Status of the MEMS industry: How mobile phone and high end applications are reshaping the MEMS business.

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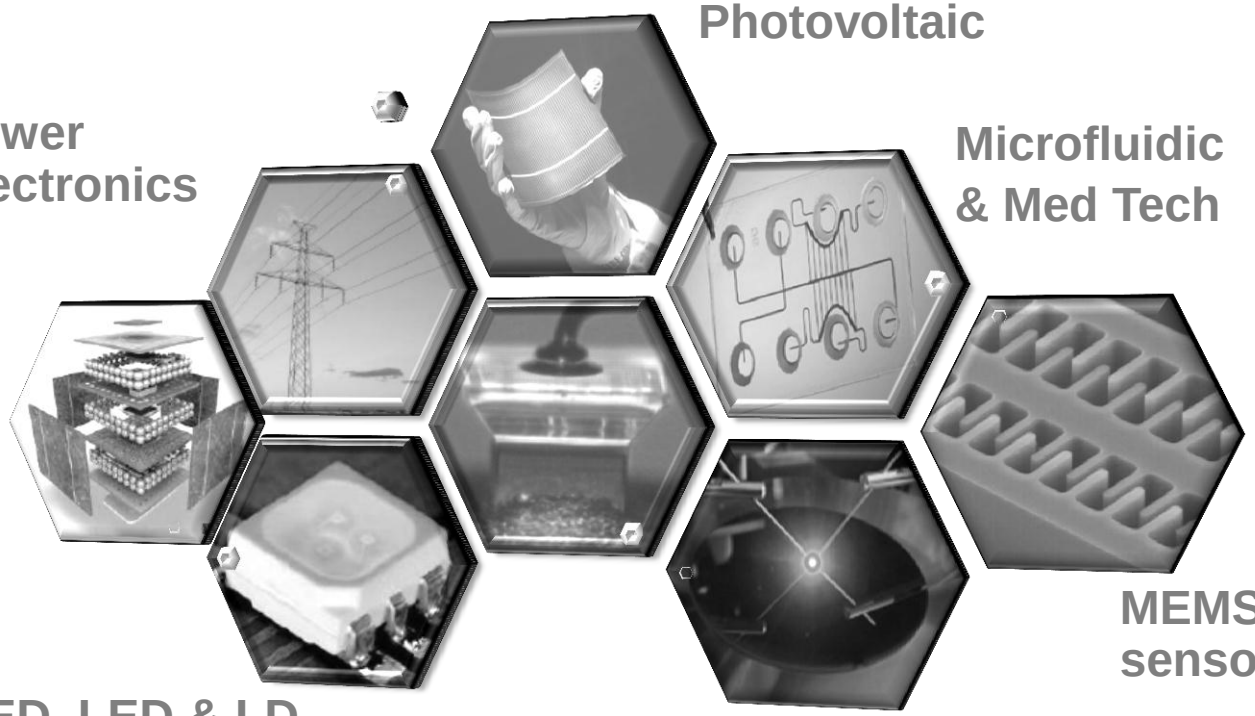
Fields of Expertise

- **Yole Developpement is a market, technology and strategy consulting company, founded in 1998. We operate in the following areas:**



- **Our expertise is based on research done by our in-house analysts, conducting open-ended interviews with most industry players.**
  - **30 full time analysts with technical and marketing degrees**
  - **Primary research including over 3,500 interviews per year**

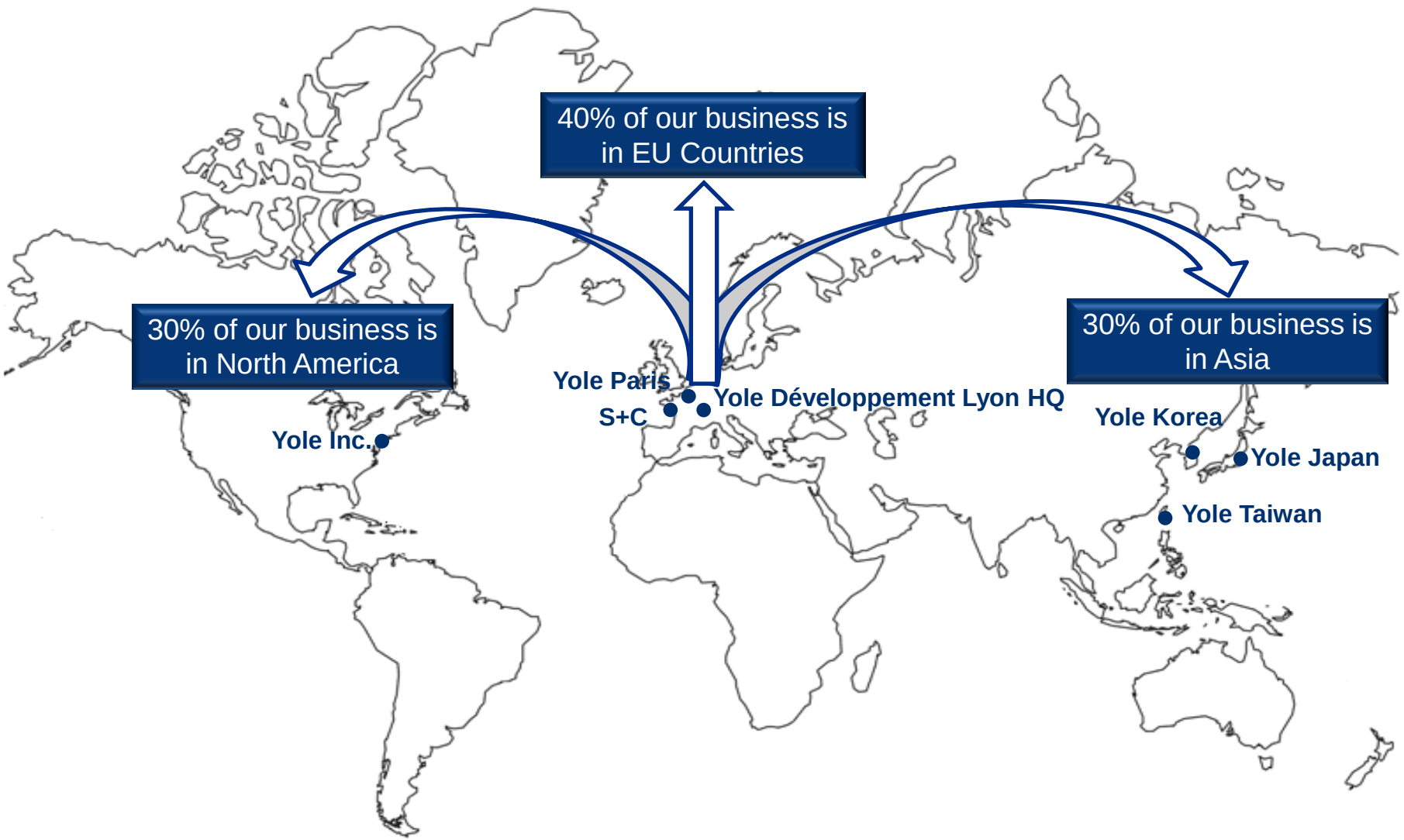
Mission Statement: Knowledge-Based Company

- **Help our customers develop their business through specific analysis, reports & services providing:**
  - **Accurate market data, market segmentation and marketing analysis**
  - **Technology evaluation; cost estimates and COO analysis**
  - **Patent portfolio analysis, licensing strategy and implementation**
  - **Identification of strategic development opportunities for companies and business units**
  - **Support for M&A, due diligence, and identifying new investors**
  - **Advertising opportunities in YOLE magazines, webcasts and specific events**
- **You get operational results from Yole analysis and actions**

