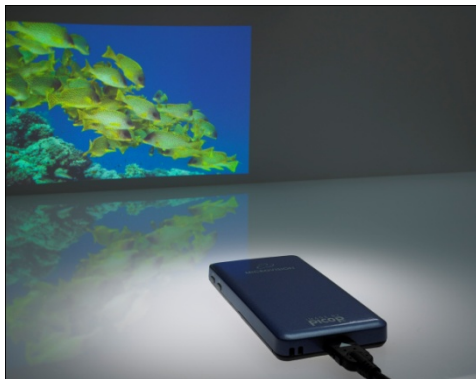


MEMS Industry Group Presents

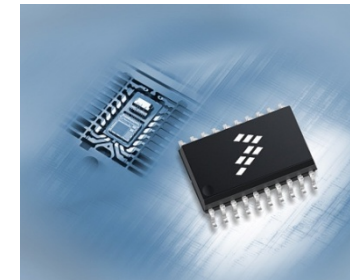


MEMS in the US Market: Emerging and Established Applications



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www.memsindustrygroup.org

Hannover Messe
19.April.2010





My presentation today

- ▶ Introduction of MEMS Industry Group (MIG)

- ▶ Overview of MIG Programs / Events
 - Resources and information
 - Upcoming events

- ▶ MEMS Growth Opportunities
 - Overview of world market
 - Growth predictions worldwide
 - US Market Overview and Growth Trends

- ▶ Conclusion

MEMS Industry Group (MIG) – Introduction



- ▶ Formed in 2001 with five companies – as outgrowth of MEMS industry executive meetings at DARPA
- ▶ Industry trade association incorporated as a not-for-profit organization, based in Pittsburgh
- ▶ Managed by a Managing Director, Karen Lightman, under aegis of Governing Council composed of representatives from member companies
- ▶ Over 80 member companies **from around the world** – from start-ups to Fortune 500 companies, MIG members represent the entire MEMS supply chain:
 - Device manufacturers, equipment suppliers, materials suppliers, foundries, software vendors, association partners, market analysts...



MEMS Industry Group Members

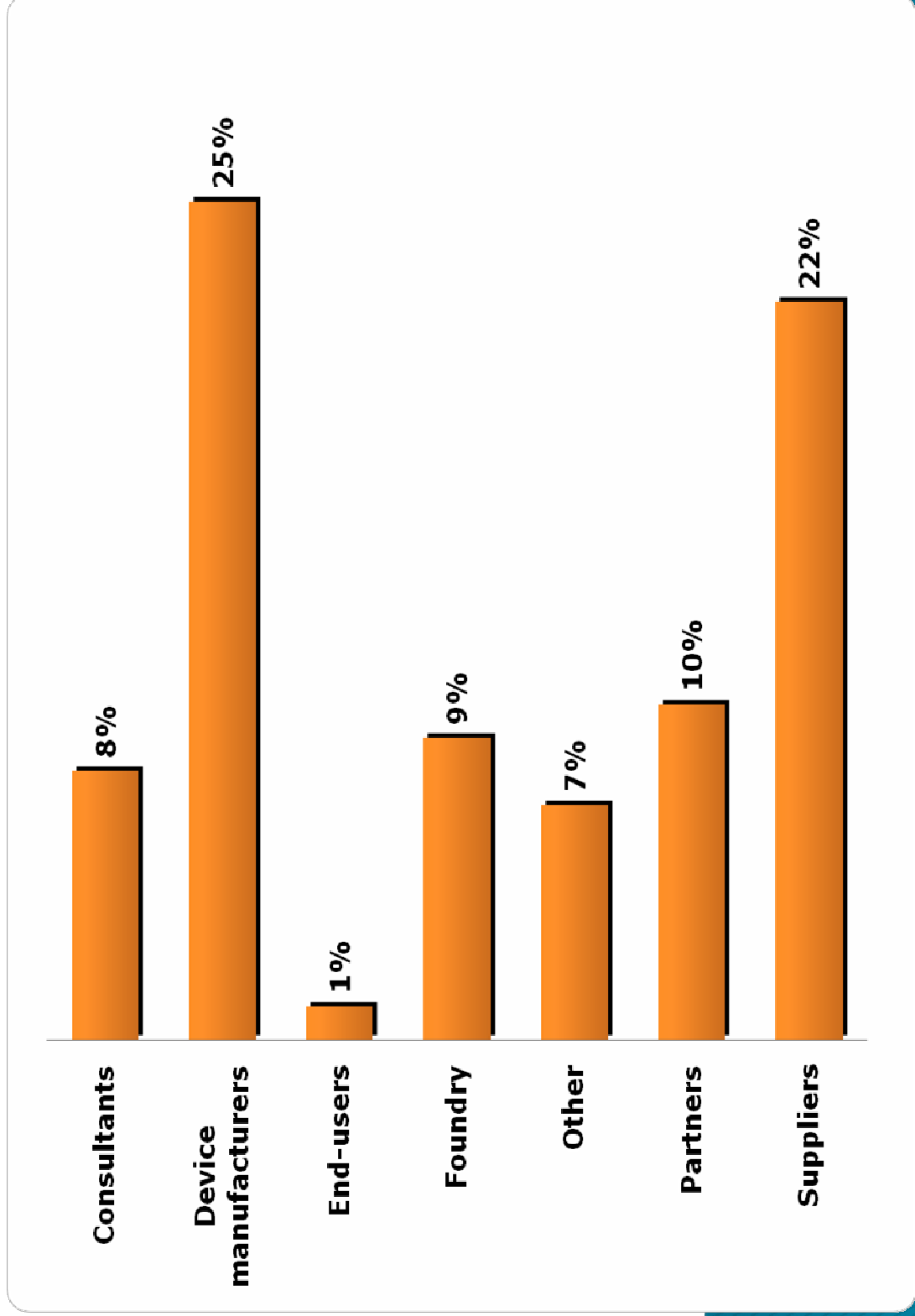


Acuity Incorporated
Acutronic USA
AEPI Grenoble-Isere France
Economic Development Agency
Alberta Centre for Advanced MNT
Products (ACAMP)
A.M. Fitzgerald & Associates
Applied Materials
Applied Microstructures
Analog Devices
Asia Pacific Microsystems
Automation & Robotics Research
Institute (ARRI)
Azept
Bosch RTC
Boschman Technologies B.V.
Bourne Research
Brewer Science
Bullen Ultrasonics
Coventor, Inc.
DALSA Semiconductor
DHarris Group
Discera
Draper Laboratory
Endevco MEMS
EPCOS Netherlands
EV Group

