

2017 SEPT. MONTHLY MEETING

Mike Walden, Dir. CMC Prog. & Bus. Dev.
Lita Shon-Roy, President / CEO
Ed Korczynski, Dir. Marketing / Sr. Tech Analyst

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Outline

- Opening and Hot Topic Identification– 5 min
- CMC Seminar
- TECHCET Analyst Update: Ed Korczynski / Photoresist – 20 min
- CMC Seminar Update– 10-15 min
- Hot Topics, Q&A – Up to 10 min (As Needed)
- Other – (Web Site Update - Time Permitting)
- Future Meeting Schedules & Wrap up – 1 min.

Hot Topics to Discuss

 _____ (your hot topics here)

 _____ (your hot topics here)

 _____ (your hot topics here)

CMC Reception & Seminar

Nov. 1, 5pm to 7pm &
Nov. 2, 8am to 5pm



CMC Seminar: Nov. 1 / Nov. 2

- ☐ Event Venue: Lakeshore Hotel, Hsinchu, Taiwan - 773, Ming-Hu Rd., Hsinchu City, Taiwan R.O.C., 30065
- ☐ We need a proper headcount so please let us know who will be joining from your company
- ☐ Please complete registration form: <http://techcet.com/wp-content/uploads/2017/09/CMCSeminarRegistrationForm-Early.pdf>
- ☐ Let Meena know if you need to reserve a room: msher@techcet.com

Day 3 – Thursday, November 2, 2017, Hsinchu

CMC Seminar – Skyrocketing Asian Supply-Chains

*Focused on the dynamics of local materials
supply-chains within global markets.*

A full day of presentations and break-out discussion groups will focus on key Asian suppliers, local government initiatives, and globalization trends to support the rapidly growing supply-chain within Greater China and Asia at large. There will be opportunities to network with CMC members who will have finished with private face-to-face meetings being held in Hsinchu earlier that week.

- **Seminar Location:** Lakeshore Hotel, Hsinchu, Taiwan
No.773 Minghu Road, Hsinchu 300, Taiwan

“Skyrocketing Asian Supply-Chains: Dynamics, Challenges & Growth”



Nov. 1, 17:30	Welcome Reception (evening)
Nov. 2	SEMINAR AGENDA
8:00 AM	Registration
9:00 AM	Opening Welcome by Mike Walden & Lita Shon-Roy, TECHCET
9:15 AM	CMC Fab Members Presentation - Invited <ul style="list-style-type: none">• <i>Material Supply Chain Challenges</i>
9:45 AM	Lita Shon-Roy, President / CEO <ul style="list-style-type: none">• <i>WW Materials Market Trends & Impact from Asia</i>
10:15 AM	Paul Stockman (or alt.), Head of Market Development - Linde <ul style="list-style-type: none">• <i>Challenges and Opportunities for Taiwan and China for Electronic Material Suppliers</i>
10:45 AM	Break
11:05 AM	John West, Managing Director- VLSI Research <ul style="list-style-type: none">• <i>Equipment Consumables Components Company Perspective</i>
11:35 AM	Todd Curtis, VP / CTO - 88Equipment <ul style="list-style-type: none">• <i>200mm Equipment Market Pinch - Dynamics and Challenges</i>
12:05 PM	Lunch
1:15 PM	Jeff Jang, Director Asia Business, Air Liquide <ul style="list-style-type: none">• <i>Rare Gas Supply Chain Challenges in Asia (tentative)</i>
1:45 PM	Korean, or Taiwanese Materials Supplier (TBD)
2:15 PM	Mike Walden, Director & Sr. Market Analyst - TECHCET <ul style="list-style-type: none">• <i>WW Silicon Wafer Supply-Chain Strain</i>
2:45 PM	Break
3:05PM	Kevin McLaughlin, SACHEM <ul style="list-style-type: none">• <i>Solvents Global Supply-Chain Dependencies</i>
3:45 PM	Wang-Su, Technical Director - Shanghai Sinyang Chemical <ul style="list-style-type: none">• <i>Metal Chemicals Supply Chain in China</i>
4:15 PM	Panel Discussion:

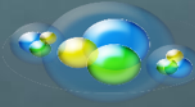
Ed Korczynski – Marketing Director and Sr. Technology Analyst



Covers Photoresist and Extensions and Ancillary materials, and is the co-chair of the Critical Materials Council (CMC) Conference. He is also a consultant for IC, LED, and MEMS process manufacturing, based on over 30 years of experience in Silicon Valley. He managed \$10M annual business in China and Korea for Applied Materials, and applications and marketing for Watkins-Johnson, Samco, TruSi, PDF Solutions, UltraClean Technology, and Intermolecular. Previously, he engineered fab processes for the world's first commercial MEMS accelerometer featuring TSV and WLP, and sustained LED HVM while developing metrology/inspection systems to boost absolute yield 2%. As technical editor with Solid State Technology magazine he won two ASBPE awards, and launched Ed's Threads in 2006 as the first IC industry blog. He holds a B.S. in materials science and engineering from MIT, and one patent.