4 Business Models

- **Custom Analysis:**
  - Largest part of Yole activities
  - Covered by NDA agreement
  - A few days to several months of work, depending on objectives
- **Published Reports:**
  - An average of 40 reports published every year
  - Available individually or through Annual Subscription Program
  - Market and technology reports, Patent analysis, Reverse Engineering/Costing reports and Reverse Costing tools
- **i-Micronews Media:**
  - Newsletters and webcasts on 3D, MEMS, Power electronics, LED and imaging
  - Advertising services providing access to our 45 000+ subscribers to be visible and diffuse information on your company and products
- **Yole Finance services:**
  - M&A (buying and selling)
  - Due diligence
  - Fund-raising services

Our Global Activity



Some of Our Customers

Financial investors & industry advocates

R&D Organizations

Suppliers (equipment, wafers, materials)

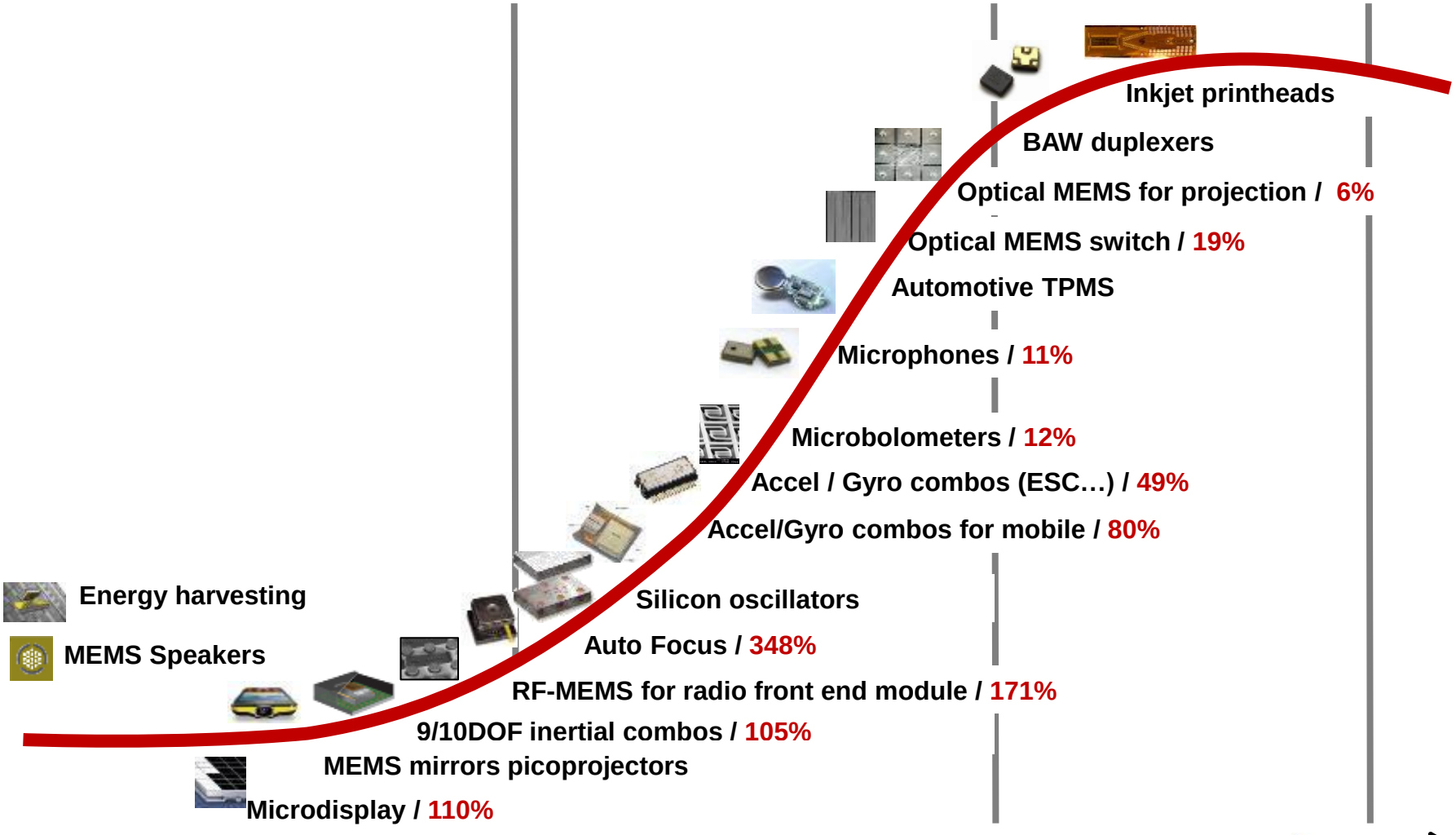
Component manufacturers

Integrators, system suppliers & end users

MEMS MARKET TRENDS

