



SW Test Workshop
Semiconductor Wafer Test Workshop

Welcome to the 27th Annual SW Test Workshop

Jerry Broz, Ph.D.
SW Test General Chair

June 4-7, 2017

Welcome Rancho Bernardo Inn



Welcome Rancho Bernardo Inn



Map of the Area



SW Test 2018
 June 3 to 6, 2018
 Rancho Bernardo Inn
 San Diego, CA

Welcome to SW-Test Workshop !

- **SW Test is a Probe Technology Forum ...**

- Focused Technical Workshop for Wafer Test Professionals
- Practical solutions to real problems
- Balanced mixture of semiconductor manufacturer, and supplier as well as collaborative presentations

- **Informal Conference ...**

- Friendly workshop format focused on technical exchange
- Great social activities to facilitate networking and informal discussions
- Meet new people, talk about probe and technology, and have some fun !

- **SW Test pursues a “Green Initiative” ...**

- Downloadable eProceedings and enviro-friendly practices

SW Test 2017 e-Proceedings ?



Password for Sunday = poppy
Password for Monday = columbine

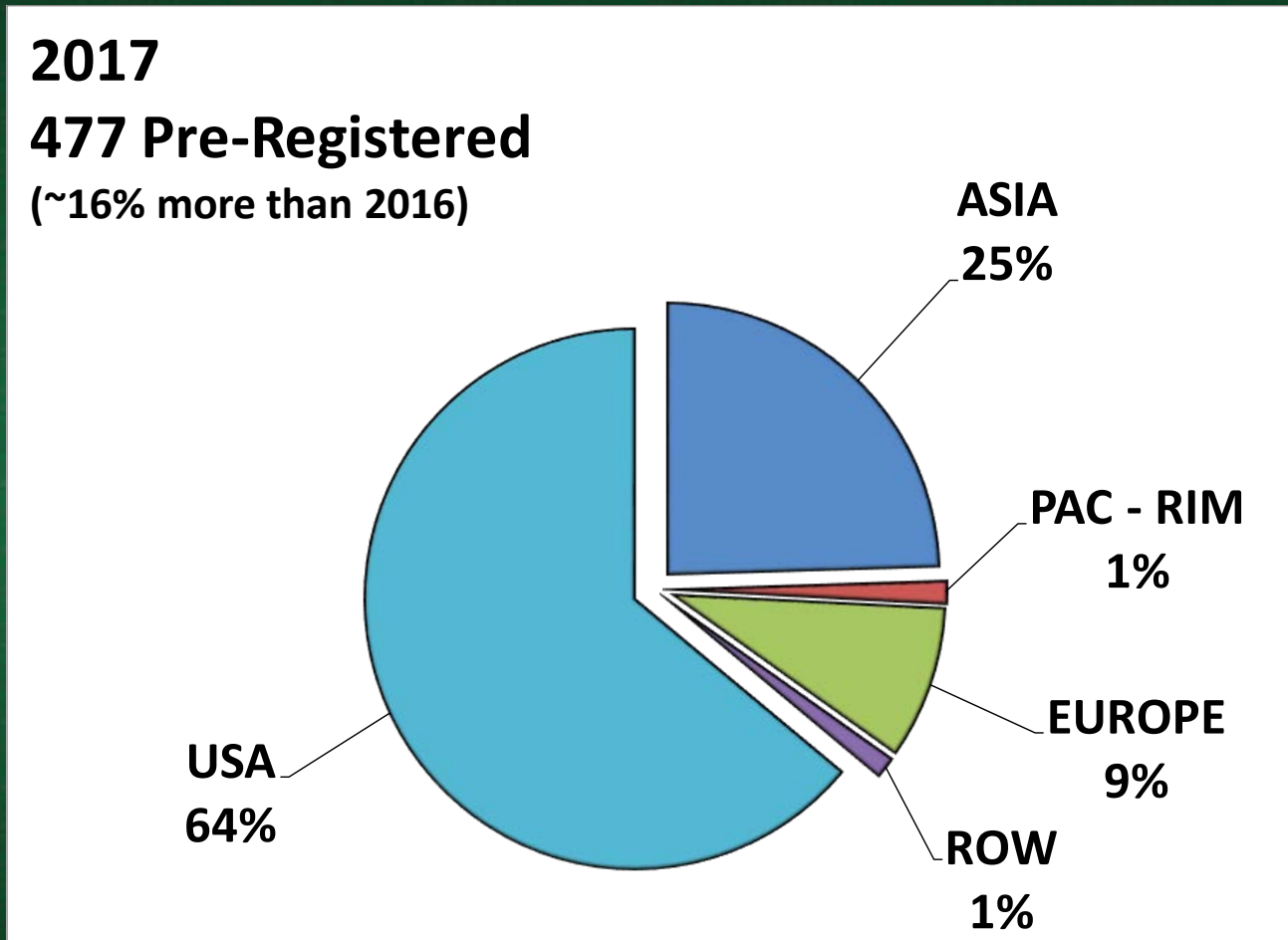
- SW Test is focused on a green initiative and reduced waste from unnecessary printing.
- Each day of the workshop will be available in an e-Version for download in a password protected file.
 - Go to ... <http://www.swtest.org>
 - Ballroom WiFi Password =
- Free WiFi access will be available during the entire workshop to allow attendee access to the downloads.
- Daily passwords to the download files will be announced through each day, respectively.
- The non-password locked files will be made available in the SW Test Archives after the workshop adjourns.

Twenty-Seven Years of Probe Technology !

Thanks more than 8500 attendees that have attended !



SW Test 2017 International Participation



29 out of the 48 Presentations have at least one international author !