Fab Owners Association
Fraunhofer IPMS
Freescale Semiconductor
Fullpower Technologies, Inc.
GE Global Research & GE Sensing
Gavin Ho - Consultant
Honeywell
IMEC
Innovative Micro Technology (IMT)
Intel Corporation
Intellisense Software
InvenSense
iSuppli
IVAM
Kionix
Kilbrydon Consulting
Knowles Acoustics
Lam Research Corporation
Leti
Maxim Integrated Products
MEI LLC
MEMSCAP
MEMStaff Inc.
MEMSSTAR
MEPTEC
Micralyne, Inc.
MicroGen Systems
Microvision
Micromachine Center - Japan

Midwest MicroDevices
Nanoshift
NIST
Northrop Grumman
Okmetic Oyj
Omron
Optical Associates Inc
Plan Optik AG
PlasmaTherm
Primaxx, Inc.
Proteus Biomedical
Radant MEMS
SEMI
Semiconductor Support Services Co.
SensoNor
Silex Microsystems
Small Times
SPP Process Technology Systems (SPTS)
SUSS MicroTec
SVTC Technologies
Tekton Consulting, LLC
Tegal Corporation
Texas Instruments
Thai Nguyen
TRONICS
VTI Technologies, Inc.
Xactix
Wispry, Inc.
Yole Développement

Membership Profile



Networking among Partners and Customers



- ▶ MIG gives you instant access to an amazing network
- ▶ Meet industry leaders throughout the MEMS supply chain
- ▶ You can:
 - Share insights and experiences
 - Collaborate to pursue new business opportunities
 - Gain inside access to the industry for competitive intelligence and “proto-marketing”

MIG Programs and Benefits



MIG offers a wide range of programs for everyone in your company -- from the top executive to the new hire:

- ▶ METRIC
- ▶ MEMS Education Series
- ▶ MEMS Executive Congress
- ▶ MEMS Marketplace
- ▶ MEMS Glossary
- ▶ MEMS Webinars and online meetings
- ▶ Information-sharing and dissemination through blogs, Twitter, LinkedIn groups, LISTSERVS, and newsletters
- ▶ Speaking opportunities at Globalpress Electronics Summit, SEMICON West MEMS panel, etc.

METRIC 2010 – San Jose, Wyndham Optimizing MEMS Fabrication



METRIC is:

- ▶ Members-only technical meeting focused on challenges to MEMS commercialization
- ▶ Based on months of primary and secondary research (industry-wide survey, interviews, paper reviews/synopses, etc.)
- ▶ One full day of working groups, kicked off by panel discussion to set stage for working groups and dinner wrap-up session
- ▶ www.memsmetric.com – May 18–19, 2010



Focus of METRIC 2010...



Optimizing MEMS Fabrication

▶ Working Groups

- Technical Challenges in Optimizing MEMS Fabrication
- New Opportunities for MEMS Fabrication
- Captive Fab vs. Fabless Models
- Working with a Foundry

▶ Panels

- MEMS Integration – Harnessing the “MEMS Inside” Potential?
- The Many Faces of MEMS Fabrication – In-house, Fab-lite, and Fab-less

2010 MEMS Education Series



- ▶ *MEMS Test & Reliability Short Course*
 - July 12 at San Francisco State University's Downtown campus, Monday of SEMICON West week
 - Instructor – Dr. John McKillop, Tekton Consulting
 - Overview of MEMS test and reliability assessment methods
 - Case studies/interviews – pressure sensors (low-volume), accelerometers (high-volume) & emerging technologies

- ▶ www.memseducationseries.com

- ▶ November 3–5, 2010
- ▶ THE event for MEMS executives to meet their end-user customers for networking and discussion relating to MEMS commercialization
- ▶ MEMS Executive Congress 2010 focused on systems enabled by MEMS in existing and adjacent markets
- ▶ Keynote: Rich Duncombe, Distinguished Technologist, Hewlett-Packard Company
- ▶ More details to be announced
 - visit www.memscongress.com for more information



MEMS Blog

MIG members blog on all things MEMS –
www.memsindustrygroup.org/blog

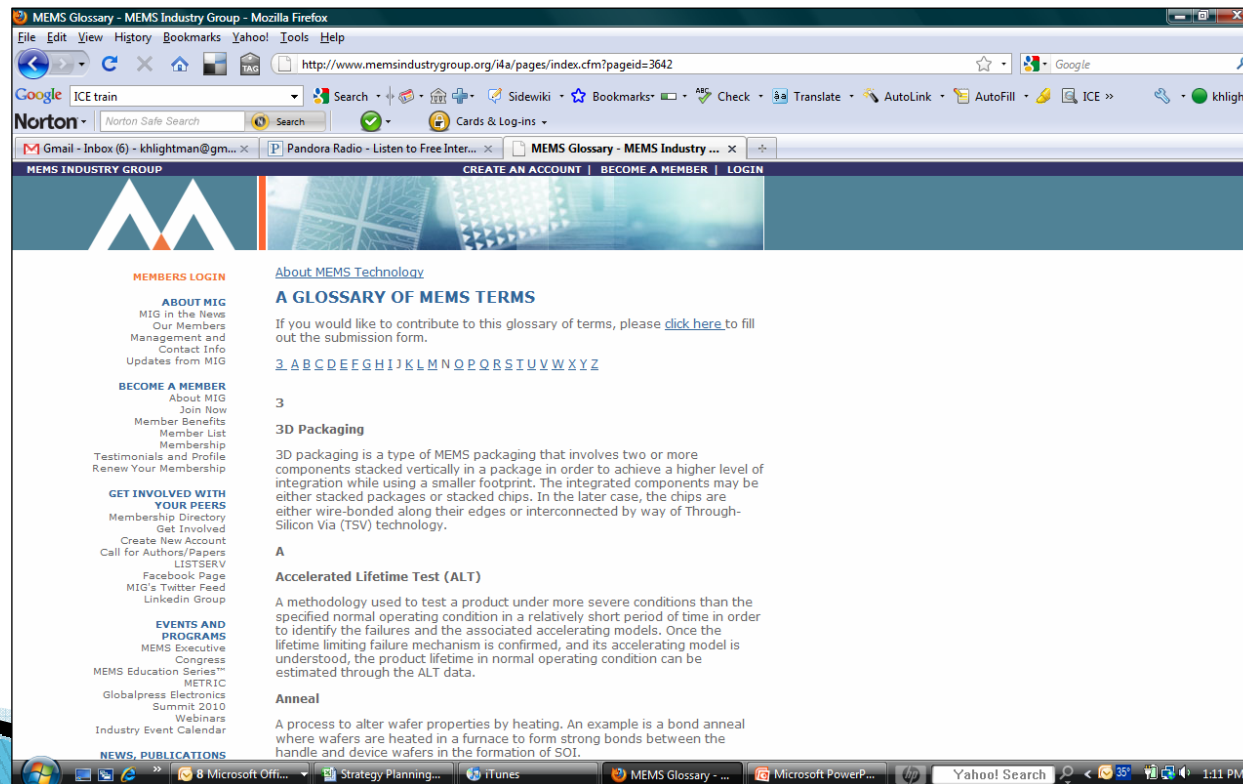


MEMS Glossary



www.memsindustrygroup.org/glossary

- ▶ Designed to create common ground for communication within the industry
- ▶ The glossary is a living document to which anyone in the MEMS community can contribute definitions