Electronics Materials Information



Photoresists, Extensions, & Ancillaries Update September 2017

Ed Korczynski, Sr. Technology Analyst

edited by Lita Shon-Roy




September 2017

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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.

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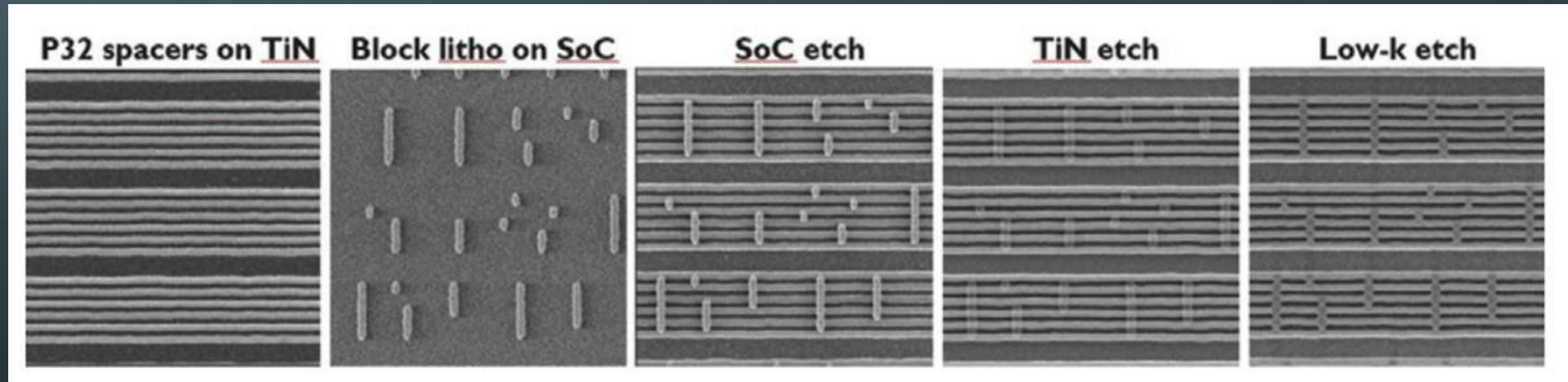
-  EUV Lithography finally ready for prime time
-  Lithography materials market update
-  Photoresist suppliers corporate activities

EUVL 2018 First Use in HVM

- 🌐 Risk of yield loss in HVM from a new unit-process – so ideally design to allow for old or new
 - 🌐 Cliff Hou, VP R&D for design technology at TSMC, reported by EETimes, “The foundry will provide a utility to port immersion design rules to the EUV process that will “clean up most of the layout differences. Overall, the work of moving from N7 to N7+ should represent about a third of the effort of migrating to a new node.”
 - 🌐 First use of EUVL likely as replacement for ArFi exposures to create identical target pattern
- 🌐 Patterning of gates and contacts and metal-one (M1) the most challenging for advanced lithography, so these are the likely insertion points for EUVL at Intel, Samsung, TSMC, GF
- 🌐 1 EUVL exposure can replace 3-5 ArFi exposures
 - 🌐 For 1D gate layouts using “grid + cut” multi-patterning approaches, the three or more “colors” of cuts needed when using ArFi may be replaced by a single EUV cut mask (*see next slide*)
 - 🌐 For 2D metal-one layouts, a single EUV mask can replace Litho-Etch-Litho-Etch-Litho-Etch using ArFi

EUVL “Cut Masks”

- “Cut” or “Block” needed for Self-Aligned Multi-Patterning (SAMP) of 1D gridded layouts
- ArFi half-pitch resolution limit = 3-5 “colors” needed for “Block litho on SoC” (below)
- 1 EUVL cut mask provides comparatively better yield, with lower design and fab costs
- Plan-views of IMEC process flow to use cut mask(s) to pattern TiN Hard-Mask for Low-k etch