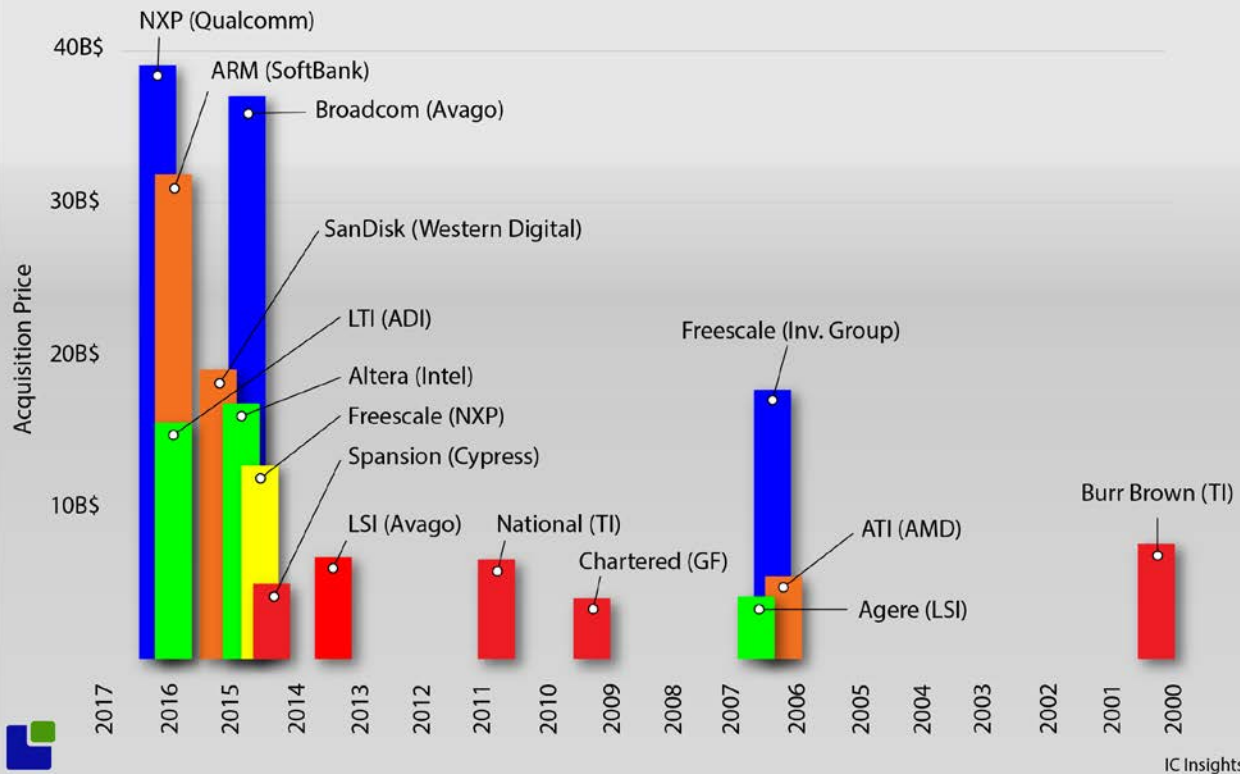
Ever Changing Semiconductor Landscape



Merger Fever Continues into 2017

Semiconductor Merger Season Over?

Top 15 Semiconductor Acquisitions by Announcement Date

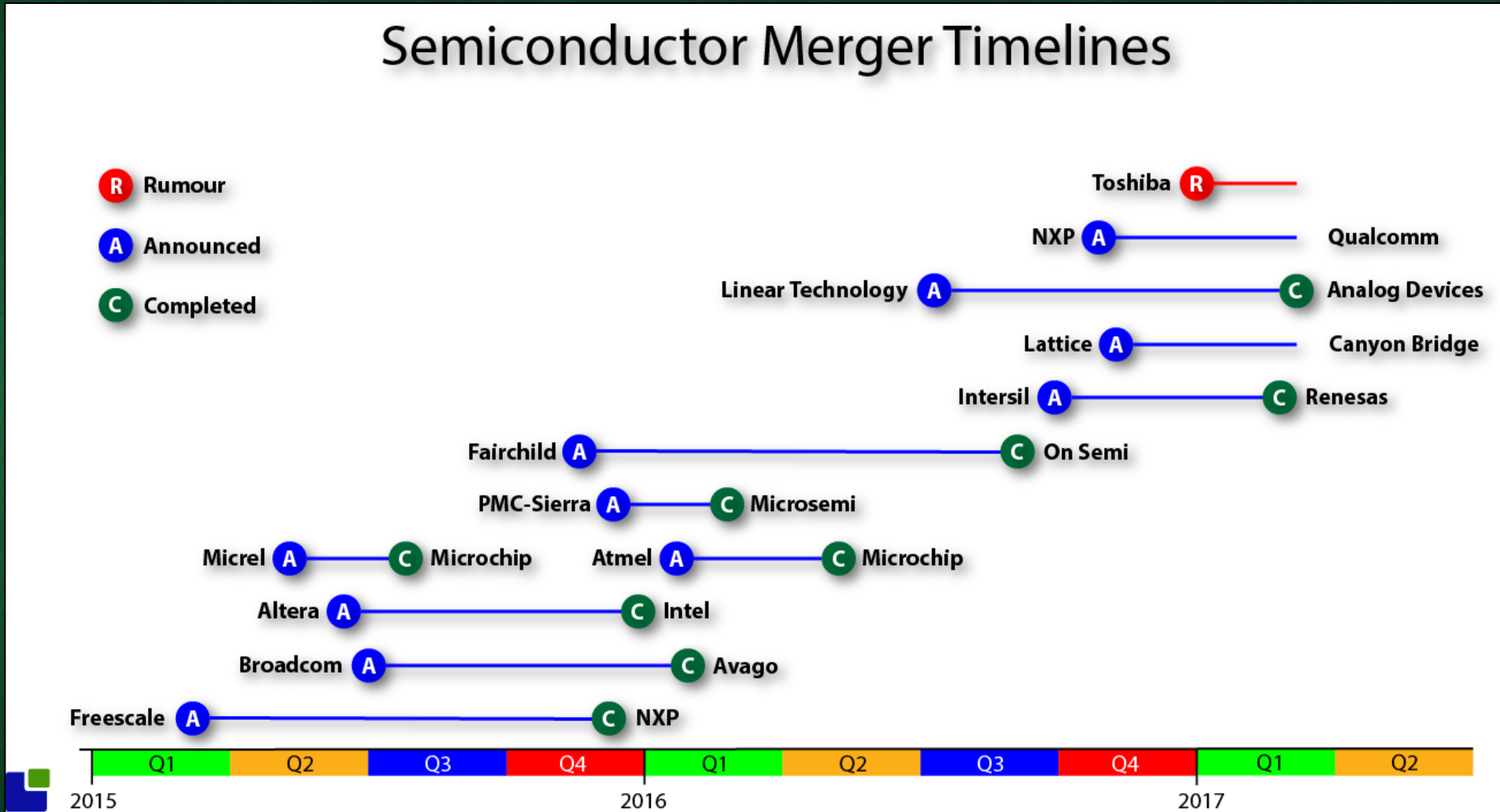


Biggest Semiconductor Acquisition Agreements

Ranking	Acquisition-Buyer (Year Announced)	Price Tag (\$B)
1	NXP by Qualcomm (2016)	\$39.0
2	Broadcom by Avago (2015)	\$37.0
3	ARM by SoftBank (2016)	\$32.0
4	SanDisk by Western Digital (2015)	\$19.0
5	Freescale by U.S Investment Companies (2006)	\$17.6
6	Altera by Intel (2015)	\$16.7
7	Linear Technology by Analog Devices (2016)	\$14.8
8	Freescale by NXP (2015)	\$11.8
9	Burr Brown by TI (2000)	\$7.6
10	LSI by Avago (2013)	\$6.6
11	National Semiconductor by TI (2011)	\$6.5
12	ATI by AMD (2006)	\$5.4
13	Spansion by Cypress (2014)	\$5.0
14	Agere by LSI (2006)	\$4.0
15	Chartered by GlobalFoundries (2009)	\$3.9

Source: Companies, IC Insights (2017 McClean Report)

Merger Fever Timelines



1Q16 Top 20 Semiconductor Sales Leaders (\$M, Including Foundries)

