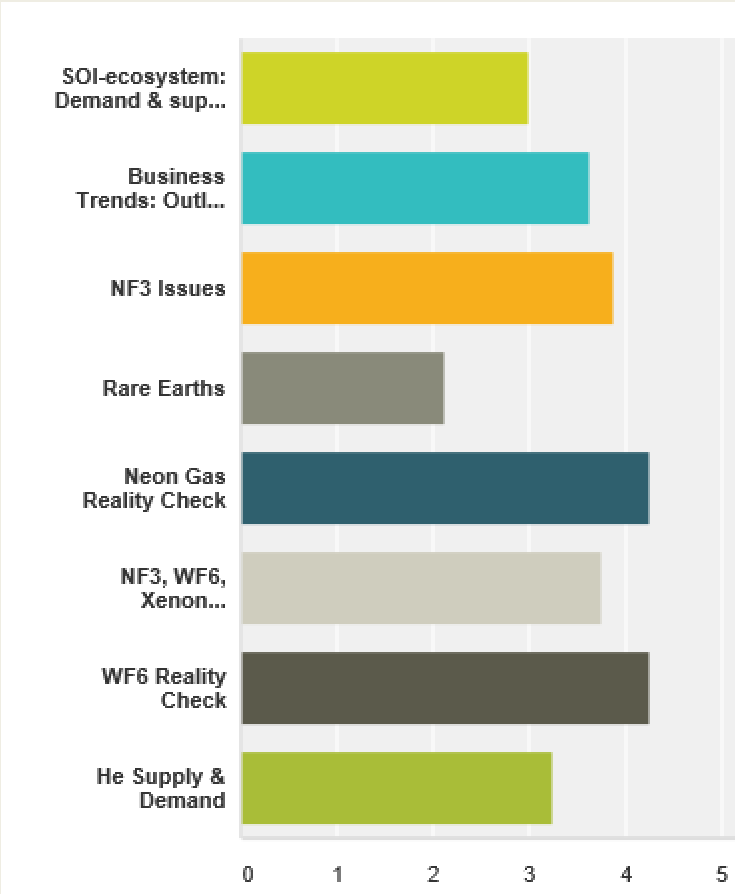
- Gases
- Wafers
- Wet Chemicals

Others:

- Laminate or Dry Film Resists and associated strippers
- Anticipated Supply Chain Future Material Shortages

Survey Results to Identify Hot Topics to Discuss

level of interest but ranking from 1 (least) to 5 (most), 2 out of 8 area are selected



- Neon Gases Reality Check
- NF3, WF6, Xenon
- WF6 Reality Check

- Others:
  - Supplier mergers and consolidation, impacts, fcs
  - 300mm silicon supplier capacity

Double Blind Survey and Mini-Surveys

- Double Blind Survey on 90-days-old on Pricing Survey NF_3/WF_6/ SiH_4 and Wet Chemicals will be conducted twice a year, 1st one in March and 2nd one in August.
- Last Blind Survey did not have enough member to participate.
- Mini-Survey will be conducted on a needed basis.

CMC Seminar Update

Seminars

CMC Seminar Overview

"Critical Materials for Device Driven Scaling"

Conference Overview

- **Keynote: "Material Requirements for the Future of Semiconductor Devices"**
- **Four Sessions**
  - **Market Briefing – electronic applications, semi devices, equipment, and materials**
  - **Tracking the Supply Chain down to Earth, Wind and Fire**
  - **Emerging Materials Evolution: ALD / ALE**
  - **Materials Revolution: "The Carbon generation" 8 yrs.**
- **Featuring Speakers from:** Materials and Equipment Suppliers, Device Technologists, Market Analysts

- CMC Seminar 2016, cont . -

"Critical Materials for Device Driven Scaling"

Keynote: "*Material Requirements for the Future of Semiconductor Devices*"
by Tim G. Hendry – Vice President, Technology and Manufacturing Group and Director of Fab Materials, INTEL CORPORATION

I. Market Briefing – Electronic Applications, Semi Devices, Equipment, and Materials

Jim Feldhan, President – Semico Research
Risto Puhaaka, President – VLSI Research
Dan Tracy, Ph.D., Director – SEMI
Lita Shon-Roy, President / CEO – TECHCET CA, ,LLC.