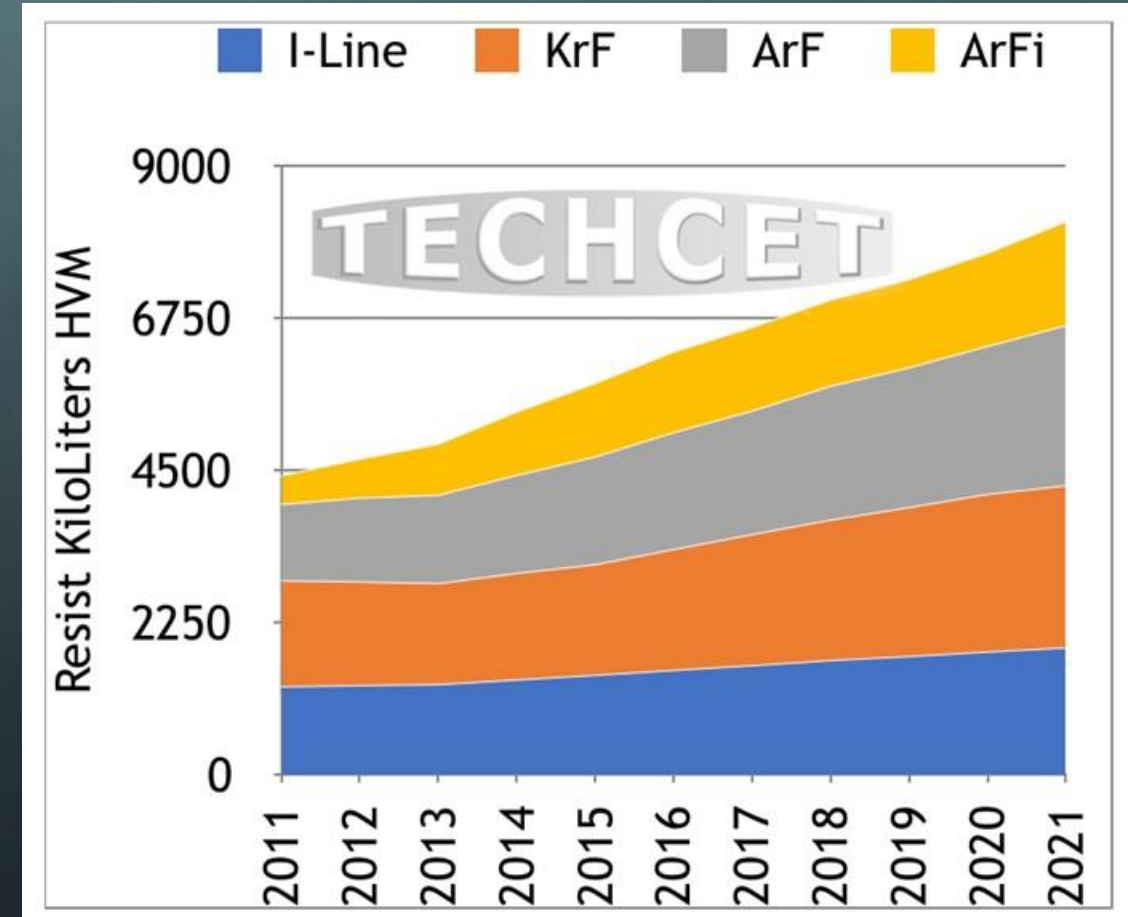
EUVL Market Analysis

- ASML reports backlog of 20+ EUVL steppers
- EUVL throughput limited by source and resist to ~80 whp (compared to 240 for ArFi), so each exposure will cost >>3X an ArFi exposure, so “complementary” in perpetuity
- EUVL limits increase in number of masks/set that would otherwise be needed for ArFi
- EUVL photoresist suppliers based on legacy PS-CAR (plus metal-oxides from Inpria)
 - PTI provided by JSR, FFEM, TOK, DowDuPont
 - NTI provided by Inpria (for R&D/pilot, likely to be acquired in next 3 years)
- TECHCET’s models show EUVL resist demand in 2020 will be just 10 KI (*see next slide*)

Photoresist Volume Demands

World-wide IC Photoresist Demand (KiloLiters)