1Q16 Rank	1Q15 Rank	Company	Headquarters	1Q15 Tot Semi	1Q16 Tot Semi	1Q16/1Q15 % Change
1	1	Intel*	U.S.	12,067	13,115	9%
2	2	Samsung	South Korea	9,336	9,340	0%
3	3	TSMC (1)	Taiwan	6,995	6,122	-12%
4	7	Broadcom Ltd. (2)*	Singapore	3,679	3,550	-4%
5	4	Qualcomm (2)	U.S.	4,434	3,337	-25%
6	5	SK Hynix	South Korea	4,380	3,063	-30%
7	6	Micron	U.S.	4,061	2,930	-28%
8	8	TI	U.S.	2,940	2,804	-5%
9	10	Toshiba	Japan	2,619	2,446	-7%
10	9	NXP*	Europe	2,636	2,224	-16%
11	12	Infineon	Europe	1,666	1,776	7%
12	13	MediaTek (2)	Taiwan	1,506	1,691	12%
13	11	ST	Europe	1,700	1,601	-6%
14	14	Renesas	Japan	1,470	1,415	-4%
15	17	Apple (2)**	U.S.	1,260	1,390	10%
16	15	GlobalFoundries (1)*	U.S.	1,436	1,360	-5%
17	20	Nvidia (2)	U.S.	1,118	1,285	15%
18	16	Sony	Japan	1,272	1,125	-12%
19	18	UMC (1)	Taiwan	1,140	1,034	-9%
20	21	AMD (2)	U.S.	1,030	832	-19%
—	—	Top 20 Total	—	66,745	62,440	-6%

(1) Pure-play foundry

(2) Fabless supplier

* Includes Intel/Altera, Avago/Broadcom, NXP/Freescale, and GlobalFoundries/IBM sales for 1Q15 and 1Q16.

**Custom processors for internal use made by TSMC and Samsung foundry services.

Source: Companies, IC Insights' Strategic Reviews Database

Overall Semi Industry Trending

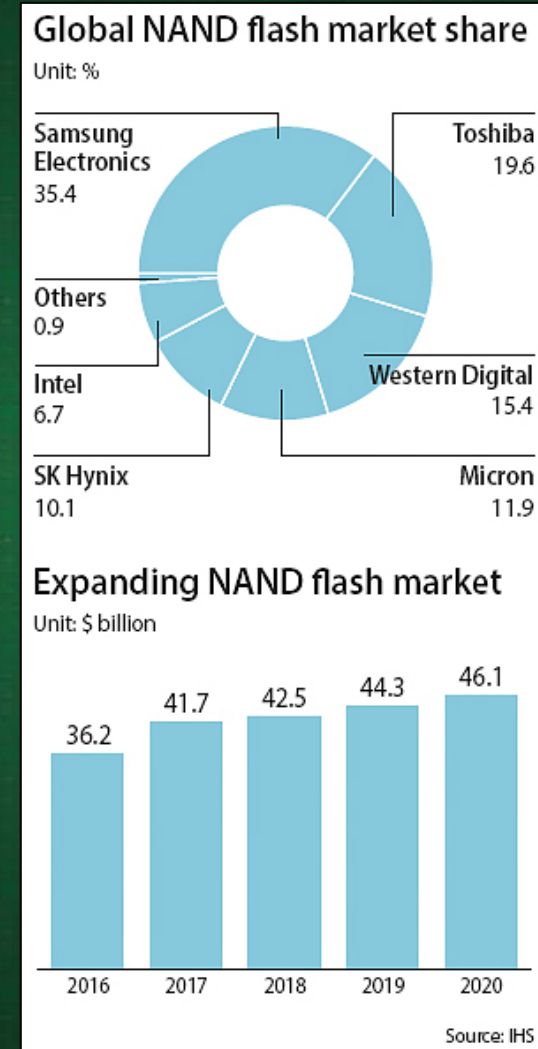
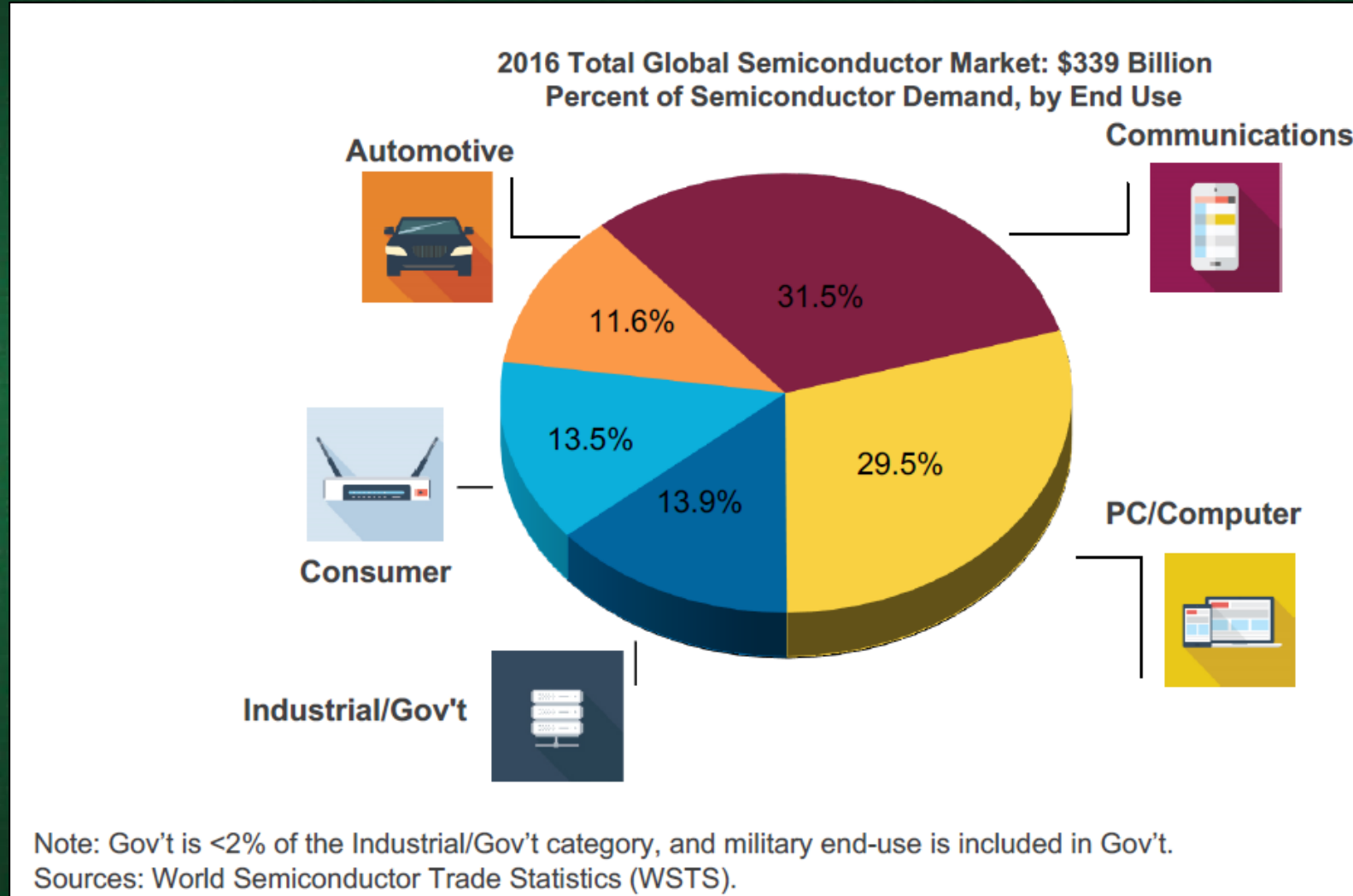
**Top 10 Worldwide Semiconductor Sales Leaders
(Excluding Foundries, \$B)**