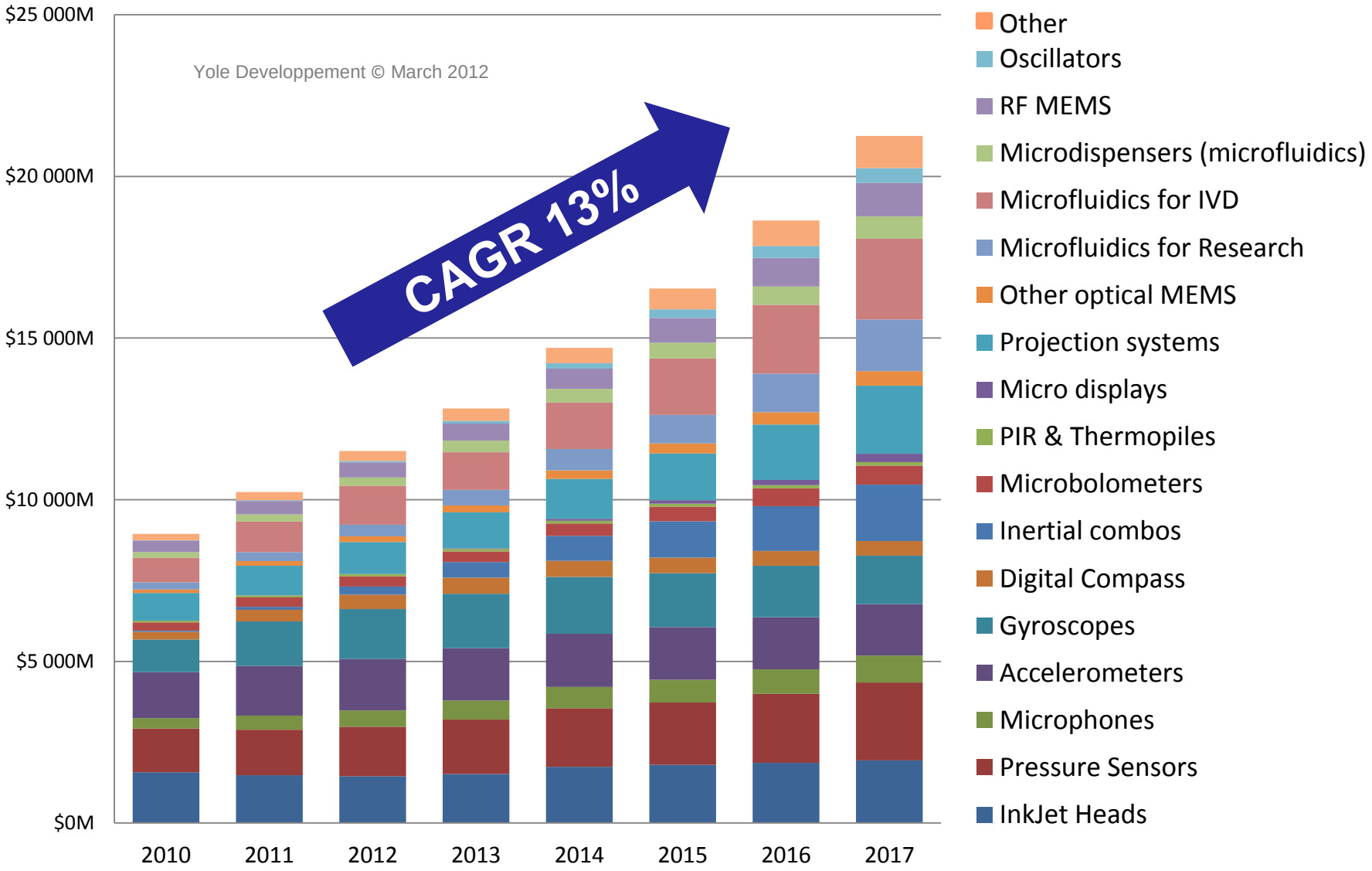
An Expanding Array of Products

maturity of selected MEMS devices with expected CAGR to 2015

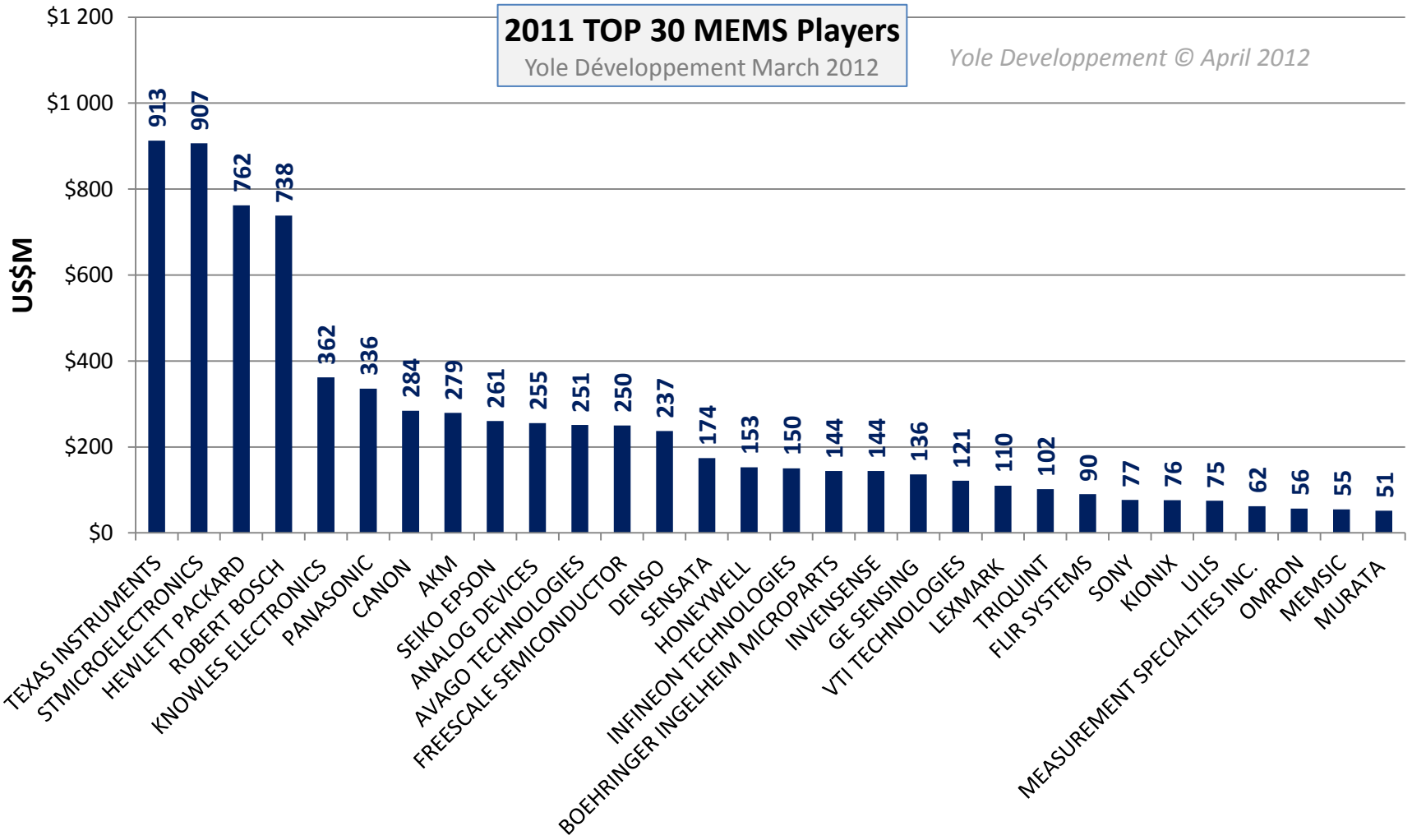


Continued Strong Growth

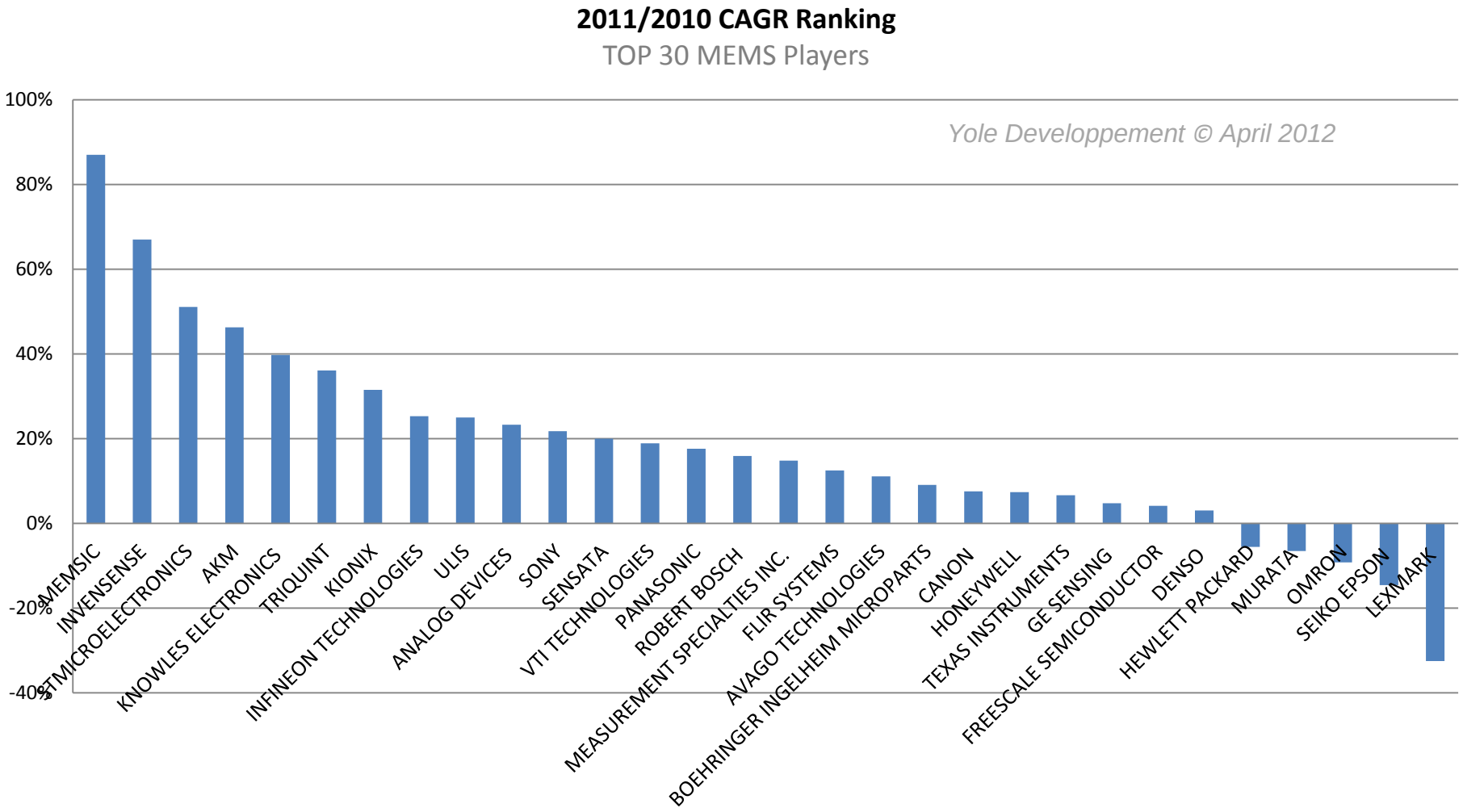
2011-2017 Forecast *(in US$M)*



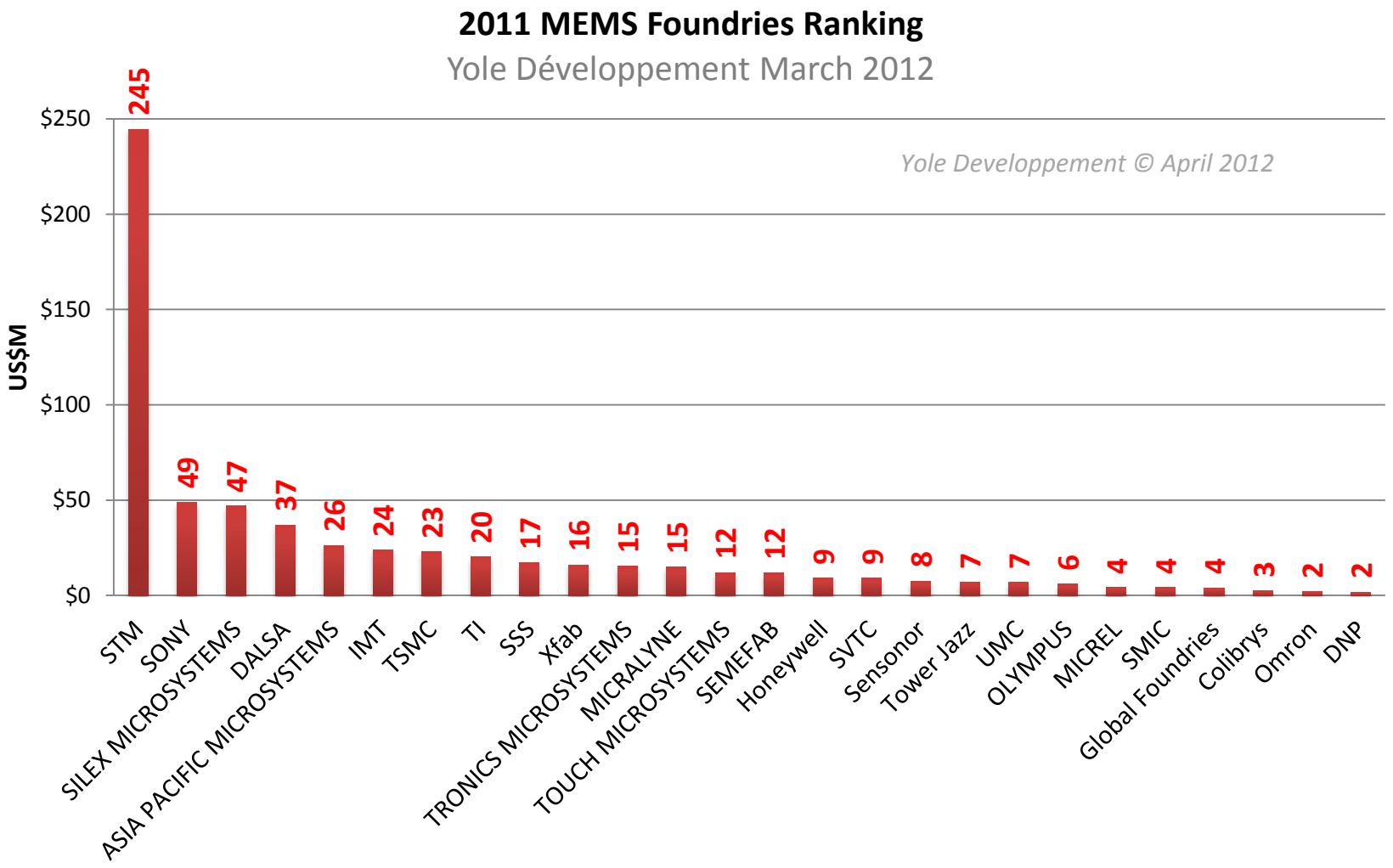
TOP 30 MEMS Players
Global ranking



2011 MEMS Ranking – 2011/2010 CAGR TOP 30 Ranking

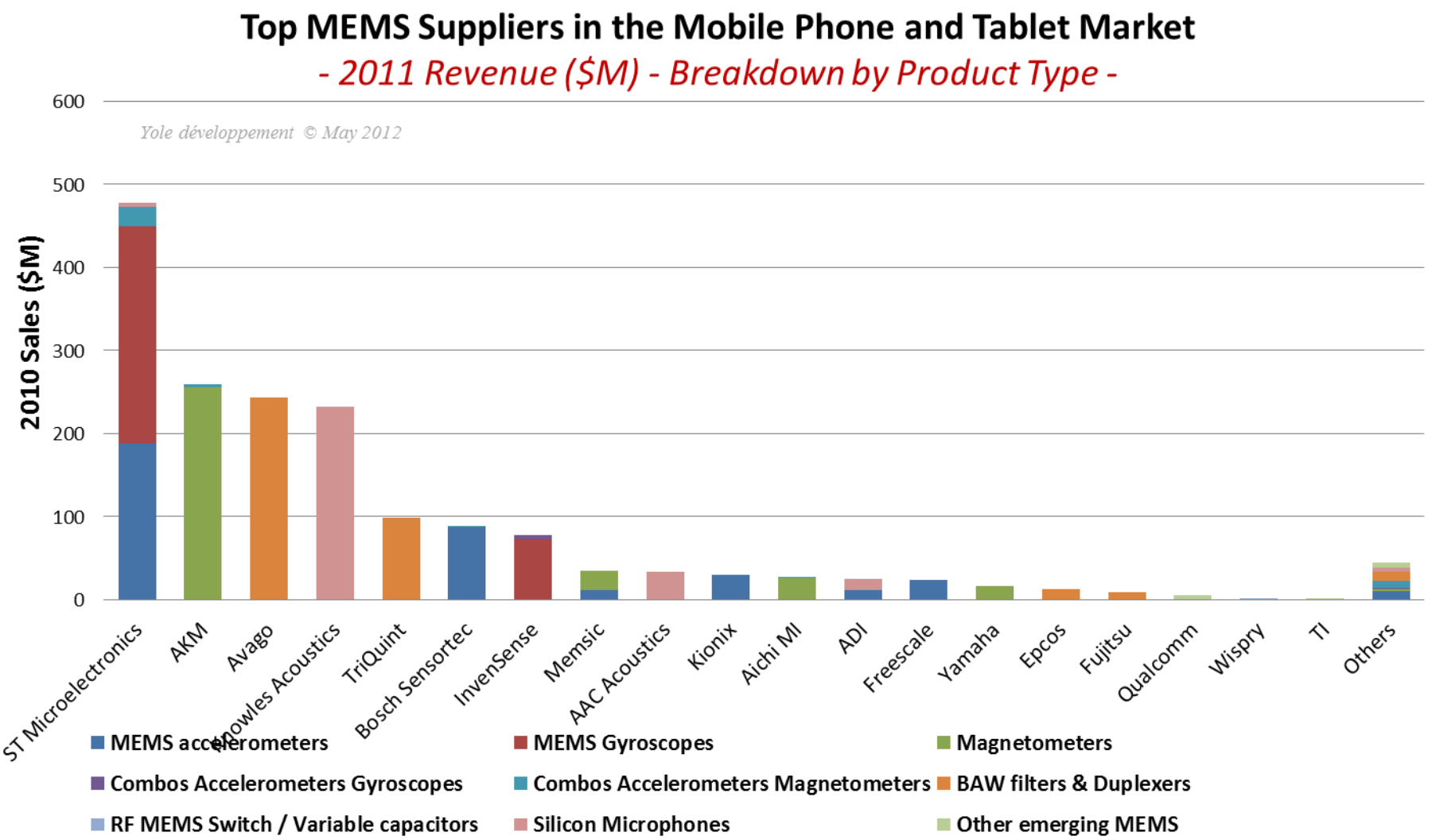


TOP 30 MEMS Foundries
Global ranking