- HVM (not including R&D/pilot) Photoresist demand based on TECHCET's wafer start forecast
- Changed assumptions from 2016 CMR; no changes in market
 - Implant @ 28nm-node and below change from KrF to ArF
 - 3D-NAND uses ArFi for peripheral FETs
 - ArFi demand steadily increasing
- EUVL total PR demand only 10 KI by 2020, ~20 KI by 2021

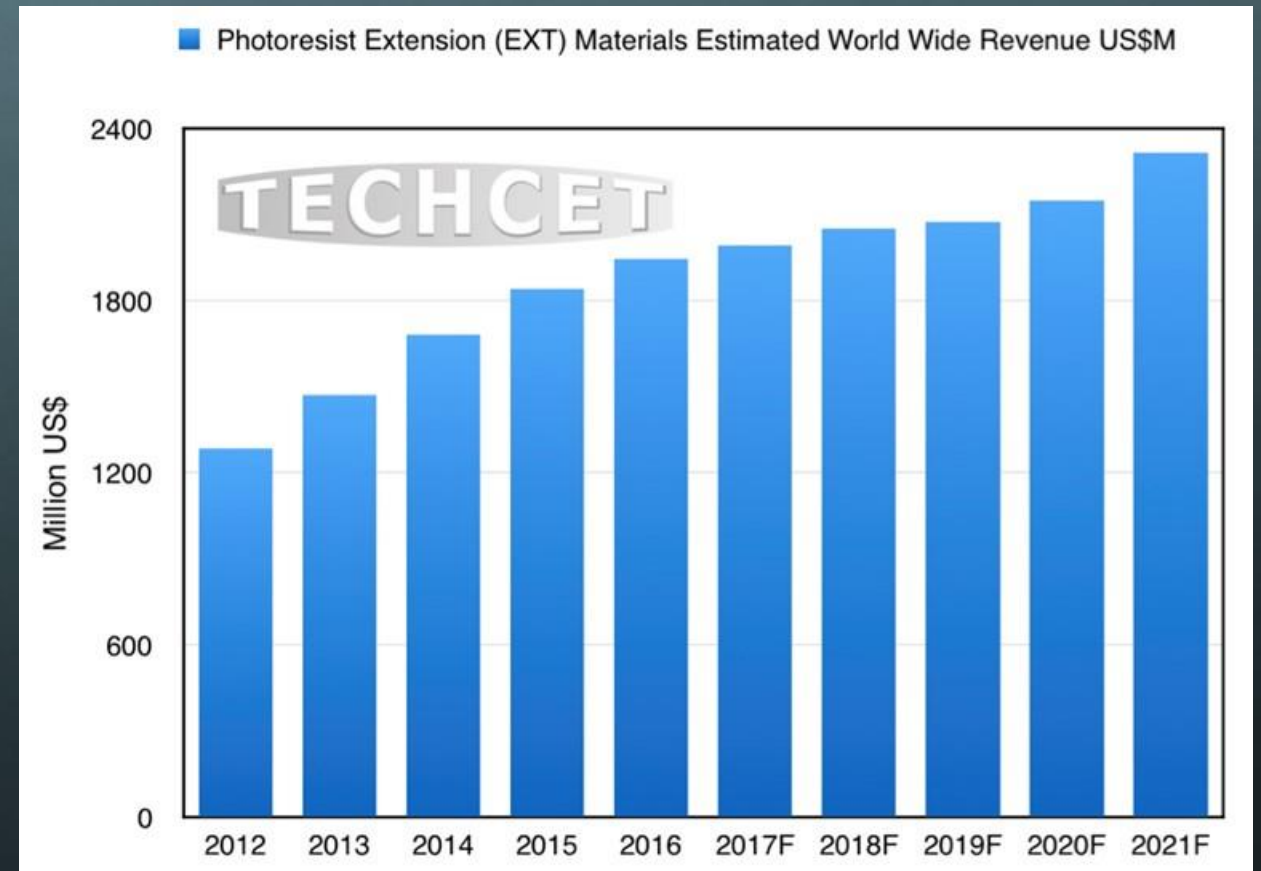


”Extension Materials” defined

- 🌐 “Extension” of resolution limit for ArFi technology <40nm half-pitch
- 🌐 Spin-on materials in the litho track
 - 🌐 BARCs were the start with KrF and ArF
 - 🌐 Top-coats layer for ArFi
 - 🌐 Shrink/Trim materials
 - 🌐 Hard-masks
- 🌐 ALD/CVD spacers for self-aligned multi-patterning (SAMP)