Rank	1993		2000		2006		2016		1Q17	
1	Intel	7.6	Intel	29.7	Intel	31.6	Intel	57.0	Intel	14.2
2	NEC	7.1	Toshiba	11.0	Samsung	19.7	Samsung	44.3	Samsung	13.6
3	Toshiba	6.3	NEC	10.9	TI	13.7	Qualcomm (1)	15.4	SK Hynix	5.5
4	Motorola	5.8	Samsung	10.6	Toshiba	10.0	Broadcom (1)	15.2	Micron	4.9
5	Hitachi	5.2	TI	9.6	ST	9.9	SK Hynix	14.9	Broadcom (1)	4.1
6	TI	4.0	Motorola	7.9	Renesas	8.2	Micron	13.5	Qualcomm (1)	3.7
7	Samsung	3.1	ST	7.9	Hynix	7.4	TI	12.5	TI	3.2
8	Mitsubishi	3.0	Hitachi	7.4	Freescale	6.1	Toshiba	10.9	Toshiba	2.9
9	Fujitsu	2.9	Infineon	6.8	NXP	5.9	NXP	9.5	NXP	2.2
10	Matsushita	2.3	Philips	6.3	NEC	5.7	MediaTek (1)	8.8	Infineon	1.9
Top 10 Total (\$B)		47.2	108.1		118.2		202.1		56.0	
Semi Market (\$B)		108.8	218.6		265.5		365.6		99.6	
Top 10 % of Total Semi		43%	49%		45%		55%		56%	

Source: IC Insights

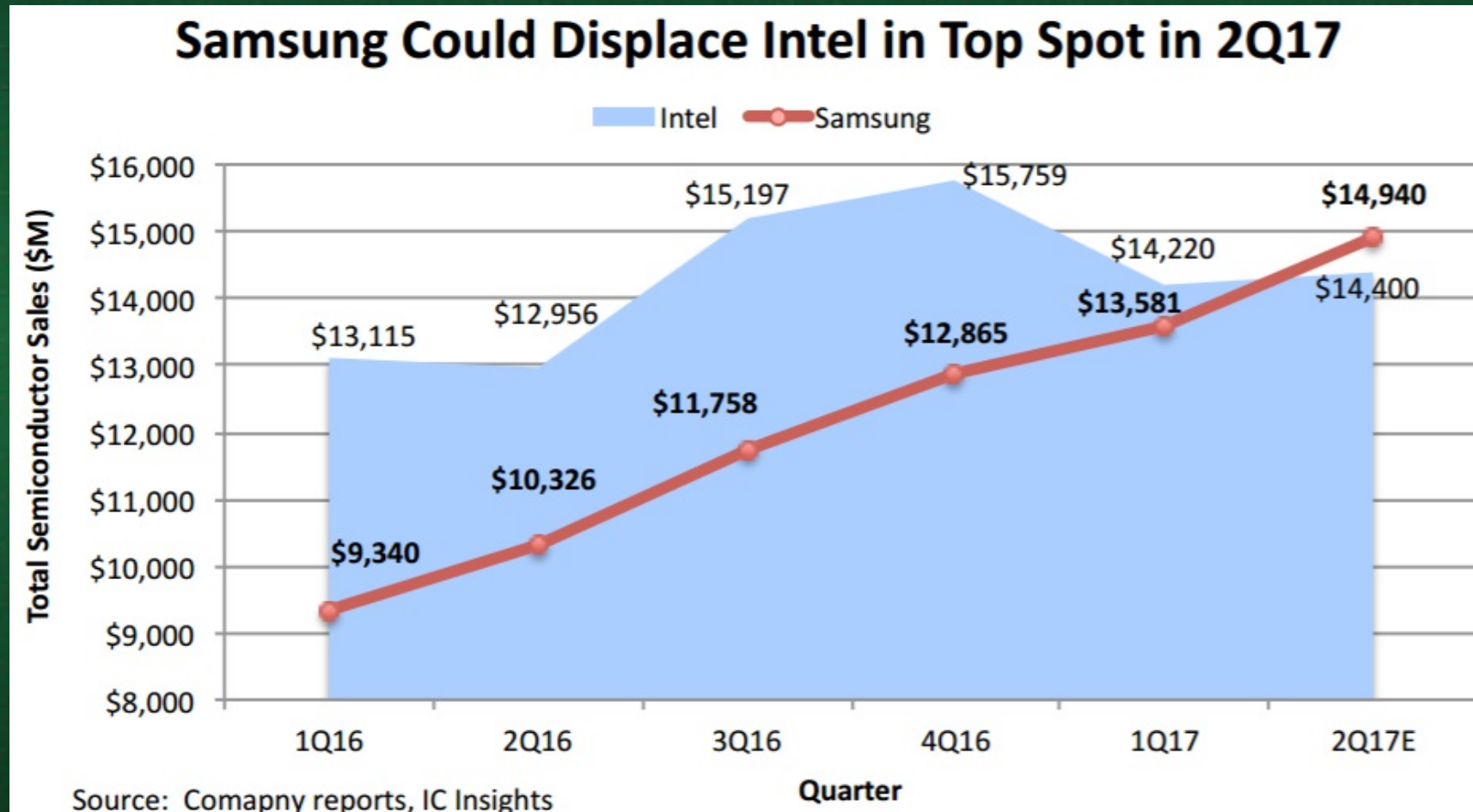
(1) Fabless

Global Market Demand and Market Share



Changing of the Guard ?

Intel has been the world's biggest chipmaker by revenue since January of 1993



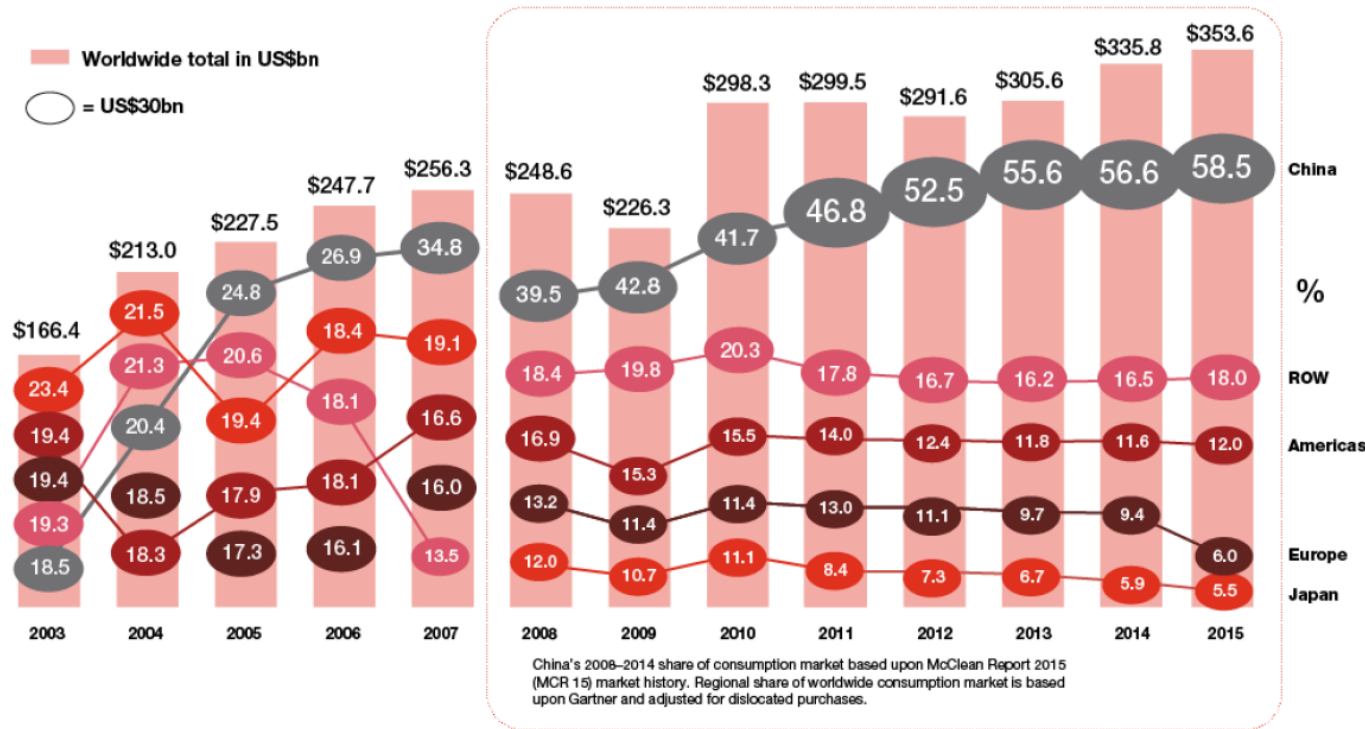
Changing of the Guard ?