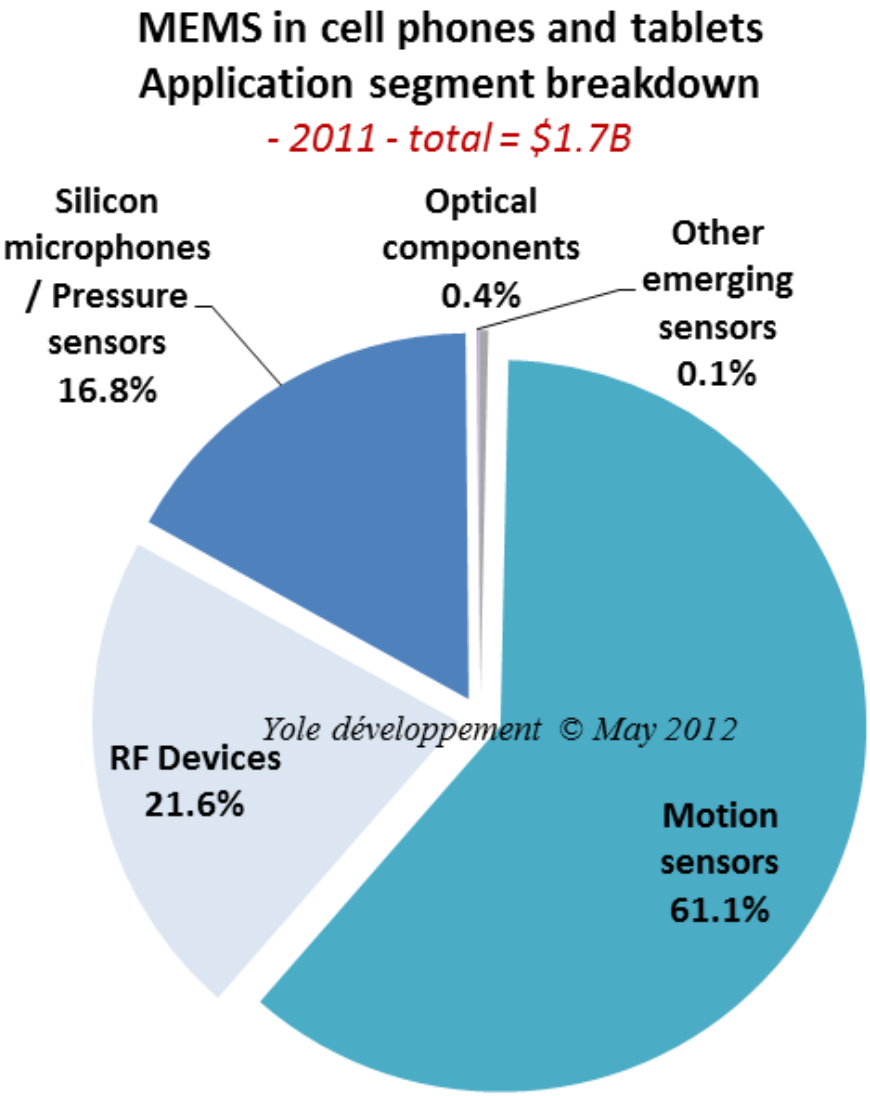


“Alpha” MEMS Companies

Top 4 suppliers have >50% market share in 5 different CE MEMS markets

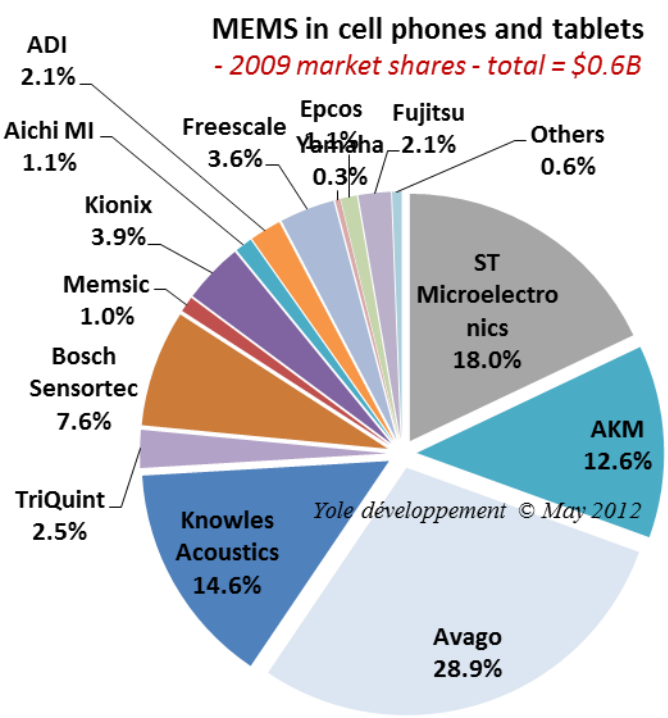


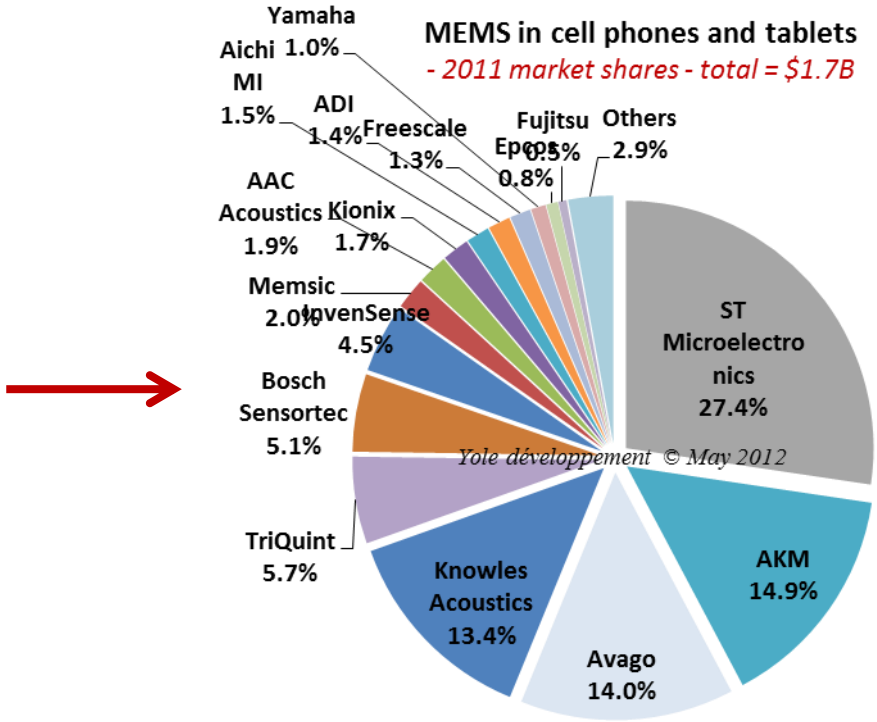
MEMS in Mobile Devices
2011 by product category



2009-2011 market shares evolutions

ST is growing, Avago decrease InvenSense appears





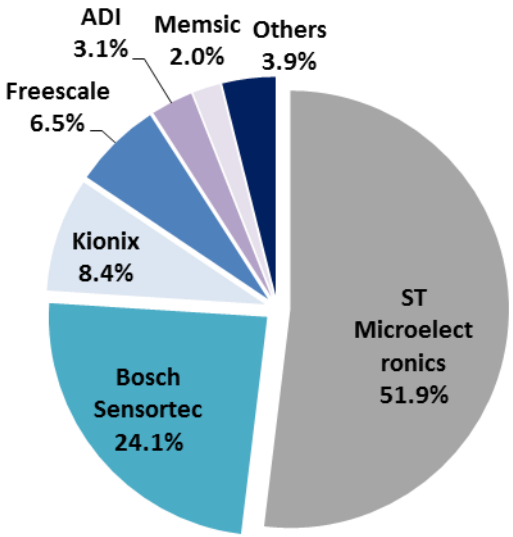
2011 market shares for discrete inertial sensors

3-axis accelerometer in mobile phones and tablets - 2011 market share

- Total = $362.7M -