WW Litho Extension Materials Market Forecast

- EXT Materials integrated with PR by definition
- EXT supplied by PR supplier
 - DowDuPont
 - FujiFilm
 - JSR
 - Shin-Etsu
 - TOK
- Brewer/NissanChemical supply BARCs and spin-on hard-masks (SOHM)
- TAM of EXTs has grown by enabling ArFi, so slowing growth >2022 with EUVL handling more of the most difficult patterning



Lithography Materials Update on Selected Suppliers

Supplier: DowDuPont

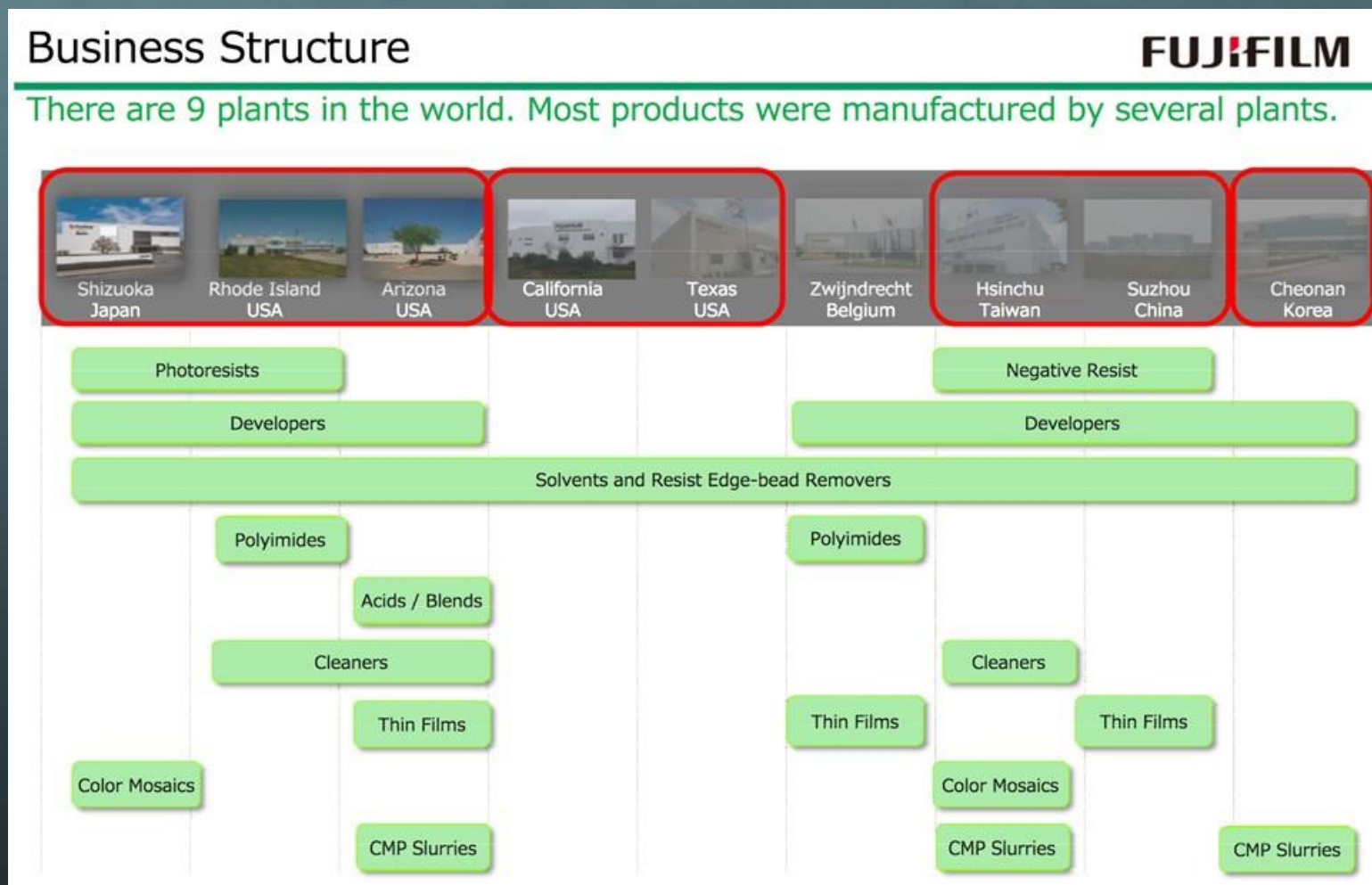
- 🌐 “Merger” of Dow and DuPont completed in August 2017
- 🌐 **Marc Doyle**, formerly EVP with DuPont **will become COO** for DowDuPont’s Specialty Products business, which DowDuPont intends to **spin-out within 18-24 months**
- 🌐 The Specialty Products business will target distinct markets, including Electronics & Imaging, Transportation & Advanced Polymers, Safety & Construction, Nutrition & Biosciences;
- 🌐 **Electronics & Imaging** = “world’s largest supplier with the broadest set of materials and technologies to solve complex problems for the semiconductor, circuit board, photovoltaic, display and flexographic printing industries”
- 🌐 The intended company will be headquartered in Wilmington, Delaware