II. Tracking the Supply Chain down to Earth, Wind and Fire

Jeff Hemphill, Sr. Materials Engineer – Intel Corp.
Keith Long, Project Chief – US Geological Society
TBD – Texas Instruments
TBD – TSMC
Yu Bibby, Ph.D., Sr. Market Analyst – TECHCET Group

- CMC Seminar 2016, cont . -

III. Emerging Materials Evolution: ALD / ALE

John Smythe, Ph.D., Advanced Technology Lead DMTS – MICRON Technologies

Jonas Sundqvist, Sr. Market Analyst – TECHCET Group

OEM Technologist TBD

Material Supplier TBD

Material Supplier TBD

IV. The Materials Revolution: "The Carbon Generation" 8+ yrs.

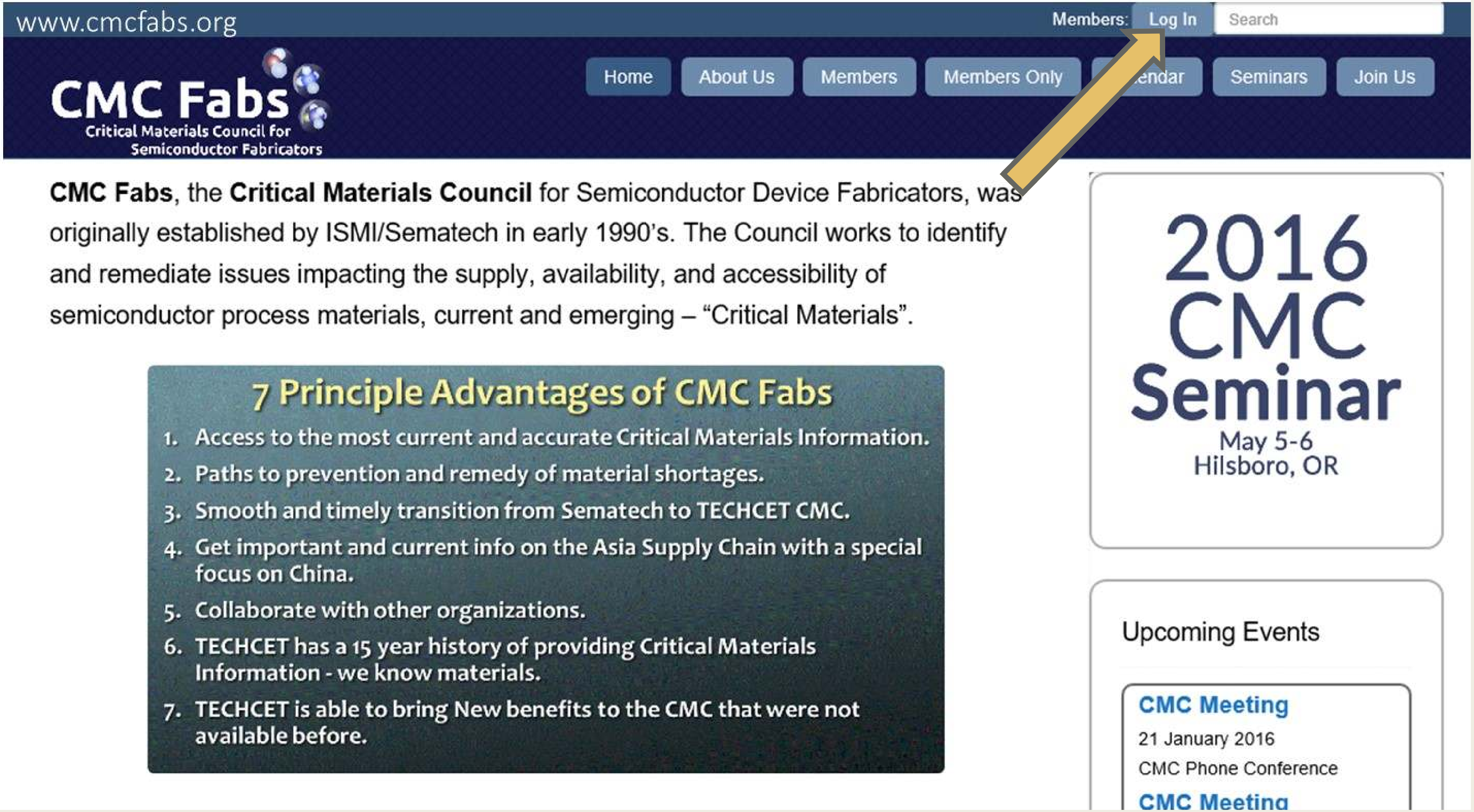
IC Fab TBD

Material Supplier TBD

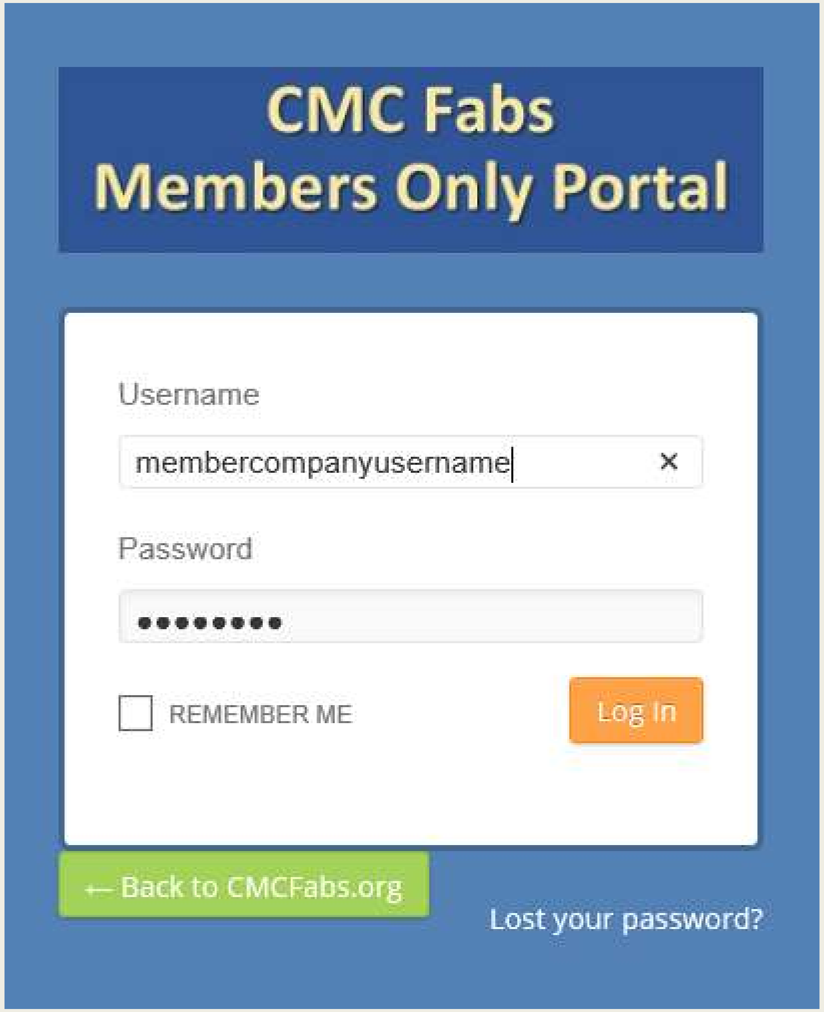
OEM TBD

Karey Holland, Ph.D., CTO, Megafluid Systems, TECHCET CA LLC.

How to Log in to CMCFabs Website



- Click on Members: <Login>
- Put in your Username and password



Members Only

Welcome to our Members Only area… You have access to the following info:

Member Only Files

FILE NAME	CATEGORY	DATE	DOWNLOAD
TECHCET Presentation to CMC Meeting	Meeting Presentations	12/17/2015	Download link
TECHCET Quarterly Update CMC	TECHCET CMR Reports and Quarterly Updates	11/30/2015	Download link
China Rare Earth Update	TECHCET CMR Reports and Quarterly Updates	10/20/2015	Download link
China Rare Earth Update	TECHCET CMR Reports and	10/1/2015	Download

Questions / AR's / Wrap-Up

- AR's
  - *Survey for supplier selection for F-2-F Day 1&2 will be sent out in Feb*
  - *Please feel free to make suggestions about the second F-2-F meeting in 2H16*
  - *A survey will be sent out to choose from three of the six reports for 2016*
  - *Please let Lita know if you are interested in participating in the CMC Seminar Committee (Lshonroy@techcet.com)*
  - *Please let Jerry know if there are additional monthly meeting participants from your company(JYang@techcet.com)*

Hot Topics to Discuss

- Neon Gases Reality Check
- NF3, WF6, Xenon
- WF6 Reality Check
- Others:

- Supplier mergers and consolidation, impacts, fcst
- 300mm silicon supplier capacity limitation in the long term, may be catch up with supply & Demand balance.
- Heraeus is getting out of Sputter Target business, and may also get out of semiconductor business as a whole in the near future.

Thank You!

Ishonroy@Techcet.com
Jyang@Techcet.com
cmcinfo@Techcet.com
+1-480-382-8336