Best Known Practices White Papers



www.memsindustrygroup.org/bestknownpractices

- ▶ Invite MIG members to share varied perspectives on successful MEMS practices
- ▶ Encourage dialogue on the “best known practice” on topics such as wafer bonding processes



MEMS Marketplace



www.memsmarketplace.com

- ▶ An online portal that serves as a matchmaker for companies in the entire MEMS supply chain, from material suppliers to OEMs

The screenshot shows the MEMS Marketplace website interface. At the top, there is a dark blue header with the MEMS Industry Group logo on the left, the date 'THURSDAY, FEBRUARY 12, 2009' in the center, and a 'LOGIN' link on the right. Below the header is a large banner image showing a close-up of a MEMS device. The main content area is divided into a left sidebar and a right main section. The sidebar contains navigation links: 'ABOUT MIG', 'ABOUT MEMS TECHNOLOGY', 'CAREERS', 'EVENTS', 'MEMBERS ONLY MEMBERS LOGIN' (with sub-links for account creation, updates, forum, portal, statistics, case studies, and materials), and 'MEMBERSHIP INFO'. The main section is titled 'MEMS MARKETPLACE - PRODUCT SEARCH' and includes navigation links for 'Category Browse', 'Product Search', 'Company Search', and 'Industry News'. Below these links is a search form with the following fields: 'Category' (a dropdown menu set to '- Structured Wafers and Substrates'), 'Manufacturer' (a dropdown menu), 'Model' (a text input field), and 'Details/Features' (a text input field containing 'SOI'). A blue 'Search' button is located below the 'Details/Features' field. A text box above the form instructs users to select search criteria and click the 'Search' button, with links for 'distributor' and 'manufacturer'.

Summary



- ▶ MIG's mission is to advance the global MEMS market
- ▶ MIG is the unifying voice of the commercial MEMS community
- ▶ It is where MEMS companies want to be
- ▶ MIG offers events and programs that serve the needs of the MEMS industry: MEMS Executive Congress, METRIC, MEMS Education Series, MEMS Marketplace, blogs, webinars, podcasts & more
- ▶ More information on member benefits visit: www.memsindustrygroup.org/benefits

Introduction – US MEMS Market



▶ Big picture

- US emerging out of a tough downturn – slow steady jobless recovery so far
- Europe still lagging behind
- Asian markets – still saw growth but not the double digits of years past

▶ What does this mean for MEMS?

- Manufacturing process and high volume = big changes for MEMS fabrication
- Cost cutting is key
- “Consumerization” is infiltrating MEMS markets
- It’s all about the system

US MEMS Market and Facts



- ▶ MEMS companies with headquarters in US recorded in 2009:
 - **\$3.4 Billion** (Yole estimation) MEMS revenues, representing **10% decrease** from 2008.
 - MEMS sales representing more than **45%** of the global MEMS market

- ▶ Main facts for US MEMS players in 2009 in the TOP 30 MEMS players:
 - **Two US-based companies** are in the TOP 3:
 - HP – inkjet printhead giant now hoping to be leader in MEMS accel’s
 - TI is taking its predominance in DLP into new markets – energy...
 - InvenSense – best performance with +500% growth to \$95 million; and first successful US fabless company...so far