Intel has been the world's biggest chipmaker by revenue since January of 1993

Top Semiconductor Companies Revenue			
Change versus prior quarter in local currency			
Company	Reported 1Q17	Guidance 2Q17	Comments on 2Q revenue
Intel	-9.6%	-2.7%	high end +0.7%
Samsung Semiconductor	5.4%	n/a	solid demand
Qualcomm	-16.4%	3.7%	high end 11.6%
Broadcom	-1.2%	n/a	1Q guidance, 2Q on June 1
SK Hynix	17%	n/a	strong DRAM demand, pricing
Micron Technology	17%	16%	includes Inotera as of 1Q17
Texas Instruments	-0.3%	4.3%	high end +8.7%
Toshiba	n/a	n/a	delayed financials
NXP Semiconductors	-9.4%	n/a	pending acquisition by Qualcomm
MediaTek	-18%	2.3%	high end +4.5%
Infineon Technologies	7.4%	3.0%	high end +5.0%
STMicroelectronics	-2.0%	5.0%	high end +8.5%

Changes to the Semiconductor Landscape

China keeps moving from a #1 Consumer to becoming a Device Producer



Source: Semiconductor Industry Association (SIA), McClean Report 2015 (MCR 15), Gartner Dataquest (GDQ), CCID Consulting (CCID)

Company	Location	Product	Begin Construction	Begin Production
Alpha & Omega	Chongqing	Power Discrete	tbd	tbd
Fujian Jin Hua	Fujian	DRAM	2016	2018
GigaDevice	Hefei	DRAM/Flash	tbd	tbd
GlobalFoundries	Chengdu	Foundry	2017	2018/2019
Hua Li Micro	Shanghai	Foundry	2016	2018
Powerchip	Hefei	Foundry	2015	2017
Samsung	Xian	3D NAND (Phase 2)	tbd	tbd
SMIC	Beijing Shanghai Shenzhen	Foundry Foundry Foundry	2016 2016 2016	2018 2018 2018
Tacoma Semiconductor	Nanjing	CMOS Image Sensor	tbd	tbd
Tsinghua Unigroup	Chengdu Nanjing	Foundry DRAM	tbd tbd	tbd tbd
TSMC	Nanjing	Foundry	2016	2018
UMC	Xiamen	Foundry	2015	2016
Yangtze River Memory/XMC	Wuhan	3D NAND	2016	tbd

Source: SEMI World Fab Forecast, 2016

Changes to the Semiconductor Landscape

China keeps moving from a #1 Consumer to becoming a Device Producer

- **China to be 15% of World Fab Capacity by 2018**
- **Once (if) all FABs move into production**
 - China's total 300mm-equalvent output is projected to more than triple
 - From 400,000 wafer starts per month today to more than 1.4 million by 2020
 - 60% of the output is geared for memory and 40% for logic.

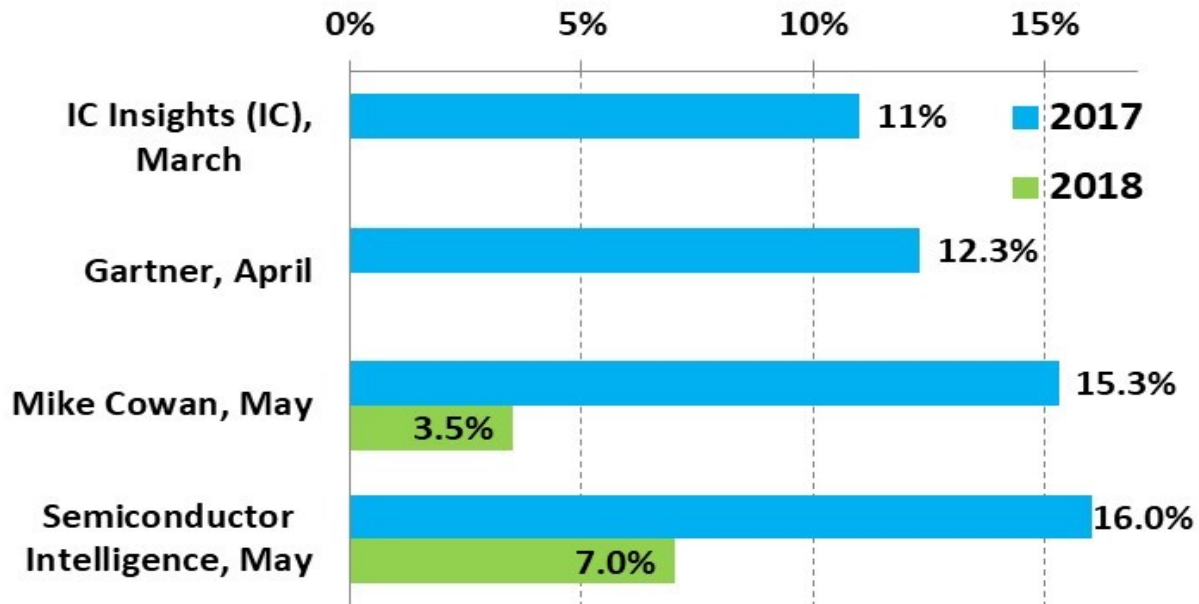
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GlobalFoundries	Chengdu	Foundry	2017	2018/2019
Hua Li Micro	Shanghai	Foundry	2016	2018
Powerchip	Hefei	Foundry	2015	2017
Samsung	Xian	3D NAND (Phase 2)	tbd	tbd
SMIC	Beijing Shanghai Shenzhen	Foundry Foundry Foundry	2016 2016 2016	2018 2018 2018
Tacoma Semiconductor	Nanjing	CMOS Image Sensor	tbd	tbd
Tsinghua Unigroup	Chengdu Nanjing	Foundry DRAM	tbd tbd	tbd tbd
TSMC	Nanjing	Foundry	2016	2018
UMC	Xiamen	Foundry	2015	2016
Yangtze River Memory/XMC	Wuhan	3D NAND	2016	tbd