- Note: accelerometers in combos not counted -

Yole développement © March 2012

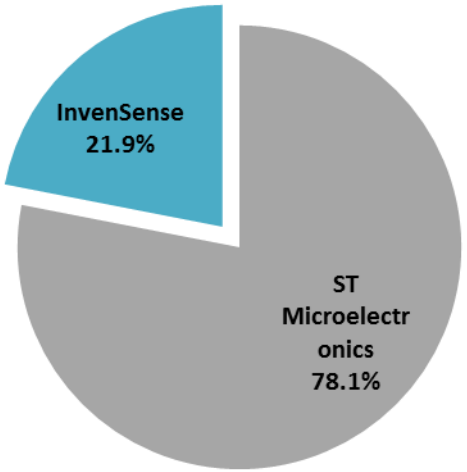


3-axis gyroscope in mobile phones and tablets - 2011 market share

- Total = $334.6M -

- Note: gyroscopes in combos not counted -

Yole développement © March 2012

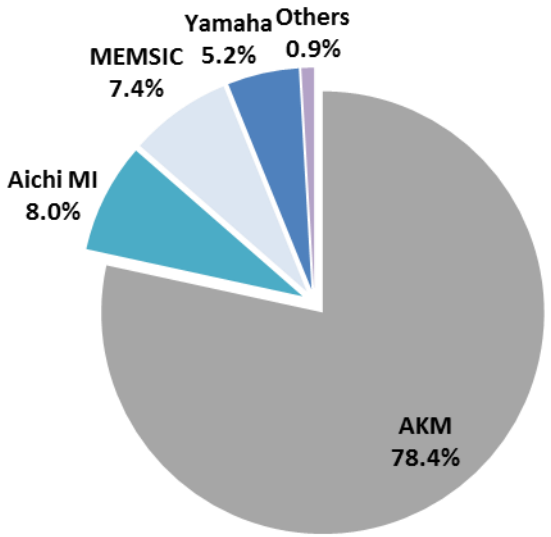


3-axis magnetometer in mobile phones and tablets - 2011 market share

- Total = $325.7M -

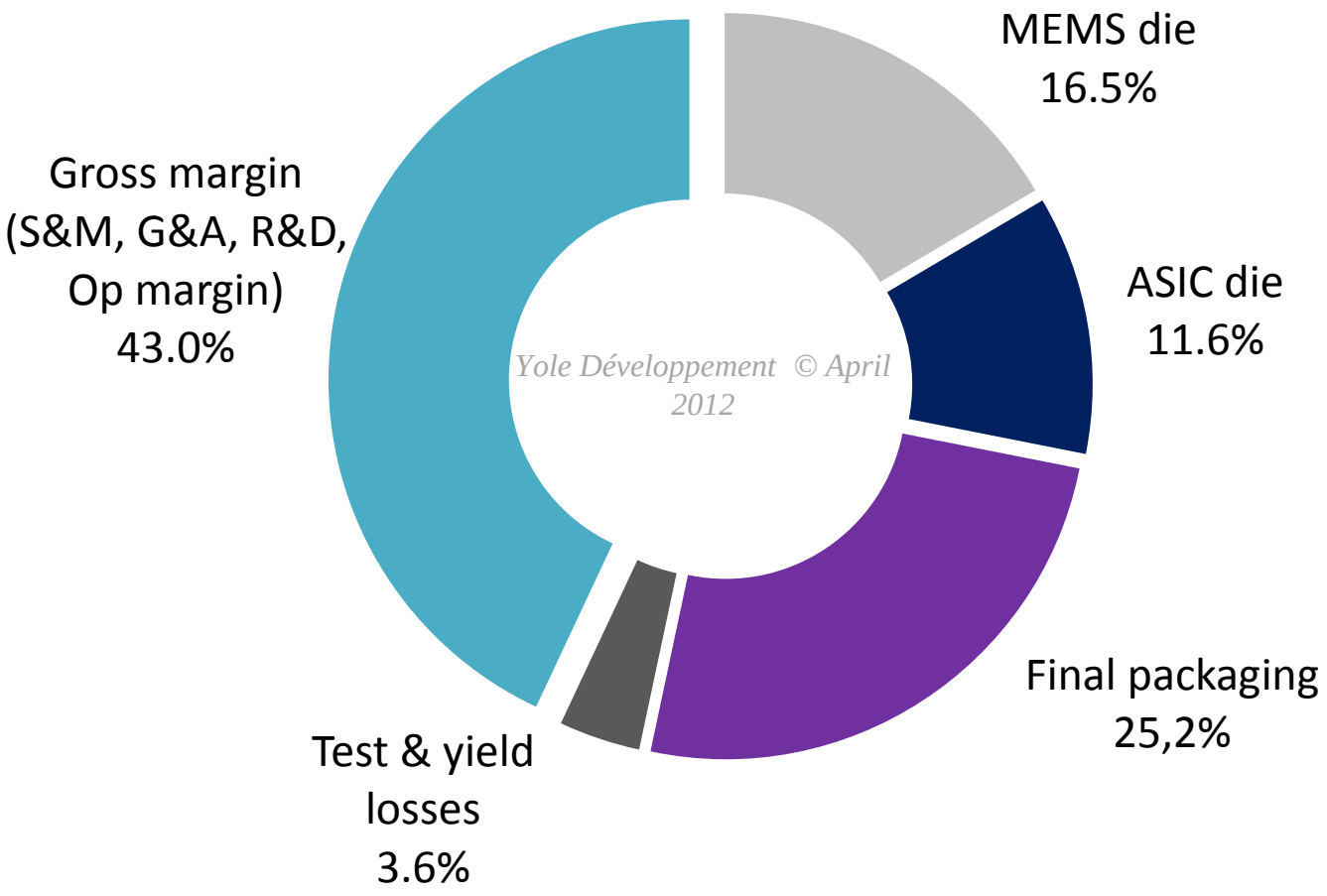
- Note: magnetometers in combos not counted -