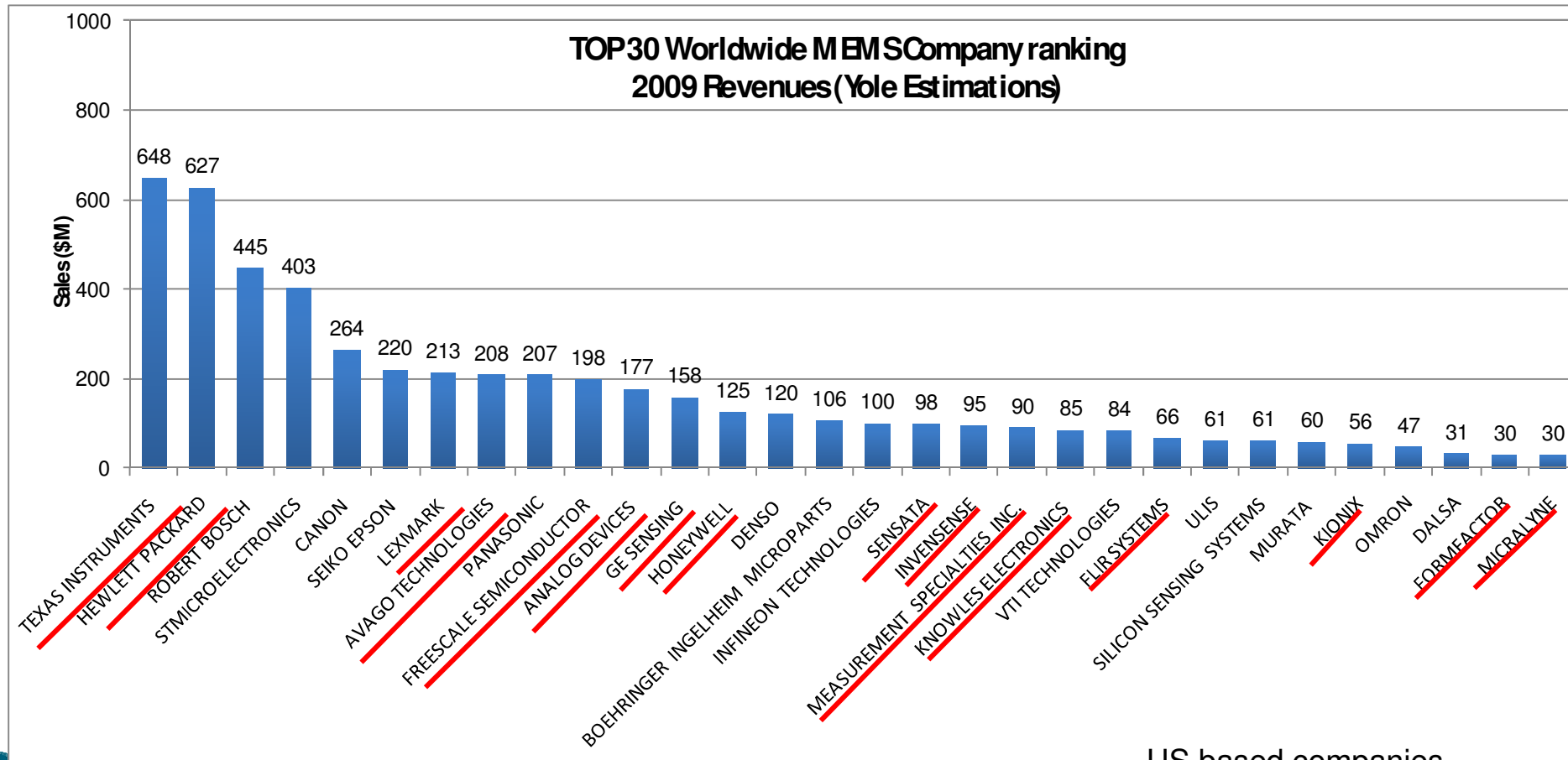
US Market Perspective



- ▶ Innovative and emerging products in US – US Competitive Advantage:
 - More than 10 Fabless companies started activities during the last 3 years: Sand9, Qualtre, Pixtronix ...
 - Emerging MEMS projects : RF MEMS with WiSpry, Analog Devices or Knowles; MEMS oscillators with Silicon Clocks; or MEMS Fuel Cells with Lilliputian Systems
- ▶ Manufacturing presence battered because of downturn, especially in automotive
 - Asia is larger threat – price pressure and IP issues are appearing to be lessened (we'll see)
- ▶ US economic rebound will likely fuel growth in MEMS – consumer, medical, smart grid...
- ▶ Saw rise in partnerships and acquisitions in 2009 in US; will likely see more as purse strings loosen up

TOP 30 MEMS Companies in 2009

Focus US Market

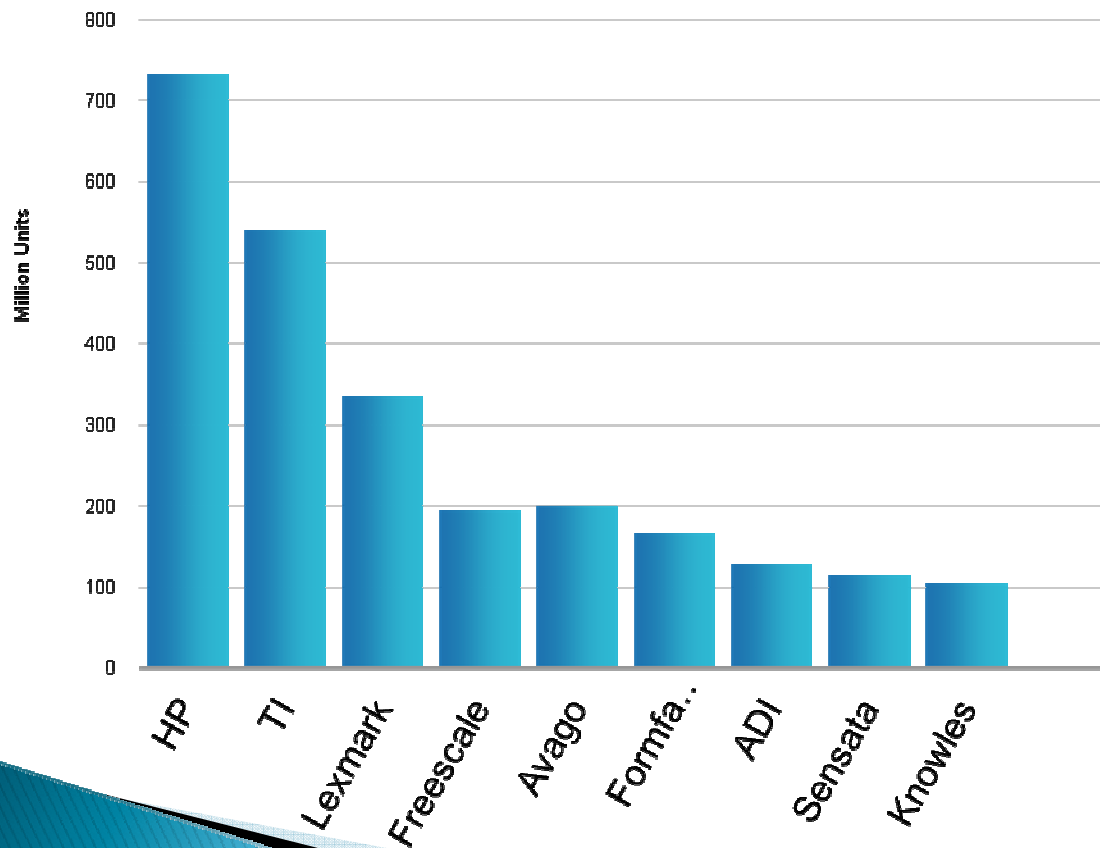


US based companies

MEMS Producers with over \$100M in the US



MEMS production at top US IDM and Fabless* companies



- ▶ HP: inkjet, 100% captive, <50% in house production, balance outsourced to ST
- ▶ TI: DLP (in house), Scanning mirrors (fabless)
- ▶ Lexmark: inkjet, fabless (outsourced to TI)
- ▶ Freescale: accelero, pressure, mostly IDM, small part outsourced to Dalsa
- ▶ Avago: IDM, BAW filters
- ▶ Formfactor: captive, IDM, wafer probes
- ▶ ADI: inertial sensors, microphones, partly outsourced to TSMC
- ▶ Sensata: pressure, 100% fabless
- ▶ Knowles: microphones, fabless, outsourced to Sony

Source – iSuppli Corporation *MEMS competitive analysis*, H1 2010

Acceleration Sensors – Market share Compilations...



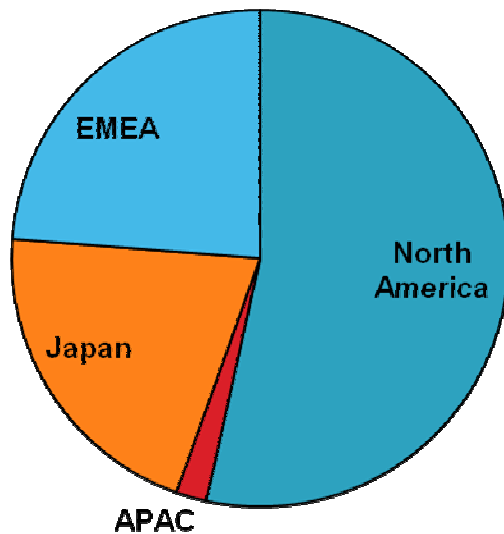
2009 Rank	Company Name	2008 Revenue	2009 Revenue	Change	Share (%)
1	STMicroelectronics	231	210	-9%	19%
2	Analog Devices	175	198	13%	18%
3	Robert Bosch	250	185	-26%	17%
4	Denso	143	132	-8%	12%
5	Freescale Semiconductor	141	127	-10%	12%
6	VTI Technologies	106	72	-32%	7%
7	Rohm	0	59	NM	5%
8	Mitsubishi	40	47	18%	4%
9	Omron	21	20	-5%	2%
10	Hokuriku Electric Industry	30	19	-37%	2%
	Others	60	18	-70%	2%
	Total Market	1197	1087	-9%	100%