Source: SEMI World Fab Forecast, 2016

Semi Market Growth Predictions

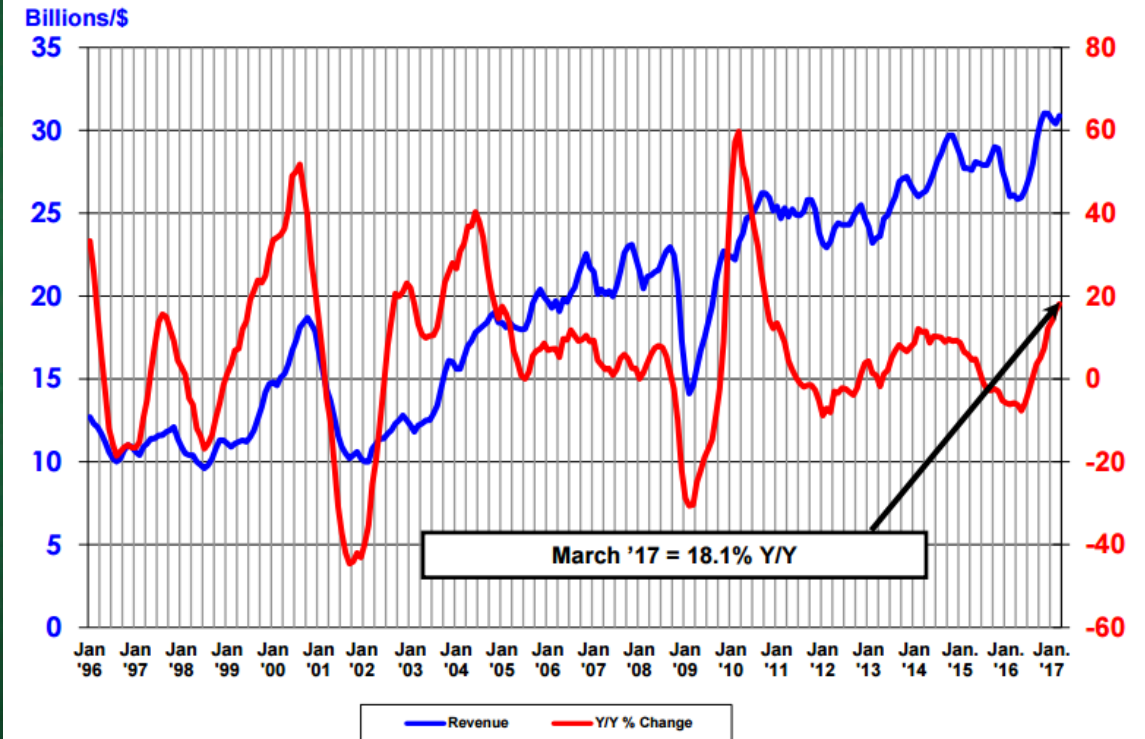
So far the trends are exceeding the predictions !

Semiconductor Market Forecasts



Worldwide Semiconductor Revenues

Year-to-Year Percent Change



Source: WSTS

Ever Changing Semiconductor Landscape



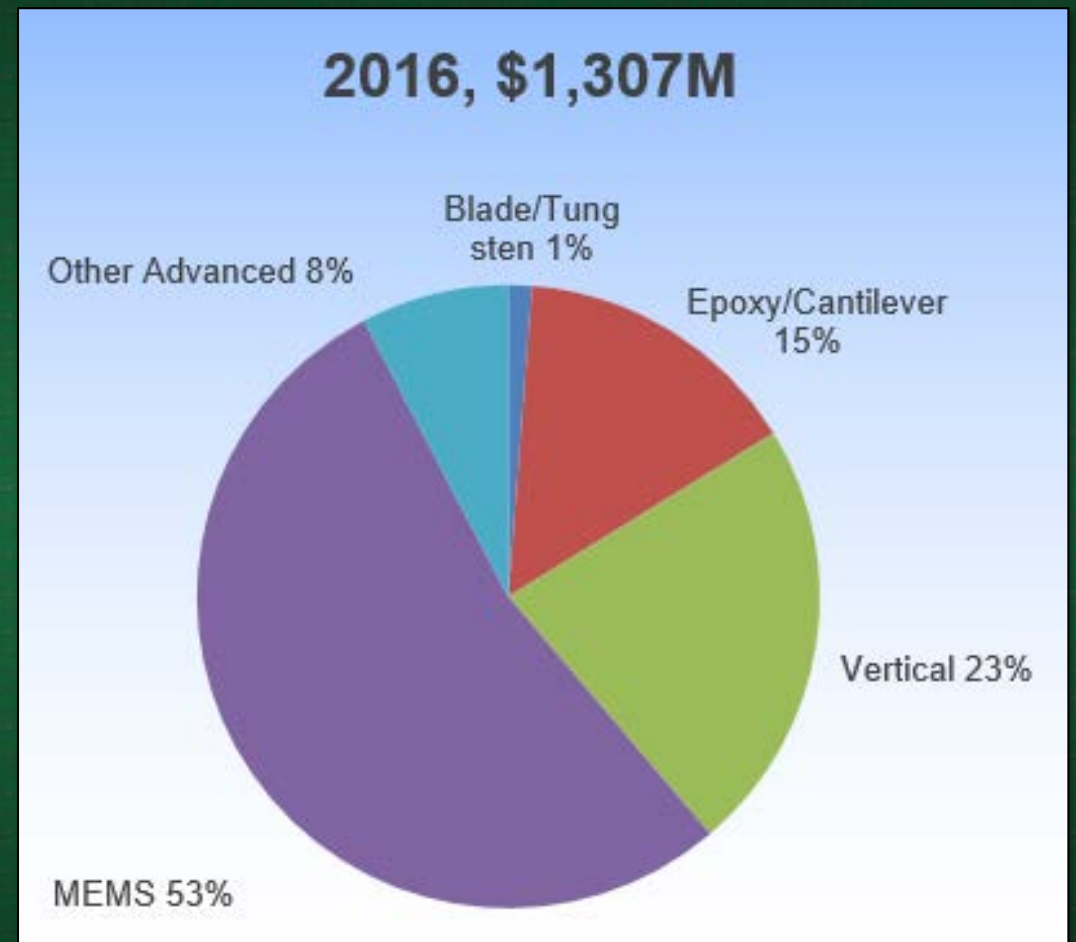
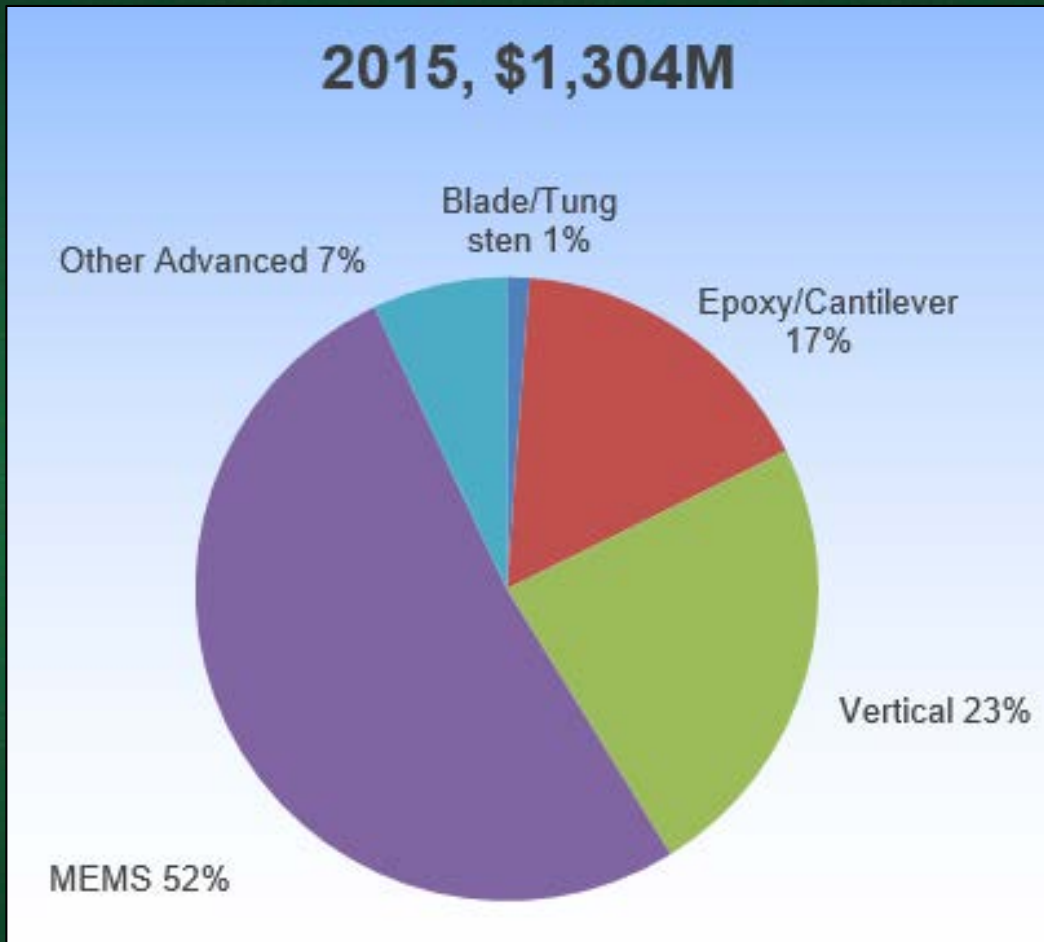
Probe Card Industry Revenues