Yole développement © March 2012



Making Money in MEMS
microphone estimation

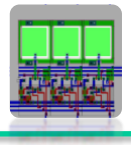
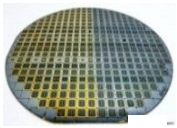
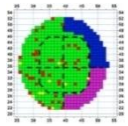
MEMS Microphone Cost Structure in 2012



2012: $508M; 1.4B units

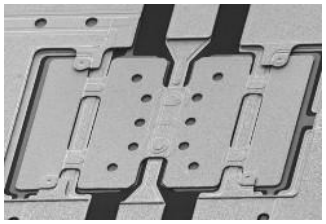
2011 Key MEMS Player Activity Estimate

outsourced packaging assembly, test & calibration

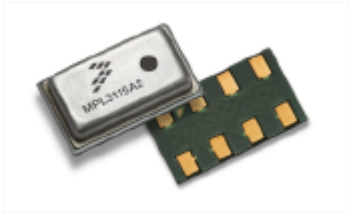
~ $2B	~ $8B	~ $0.4B	~ $1B	~ $430M			~ $250M
							
Fabless / Fab-light	IDMs	ASIC foundries	MEMS foundries	WLP houses	BE & Test houses	OSATs	Substrate houses
hp	Texas Instruments	tsmc	ST	Xintec	KYEC	Amkor Technology	KYOCERA
KNOWLES	BOSCH	ae	Texas Instruments	Teramikros	LINGSEN		SHINKO
ANALOG DEVICES	ST	SMIC	silex MICROSYSTEMS	WLCSP	MEM HITECH	unisem	TONG HSING
InvenSense	Panasonic		sensonor	jcap		BPIL	Unimicron
VTI TECHNOLOGIES	EPSON		SONY	EP WORKS		TONG HSING	OAK-MITSUI
Infineon	Canon		tsmc			STATSChipPAC	tecnisco
LEXMARK	AVAGO TECHNOLOGIES		DALSA			J DEVICES	NEC/SCHOTT
SiTime	DENSO		apm			UTAC	
Discera	freescale		UMC				
	ROHM						
	TDK						

* Revenue estimates related to MEMS

Next Wave of MEMS

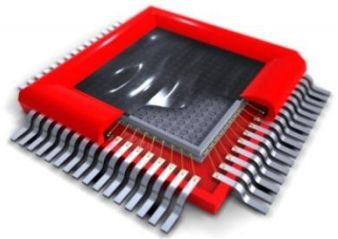


DelfMEMS switch



Freescale pressure sensor

Sand 9 MEMS Oscillator



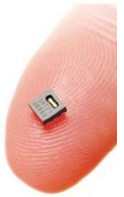
AudioPixel microspeaker

Samsung Galaxy Beam features TI DLP

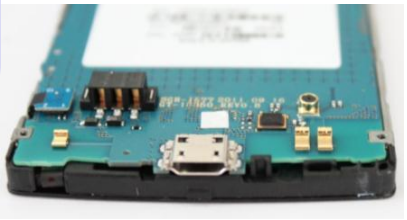
Oscillators + micromirrors + displays + switches & variable capacitors + temperature sensors + AF + microspeakers + other emerging MEMS

From $13M to $2.3B market (2017)

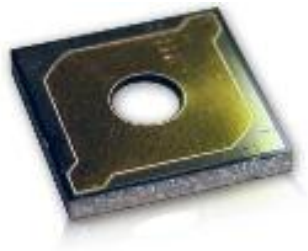
(in cell phones and tablets)



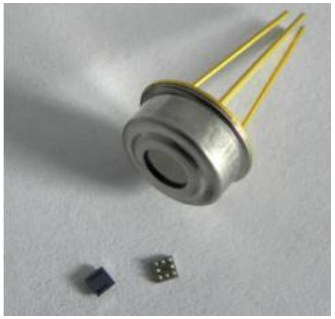
Sensirion Humidity Sensor



Wispry antenna tuner on cell phone board



Polight MEMS autofocus

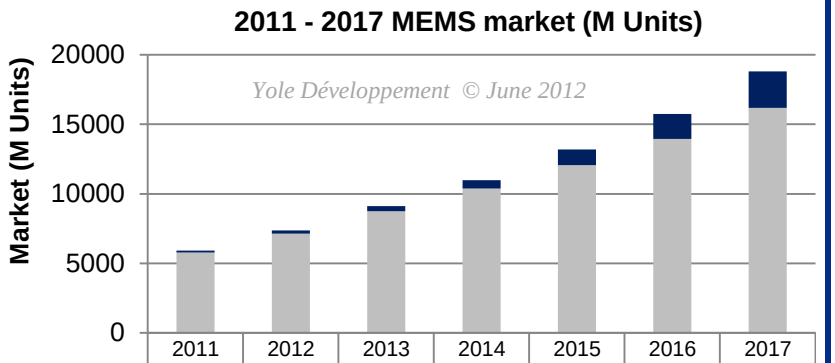


TI temperature sensor versus a competing thermopile sensor

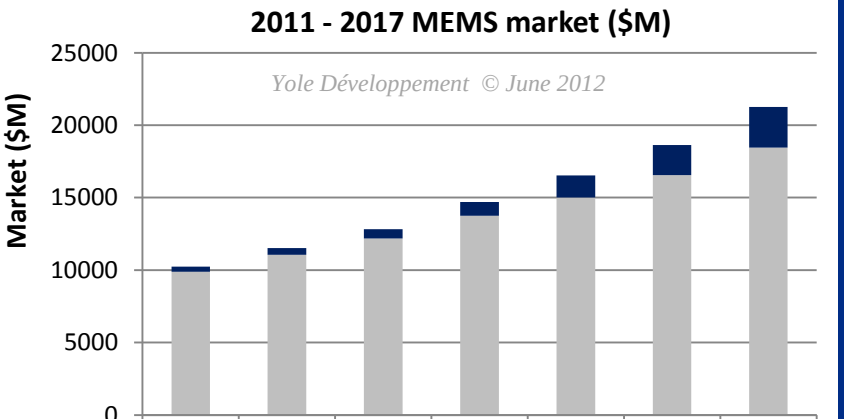
NextInput SoftTouch interface

Emerging MEMS
Overview

- **Established MEMS includes**:
  InkJet Heads, Pressure Sensors, Microphones, Accelerometers, Gyroscopes, Magnetometers, Inertial combos, Microbolometers, Other optical MEMS, Other RF MEMS (BAW…), Microfluidics for Research, Microfluidics for IVD, Microdispensers (microfluidics)
- **Emerging MEMS includes: PIR & Thermopiles, Microdisplays, Micromirrors for mobile phone and tablet embedded picoprojectors, Auto focus, RF MEMS switch & varicap for mobile devices, Oscillators, Others (microstructures, micro speakers…)**