Source: Gartner Estimates (March 2010)

North America Dominates Supply of MEMS



% of MEMS production by region of HQ

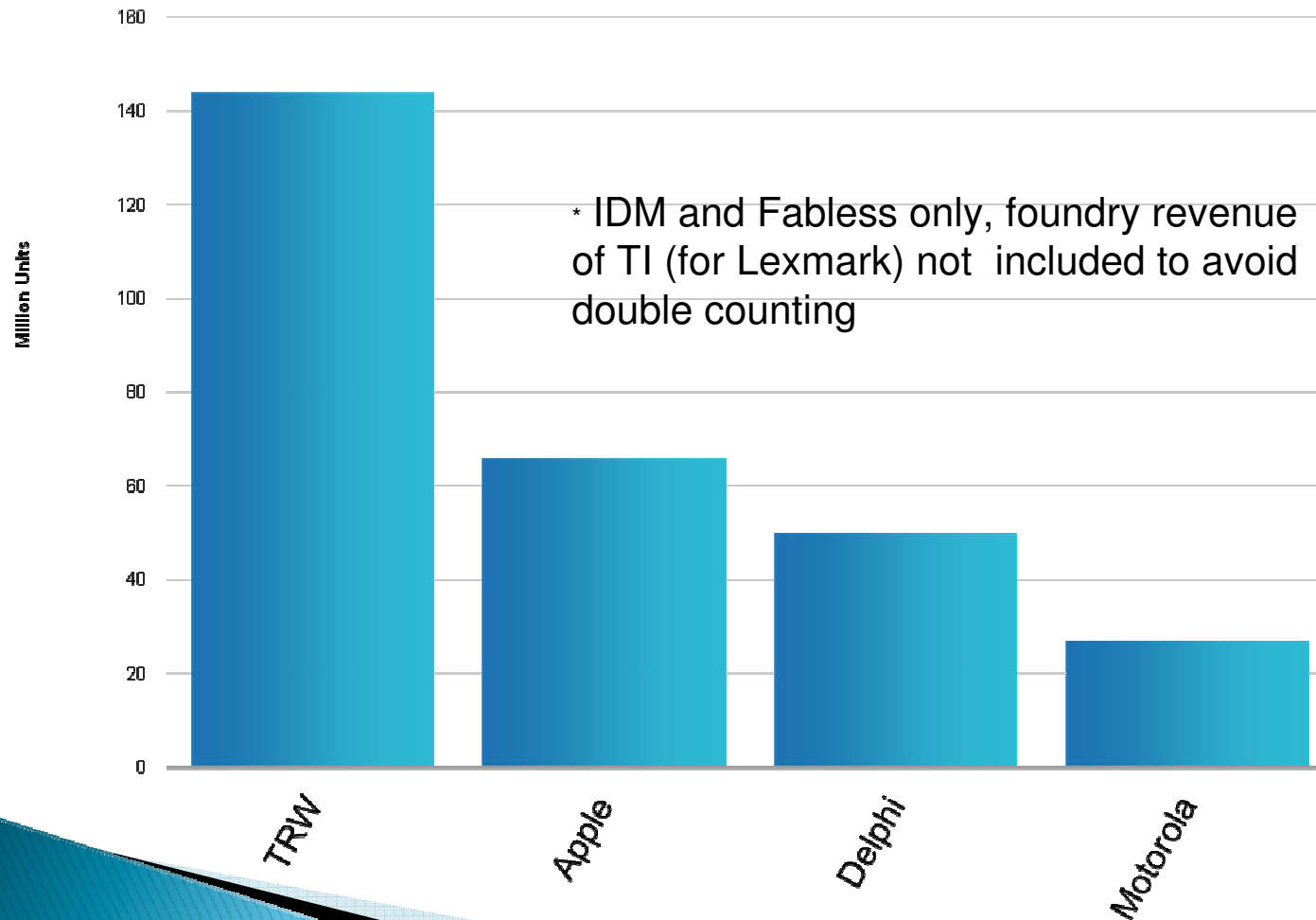


- ▶ North America accounts for over 50% of the production of MEMS
 - Considering location of HQ, not of production (e.g. Freescale counted for US although most of MEMS production is located in Sendai Fab in Japan)
 - Considering IDM and fabless MEMS producer only (no double counting of foundry revenue)
- ▶ Largely influenced by 800 pound Gorillas HP and TI, the top two MEMS manufacturers for several years