Supplier: FujiFilm Elect. Mats.

- 🌐 From the 2017 August “VISION2019” Medium Term Management Plan
“The electronic materials business will continue to expand the sales of existing products, such as peripheral materials for cutting-edge photolithography, and introduce new peripheral materials to expand the product lineup to achieve the level of business growth outperforming competitors.”
- 🌐 “Peripherals” due to acquisition of US-based UltraPure for solvents
- 🌐 Corporate focus on “Imaging,” “Healthcare,” “Information” and “Document” businesses ... electronic materials has seen significant global investments over the last three years (*see next slide*)

Supplier: FujiFilm Elect. Mats.

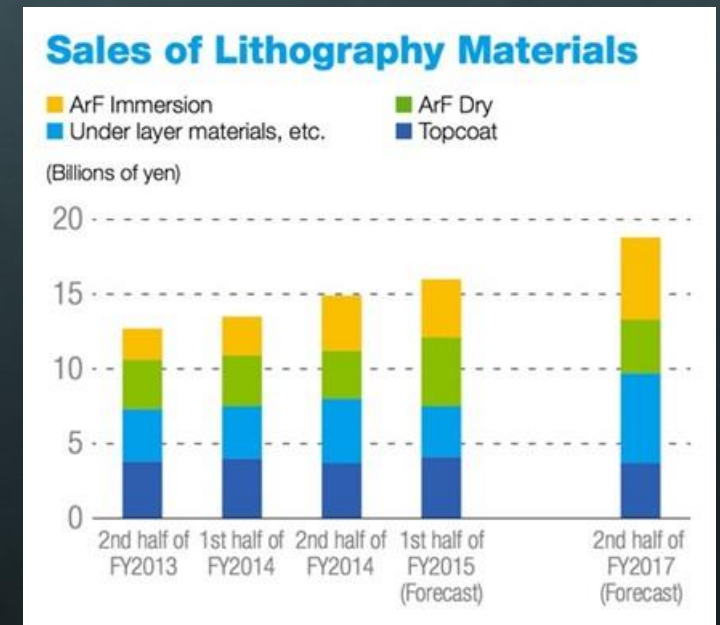
All plants except Zwiijndrecht, Belgium were either opened or saw significant investment in the last three years.



Supplier: JSR Litho Materials

- JSR semiconductor materials include litho materials & CMP slurries, focuses on advanced litho <22nm node
 - ArFi volumes and revenues continuing to grow
 - TLR growing
 - EUV resists growing rapidly from near zero
- 1Q18 FY results for litho materials YoY growth
 - ArF Photoresists ~20%
 - Multilayer Materials ~5%
 - Other Lithography Materials >12%




Figure: JSR Litho Materials Sales Plan
(Source: JSR 2015 Annual Report)