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Thanks to John West and Risto Puhakka!

2016 Revenues by Technology



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Top Probe Card Vendors in 2016

Top 10 Semiconductor Probe Card Vendors 2016
Revenues in \$M, Calendar Year (excludes service and spares)

Rank		Company	2015	2016	% Change
2016	2015				
1	(1)	FormFactor, Inc.	280	335	16.4%
2	(2)	Micronics Japan Co., Ltd.	230	180	-27.8%
3	(3)	Technoprobe	120	124	3.2%
4	(4)	Japan Electronic Materials	100	95	-5.3%
5	(5)	MPI Corporation	75	90	16.7%
6	(7)	SV TCL	45	50	10.0%
7	(10)	Microfriend	30	40	25.0%
8	(9)	Korea Instrument	35	40	12.5%
9	(6)	Cascade Microtech	65	35	-85.7%
10	(11)	FEINMETALL	30	30	0.0%
Other (Rest of the Industry)			294	288	-2.1%
Semiconductor Probe Cards			1304	1307	0.2%

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Thanks to John West and Risto Puhakka!

27th Annual SW Test Workshop

- **Technical Program for 2017**

- Technical Tutorial on Sunday
- Nine Podium Sessions and Two Poster Sessions across Three Days
- 32 Podium and 8 Poster Presentations

- **Products / Services EXPO**

- 42 full size booths ... SOLD OUT !
- EXPO does not compete with Technical Program

- **Corporate Sponsors Program ... MANY THANKS !**

Platinum Sponsors

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“We’re not in it for the money ...”

- **SW Test Team has worked closely with the RBI staff such that every attendee has free parking, in-room internet, no resort fees, WiFi access during the entire workshop, and the best on-site conference room rate for this level of property.**
- **SW Test Executive Team ...**
 - Jerry Broz, Ph.D., General Chair and Sr. Member IEEE
 - Rey Rincon, Freescale Semiconductor, Technical Program Chair
 - Maddie Harwood, CEM Inc., Finance Chair & Registration Coordinator

“Who’s Really to Blame ...”

- **Program Committee ...**

- John Caldwell (Micron Technology)
- Darren James (Rudolph Technologies)
- Patrick Mui (JEM America)

- **Steering Committee ...**

- Gunther Boehm (FeinMetall GmbH)
- Michael Huebner, Ph.D. (FormFactor)
- Amy Leong (FormFactor)
- Clark Liu (PTI - Taiwan)
- Mark Ojeda (Cypress Semiconductor)
- Joey Wu (MPI - Taiwan)
- Karen Armendariz (Celadon Systems)
- Al Wegleitner (Texas Instruments)
- Sang Kyu (SK) Yoo (Samsung Electronics – Korea)
- Fred Taber (Taber Consulting) ... *Emeritus Member*
- Gary Maier (IBM) ... *Emeritus Member*
- Stevan Hunter, Ph.D. (ON Semi / BYU Idaho) ... *Emeritus Member*

SW Test is organized, coordinated,
and executed through the efforts
of your colleagues.

Technical Program / Agenda

- **Sunday, June 4, Technical Tutorial on Sensors and Sensors Testing**
 - **Sensors at Test - “Magnetic” Probe Cards**
Dr. Rainer Gaggl and Georg Franz (T.I.P.S. - Austria) and Al Wegleitner (Texas Instruments, Inc., USA)
 - **Multiplexer™ - Innovative Vertical Probe Card Structure for High Parallelism Image Sensor Probe Card**
Daisuke Miyamoto and Koji Ogiwara (SV TCL - Tokyo, Japan)
 - **Typical "Pain Points" in Wafer Level Testing of Mixed-Mode Sensor SOCs'**
Ranauld Perez (Johnstech International - USA)
 - **New Inspection Solution for Probing Technology**
Clark Liu (PTI - Taiwan)

Keynote Speaker

Phil Nigh, Ph.D.

**Distinguished Member of Technical Staff
GLOBALFOUNDRIES**



Emerging Test Methods ...