Top Buyers of MEMS in North America



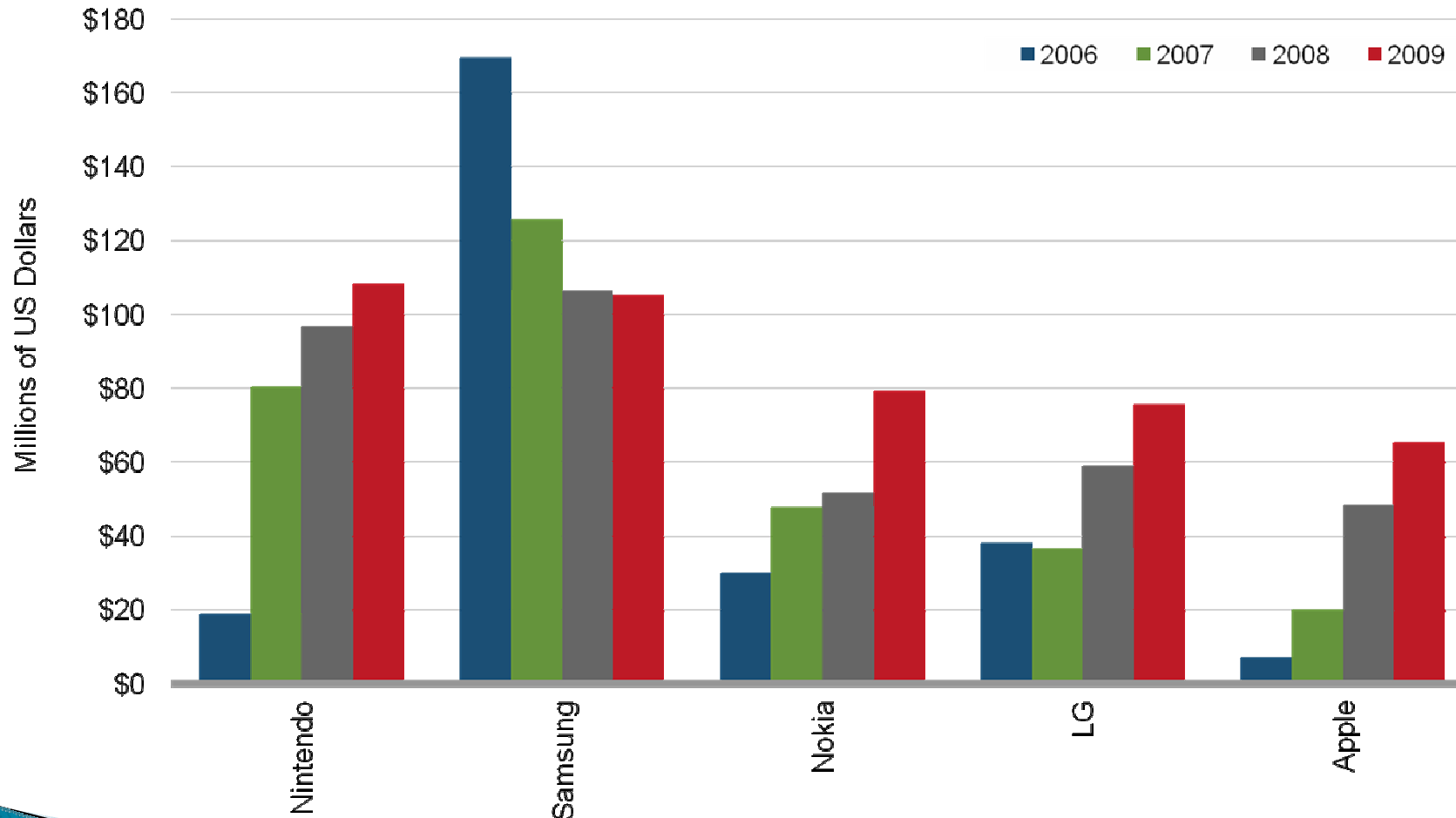
MEMS purchase by North American Companies



- ▶ Largest buyers worldwide are in Europe
- ▶ TRW: automotive
- ▶ Apple: iPhone, iPod, MacBook, iPad
- ▶ Delphi: automotive
- ▶ Motorola: cell phones

Source – iSuppli Corporation *MEMS competitive analysis, H1 2010*

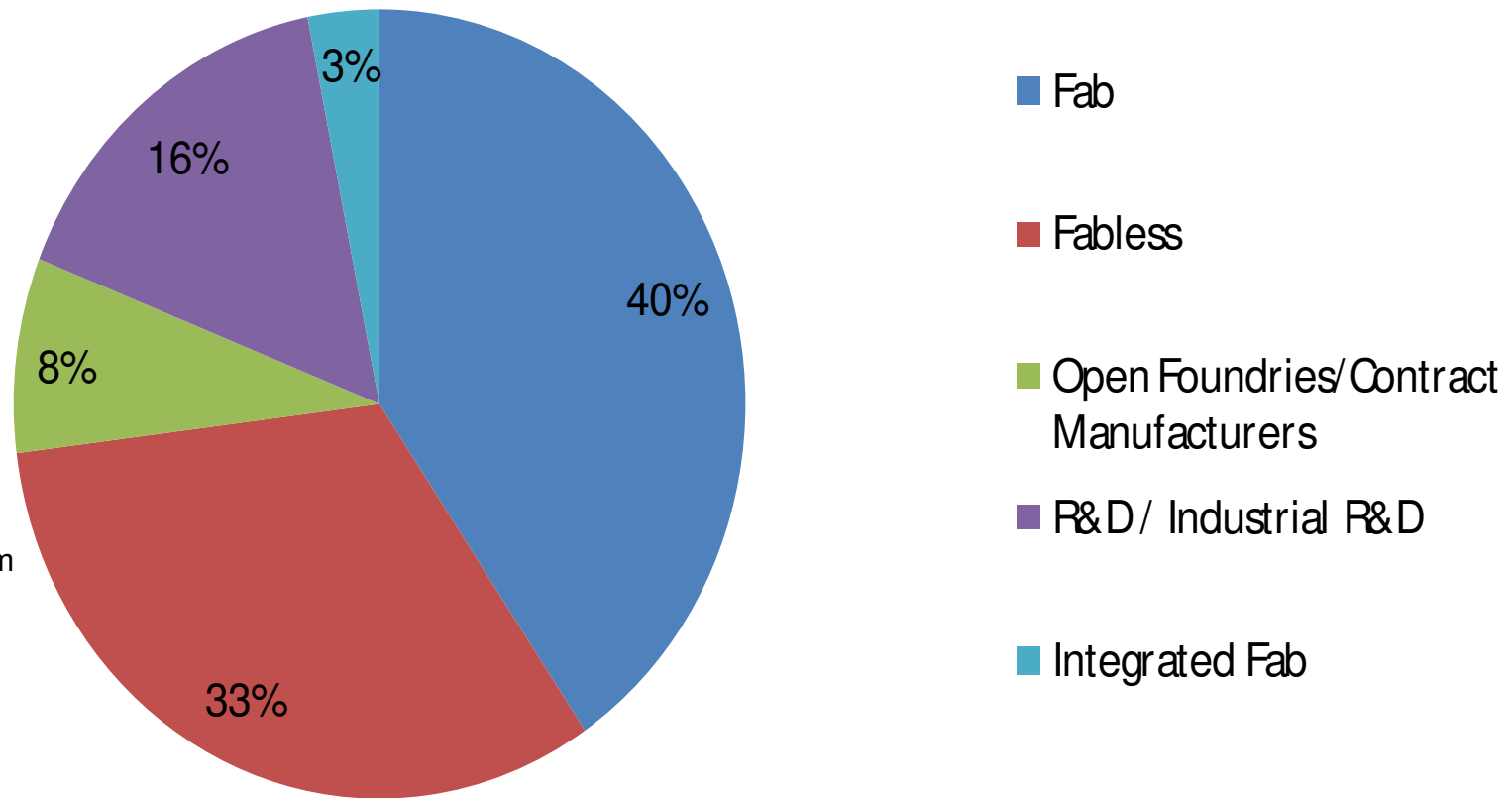
Top OEMs Consuming MEMS for Consumer & Mobile Handsets



Business Model of US-based MEMS Companies



2010: Businessmodel breakdown (by number of companies)