Supplier: JSR EUVL JV w. imec

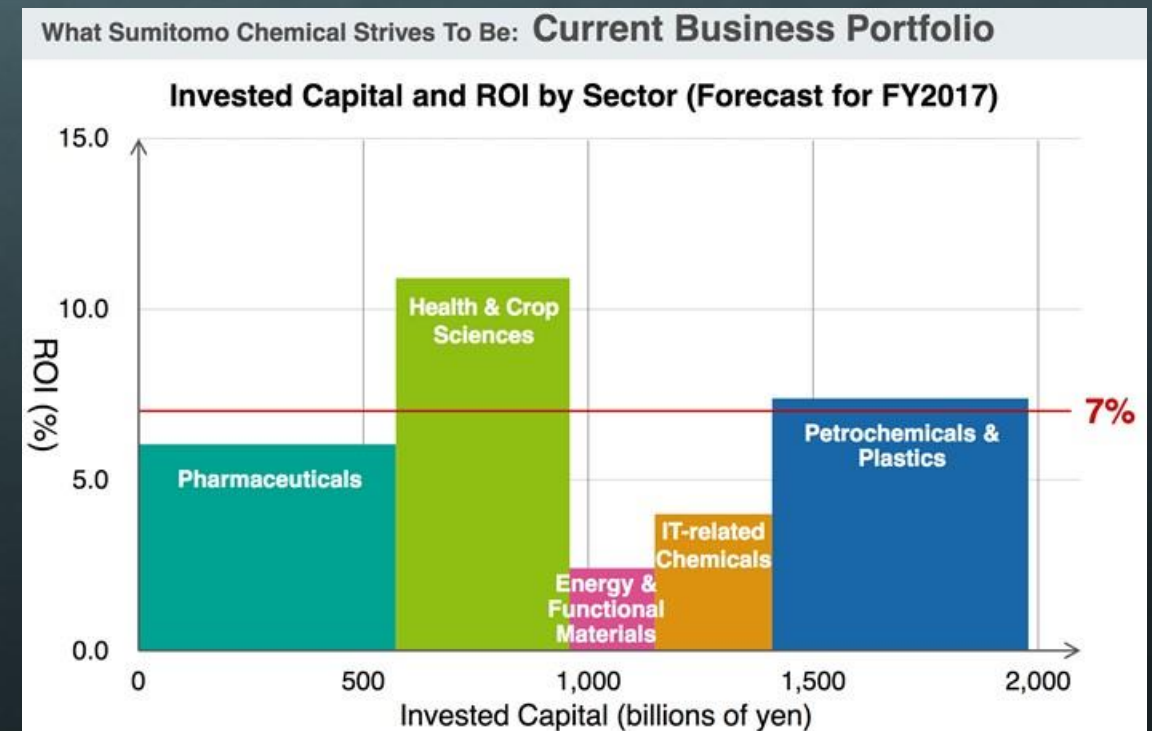
- 🌐 JSR with imec long-term investment for EUVL
 - 🌐 Extending Positive-Tone (PT) ArFi Chemically-Amplified Photo-Acid-Generator (CA-PAG) with targetted blends
 - 🌐 R&D into new Negative-Tone (NT) CA-PAG PR technology to try to compete with Inpria's metal-oxide formulations
- 🌐 In March 2017, the EUV Resist Manufacturing & Qualification Center NV (EUV RMQC, a joint venture between JSR Micro NV and imec) announced the completion of a new manufacturing facility in Belgium, enabling manufacturing and quality control of EUV photoresists for the semiconductor industry. The new facility is equipped with four sizes of vessels in its clean-room environment and is run by a team of trained staff.

Supplier: Shin-Etsu Chemical

-  In Taiwan investing ¥13.0 billion to construct a new photoresist-related products plant, scheduled for completion in the autumn of 2018
-  Meets rising demand, the establishes multiple production bases
-  “Photoresist products business, ArF resists and trilayer materials continued to perform steadily” for FY ending early in 2017

Supplier: Sumitomo Chemical

- Sumitomo not investing in photoresists to focus on pharmaceuticals and medical and agricultural and batteries and FPD - no mention of IC fab materials in last Annual Report
- FY17-end division revenue down ~7% YoY to ¥1954B
- “IT-related Chemicals” ROI of only ~4% despite CapEx
- Business rumored for sale



Thank you!

<http://techcet.com/product/photoresists-and-photoresist-ancillaries/>

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Hot Topics to Discuss

 _____ (your hot topics here)

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Other Discussion



Upcoming Meeting Schedule

- CMC Seminar – Hsinchu Taiwan, Lakeshore Hotel; November 2 (with reception on Nov. 1, evening)
- (No Monthly Phone meeting for October)
- Review **CMC Renewal** Paperwork: October - January
- CMC-A Monthly Phone/Web Meeting: November 15th – Gases Update
- CMC-A Monthly Phone/Web Meeting: December 13th – ALD/CVD Precursors
- December 7th CMC-A supplemental meeting for CMC F2F in Phoenix
 - *Organize Joint Session - by the CMC Associate Members*
 - *Sign up for Round Table Session Leadership*
- CMC F2F / Conference – Phoenix (Chandler), Arizona, April 24-27

Thank You – Let Us Know How We Can Be of Assistance!

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