**How Auto IC Requirements, Adaptive Testing and
Multichip Products are Changing the Industry**

Technical Program / Agenda

- **Monday, June 5**

- Registration and Breakfast
- Diverse Probe Challenges
- Modelling and Measurement
 - Lunch (Aragon Lawn)
- Memories (HBM, Cu-Pillars)
- Poster Session 1 during the Afternoon Break
- Contact and Performance
- SW Test EXPO 2017 w/ Dinner served at the Reception Stations
 - Hospitality Suites for more networking
 - Even more networking at La-Taberna Bar

SW Test EXPO 2017

- Advantest ... Silver Sponsor
- **Aehr Test Systems**
- **Celadon Systems**
- Chunghwa Precision Test Tech.Co.,Ltd ... Platinum Sponsor
- **Cohu**
- **Complete Probe Solutions Inc.**
- **Daeduck Electronics Co., LTD.**
- **Everbeing Int'l Corp.**
- **Feinmetall GmbH**
- **Ferrotec (USA) Corporation**
- FormFactor / Cascade Microtech ... Platinum Sponsor
- Harbor Electronics ... Platinum Sponsor
- **Integrated Technology Corporation**
- International Test Solutions ... Platinum Sponsor
- **InTEST Corporation**
- **IWIN CO.,Ltd.**
- JEM America Corp. ... Platinum Sponsor
- Johnstech International ... Silver Sponsor
- Kita USA
- **KJet Laser Tek Inc.**
- **MarTek, Inc.**
- **Microfriend Inc.**
- Micronics Japan (MJC) ... Platinum Sponsor
- MPI Corporation ... Platinum Sponsor
- **Nidec-Read Corporation**
- **NTK Technologies**
- **OpTek Systems Inc.**
- **Oxford Lasers**
- **Prober.com**
- R&D Altanova ... Silver Sponsor
- **Reid-Ashman Mfg., Inc.**
- **Rika Denshi America Inc.**
- **Rudolph Technologies**
- **Specialty Coating Systems**
- STAr Technologies, Inc. ... Gold Sponsor
- SV TCL ... Gold Sponsor
- Synergie CAD Group ... Gold Sponsor
- **Tanaka Precious Metals**
- **Technoprobe America Inc.**
- Teradyne Global Services ... Platinum Sponsor
- T.I.P.S. Messtechnik GmbH ... Gold Sponsor
- **Vermont Microtechnologies**

SW Test EXPO 2017



- **QR codes on the backside of the badges**

- First and Last Name
- Organization
- Email Address

- **Many Free Readers**

- iTunes Store
- Android Store



Technical Program / Agenda

- **Tuesday, June 6**

- Registration and Continental Breakfast
- Substrates - Space Transformers
- Poster Session 02 during the morning break
- CCC & MAC Methods
 - Lunch (Aragon Lawn)
- Challenges of Probing Ever-Finer Geometries
- EXPO 2017 w/ Refreshments will be served
- “New Orleans River Boat” ... Casino Night and Social Club

Tuesday Social Celebrates New Orleans

- Network and Socialize from 6:00 to 9:00PM
- Cocktails, Dinner and Gambling, Golfing, Lounge Singing



Technical Program / Agenda

- **Wednesday, June 7**
 - Registration
 - RF and Radar Applications
 - Process Improvement
 - Awards and Adjournment
 - Box Lunch (Aragon Lawn)

Recognition & Awards

- Most “Inspirational” Presentation
- Best Presentation, Tutorial in Nature
- Best Data Presented
- Best Overall Presentation

- A presentation from SW Test 2017 will be selected for the **TESTVISION 2020**
 - Program on July 12 to 13, 2017
 - SW Test will award a travel grant to each speaker



SW Test 2016 Awards

Most Inspriational Presentation

**Automated Probe Card Exchange and Docking for
RADAR Products**

Jory Twitchell (NXP Semiconductor)



Best Presentation, Tutorial in Nature

**Production Test RF Calibration for Multi-DUT Probe
Cards: How to get the most accurate measurements**

Daniel Bock, Ph.D. (Cascade Microtech, USA)



SW Test 2016 Awards

Best Data Presentation

AMD High Pin Count Probing Challenges on Leading Edge GPU

Foo Xin Reng (AMD), Raffaele Vallauri (Technoprobe) and Claus Ploetz (Advantest)

Nominated for Best ATE Publication of the Year
(to be announced at Test Vision 2020)



Best Overall Presentation

Probing Cu Pillar Application w/ Vertical Technologies

Brandon Mair (Texas Instruments, Inc., USA)

Nominated for Best ATE Publication of the Year
(to be announced at Test Vision 2020)



That “Special” Award ...



Bill Mann's Poorest Disguised Sales Pitch

*“What happens at SW Test
stays at SW Test !!”*

Want to Learn More ?

- **IEEE Holm Conference on Electrical Contacts**
<http://www.ieee-holm.org>



- **IS-Test Workshop**
<http://www.is-test.com>



- **SEMI TESTVISION 2020**



- **IEEE North Atlantic Test Workshop**
<http://www.is-test.com>



- **Burn In & Test Strategies Workshop**
<http://www.bitsworkshop.org>



- **Electronic Components and Technology Conference**
<http://www.ectc.net>



- **VLSI Research**
<https://www.vlsiresearch.com/>



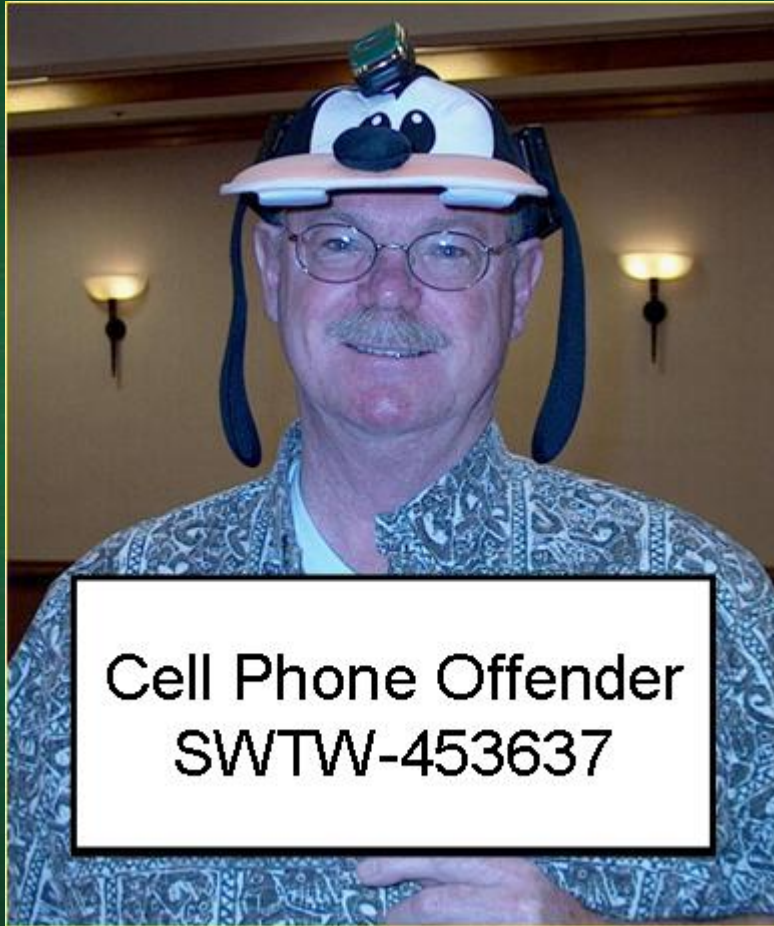
- **ProbeCard Insider**
Technology Blog by Paul Meyer on Probe Cards
<http://probecardinsider.com>



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Silence your cell phone !!!



Thanks for your Support !

- Contact the SW Test Team with any questions ...

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