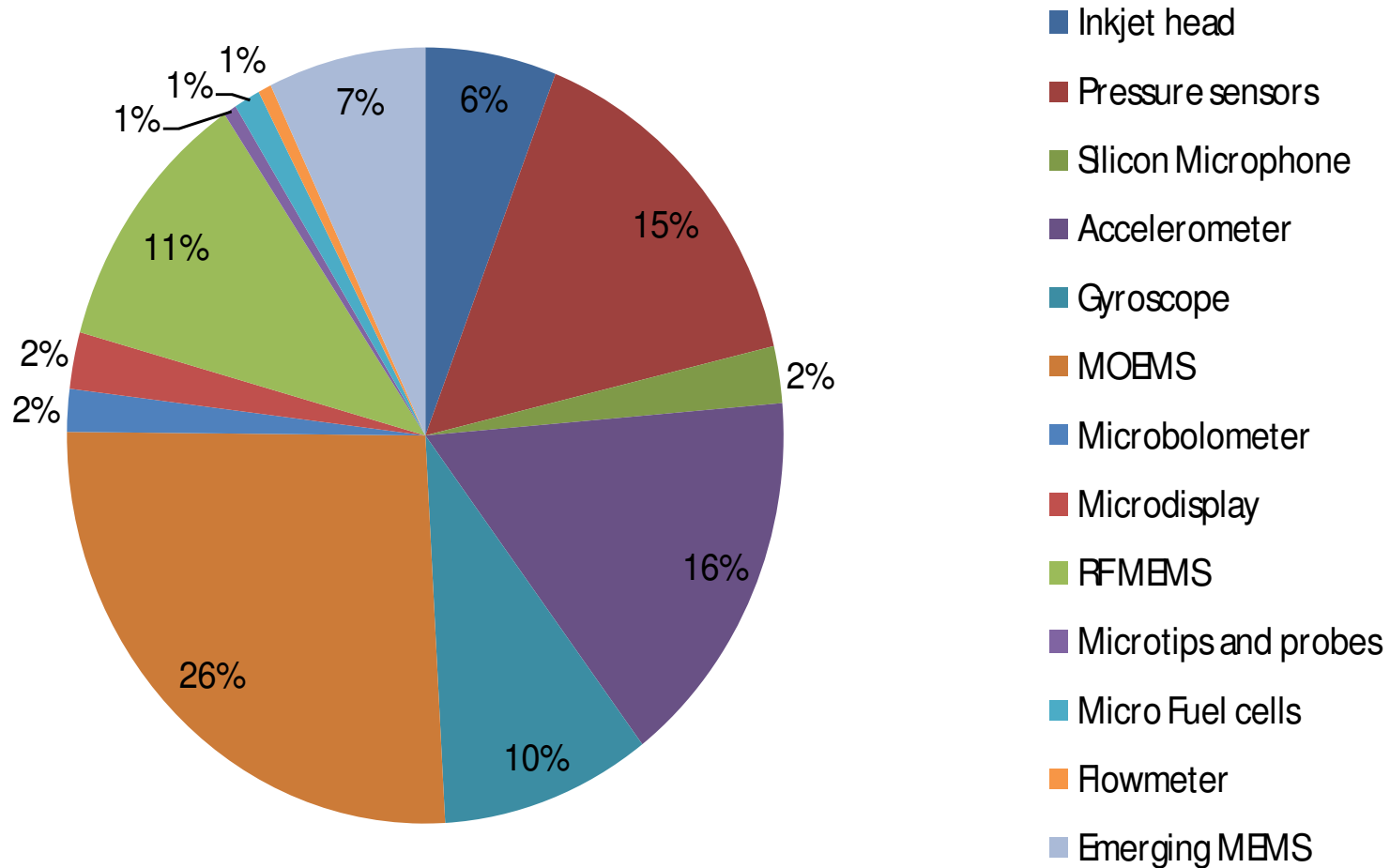


Source; Extracted from
World MEMS players
2010; Yole
Développement

MEMS product breakdown – US Market

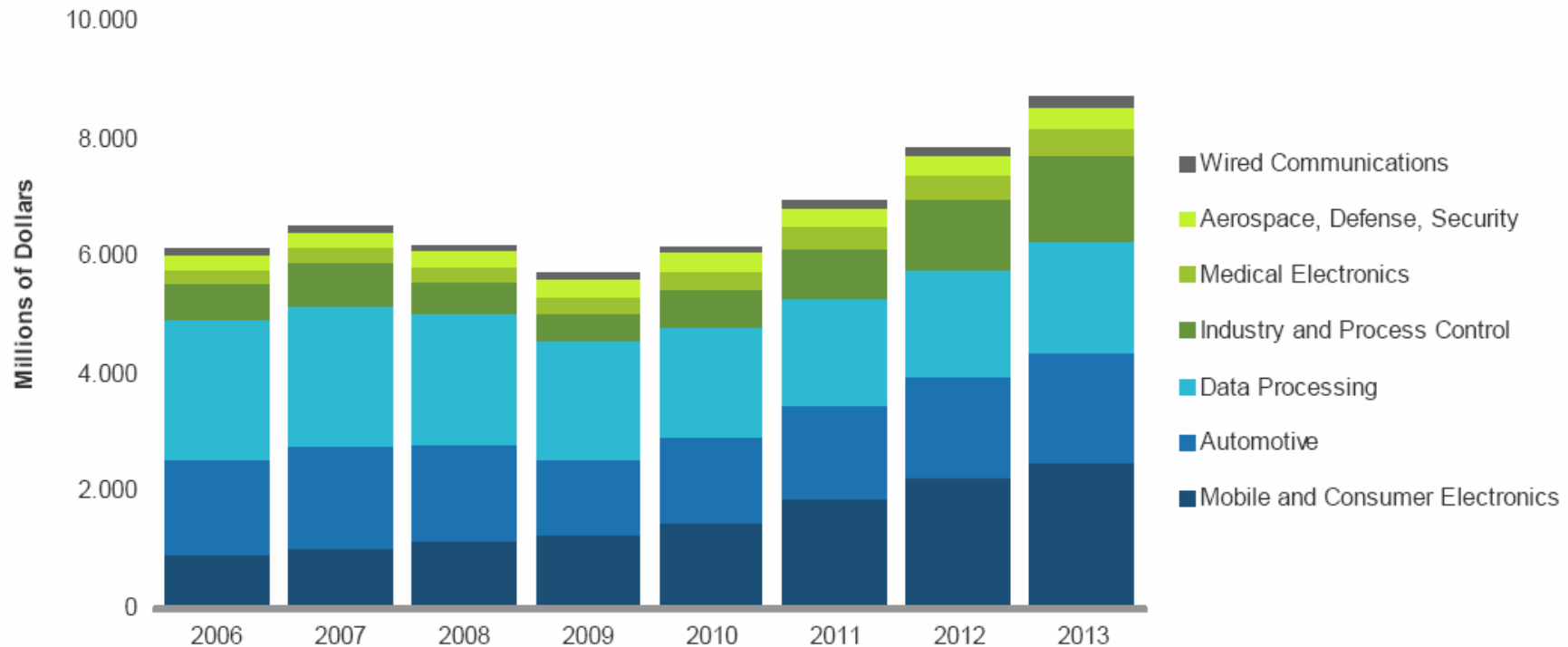


2010: Product breakdown in US (by number of companies)

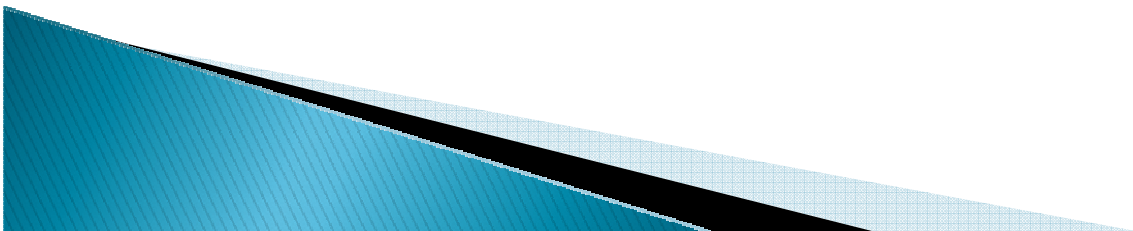


Source;
Extracted from
World MEMS
players 2010;
Yole
Développement

MEMS Growth Areas



Note: emerging MEMS categories not counted in this breakout (\$180 M in 2013 up from \$30M in 2009)



MEMS Market Forecasts per Device in Million US\$



Market value (MUS\$)	2007	2008	2009	2010	2011	2012
<i>IJ heads</i>	\$1 867	\$1 658	\$1 462	\$1 610	\$1 820	\$2 327
<i>Pressure sensors</i>	\$1 116	\$1 046	\$990	\$1 041	\$1 141	\$1 314
<i>Si microphones</i>	\$117	\$135	\$159	\$193	\$238	\$325
<i>Accelerometers</i>	\$908	\$1 028	\$1 119	\$1 300	\$1 439	\$1 572
<i>Gyroscopes</i>	\$787	\$794	\$800	\$911	\$1 025	\$1 150
<i>MOEMS (fiberoptics telco, μspectrometers)</i>	\$188	\$198	\$244	\$270	\$272	\$369
<i>Microbolometers</i>	\$161	\$187	\$228	\$254	\$301	\$356
<i>Microdisplays</i>	\$804	\$714	\$661	\$677	\$850	\$1 224
<i>Microfluidics for research</i>	\$238	\$270	\$300	\$333	\$365	\$402
<i>Microfluidics for diagnostics</i>	\$419	\$479	\$548	\$648	\$1 088	\$1 448
<i>Microfluidics for drug delivery</i>	\$20	\$38	\$50	\$71	\$93	\$97
<i>RF MEMS</i>	\$250	\$261	\$314	\$499	\$748	\$1 154
<i>Micro tips & probes</i>	\$125	\$127	\$113	\$134	\$155	\$166
<i>Micro fuel cells</i>	\$0	\$1	\$26	\$65	\$104	\$448
<i>Emerging MEMS (auto focus, energy harvesting ...)</i>	\$0	\$3	\$4	\$5	\$7	\$10
TOTAL	\$7 000	\$6 939	\$7 019	\$8 010	\$9 647	\$12 363

MEMS Influencers in the US



- ▶ Apple has created the market for accelerometers in cell phones with the iPhone
- ▶ Qualcomm: leading wireless semiconductor worldwide (source iSuppli Semiconductor Competitive Landscape Q1 2010)
- ▶ Google and Microsoft: Operating Systems for mobile phones Android (Google) and Microsoft Windows Mobile 7 are largely facilitating use of sensors in phones for OEM
- ▶ Texas Instrument has a similar approach with its OMAP application processor that is ready to handle 6 sensors and 6 digital microphones
- ▶ DARPA and DoD – Defense and commercial
- ▶ NHTSA – huge impact on automotive sensor market

US: The Most Fertile Ground for Innovative Start-ups



- ▶ InvenSense – the most successful MEMS start-up today:
- ▶ WiSpry– first company worldwide to ship MEMS switches
- ▶ The only 4 MEMS oscillators start-ups are in the US
 - SiTime and Discera
 - Silicon Clocks
 - Sand9
- ▶ Microvision – only supplier of MEMS scanner projector displays today
- ▶ Qualtre: innovative 3-axis gyroscope approach

Factors Affecting US Market Growth and Potential Growth – Different Life Cycles



- ▶ Several devices have reached maturity:
 - Pressure sensors, BAW filters and ink jet heads
- ▶ Other devices are in extremely high growth phase:
 - Accelerometers, gyroscopes, silicon microphone, micro-bolometers
- ▶ The pipeline of new products in development has been quite the same for the past 3 years:
 - RF switches, micro display, auto focus, fuel cell
- ▶ New emerging products include: MEMS oscillators, MEMS RF IDs, micro speakers

Show me the Money

- ▶ Big issues remain – to fuel entrepreneurship and technology advancement:
 - Where's the R&D?
 - Where's the venture capital and investment?
- ▶ Several unique models for further commercialization of technology in US:
 - University/corporate partnership
 - VC funded initiatives – BSAC
 - Large integrated corporate models – GE Global Research
 - Academic/corporate model
 - Government funding – DARPA and now ARPA-E

Conclusion



- ▶ Strongest growth potential in US MEMS:
 - Consumer – MEMS is opening up a whole new world (MEMS-enabled apps)
 - In numerous markets we'll see rise in motion sensors, microphones, micro displays

- ▶ Other areas of growth:
 - Medical –blurring of lines between consumer and medical
 - Energy – smart grid
 - Automotive, especially energy saving/harvesting and safety

- ▶ High-volume manufacturing is key to growth:
 - MEMS originally designed and vetted for automotive applications now repurposed for consumer electronics
 - Enabled by more abundant and efficient design tools and processes
 - Marks new era in consumer understanding and acceptance of MEMS

A few more Conclusions...



- ▶ Manufacturing changes:
 - There have been great change in MEMS fabrication – we'll likely see more consolidation and partnership in the next five years...
- ▶ Cost is critical factor BUT:
 - With increase in technology and algorithms enabled by MEMS, we'll see more “system sell” where the use of a single more expensive MEMS device can **save BOM for the full system**
 - We'll see more on-chip integration, CMOS, TSV and other fabrication techniques to enhance functionality AND reduce costs
- ▶ **It's all about the system**
 - MEMS-enabled, Low cost, Low power, High volume – you no longer have to “pick two”

Thank you!



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