	2011	2012	2013	2014	2015	2016	2017
Emerging MEMS	142	234	368	615	1 139	1 792	2 620
Established MEMS	5 775	7 135	8 754	10 378	12 054	13 941	16 181



	2011	2012	2013	2014	2015	2016	2017
Emerging MEMS	$339M	$445M	$639M	$956M	$1 523M	$2 080M	$2 803M
Established MEMS	$9 896M	$11 065M	$12 182M	$13 740M	$15 011M	$16 554M	$18 448M

Emerging MEMS
Application breakdown

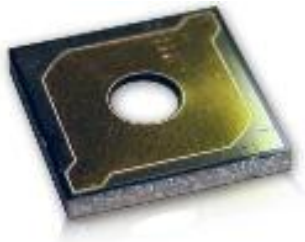
	2011 market ($M)	2017 market ($M)	2011-2017 CAGR
PIR & Thermopiles	$61M	$107M	9.8%
Microdisplays	$5M	$261M	91.0%
Micromirrors for mobile phone and tablet embedded picoprojectors	$1M	$434M	188.6%
Auto focus	$0M	$327M	-
RF MEMS switch & varicap for mobile devices	$1M	$220M	160.4%
Oscillators	$24M	$463M	63.6%
Others (microstructures, micro speakers…)	$247M	$991M	26.0%

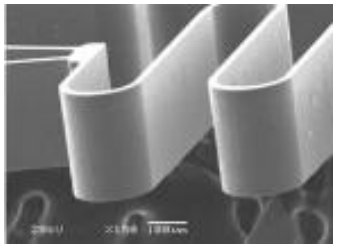
Note: Microbolometers were counted as emerging MEMS in our previous forecasts. Now this is not considered as emerging MEMS anymore

MEMS Autofocus for Consumer Camera Modules

A new killer application for MEMS starting in 2013

- **By 2017, we believe the WLAF market could be a $330M market, mostly for cell phones**
- **Existing players are in a product introduction phase and new players are emerging:**
  - **PoLight is expected full volume production beginning of 2013**
  - **Lensvector and Tessera Digital Optics are developing new products**
  - **WaveLens is a start up from CEA LETI. Wafer level liquid lens technology is developed both for visible auto focus and for infrared autofocus**
  - **Other players could appear. Rumors about MEMS AF development at several large Mems manufacturers…**





→ Piezo MEMS option:

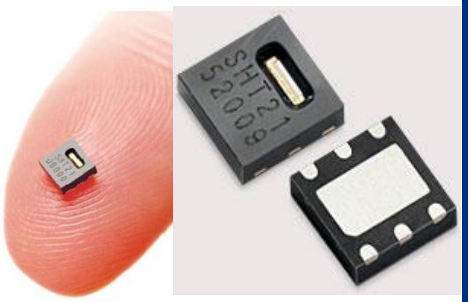
- Polight development (production 2012)
- Very small size
- Very fast
- But degrades image quality (because a lens is added), but less degradation than with Liquid Crystal
- Could be more expensive than VCM

→ MEMS actuator option:

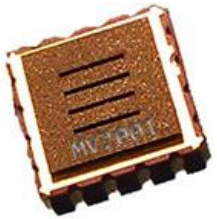
- Tessera DOC development
- Silicon actuator (2nd generation). Tessera keeps investing this year, but success is not sure
- Low power consumption
- But fragile & expensive
- Different designs are needed at the system level (only one lens moved, not entire set of lenses)

Increasing Interest for Temperature and humidity Sensors

- **Low cost temperature sensors are commodity products**
  - Offered by TI, Maxim… (not MEMS technologies). E.g. Motorola Droid RAZR integrates a digital temperature sensor from TI
  - Combination with humidity sensors is also of interest for some mobile applications
- **Sensirion is a leading manufacturer of temperature and humidity sensors**
  - 300 employees
  - Largest markets are industrial, automotive for mass flow sensors and pressure sensors
  - Sensirion started to supply temperature + humidity sensors to Lenovo phones in China (low volumes)
- **MEMS vision is a new startup involved in this space**
  - Humidity sensors based on SiC MEMS above CMOS technology
- **This type of sensor has a bright future in mobile devices**
  - Smaller, cheaper version are expected (now less than $1 in volume)
  - Specific Android APIs from Android 4 have been developed → market can take off more easily (various uses: applications such as mobile weather station, sports, cosmetic – sense humidity of skin, user interface…)



Humidity Sensor SHT21

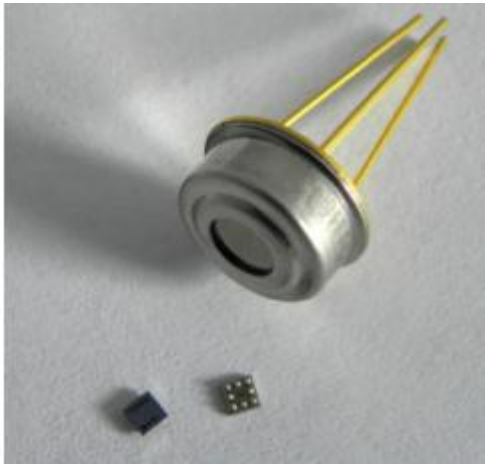


MEMS vision digital humidity and temperature sensor

MEMS Thermopiles Enable New Markets

E.g. Texas Instrument, Omron, Panasonic

- **Texas Instrument introduced an infrared thermopile in 2011**
  - **Manufacturing on a 6 inch fab. CMOS is done first, then MEMS thermopiles on top of it**
- **Omron and Panasonic have announced Mems based thermopile simple imager for mobile applications**
- **Many different applications are being developed**
  - **This does not sense ambient temperature but temperature of objects (contact-less). Not really the same use as temperature sensors**
  - **Body heat is the next application**
  - **But many other applications are developed by users now**
- **Smartphone application is on the roadmap of all these manufacturers**
  - **Can IR imaging be implemented in a mobile phone?**



TMP006 temperature sensor versus a competing thermopile sensor

Change in the market situation

- **Because of the increase of the competition among Mems companies, all Mems manufacturers are searching to propose more devices to existing customers**

- **It drives also the interest on these new emerging devices from large companies**

STMicroelectronics Partners

5 types of collaborations

High volume foundry customers with specific agreements (co-design…)

HP
Inkjet heads
Co-development, ST manufactures component
1998: Beginning of collaboration

Kodak
Inkjet heads
Cross Licensing with HP ST manufactures the entire head
Collaboration since end 2006 – beg 2007 (never announced)

→ For HP: 6inch fab in Singapore + 8 inch fab in Italy *(more recently: for fixed heads)*
→ For Kodak: 8 inch fab in Italy

New foundry customers

DEBIOTECH
Insuline nanopump (microfluidic).
Co-design, ST supplies sensor
2007: Beginning of collaboration
2010: commercialization

bluechiip
Tracking tags (Biobanks)
Co-design, ST supplies components
2011: beginning of collaboration

bTendo
Pico projector (mobile phones)
Co-design, production and promotion by ST
2011: beginning of collaboration

MAYO CLINIC
Platform for the remote monitoring of patients
Co-development, ST supplies components
2009: collaboration announcement

VEREDUS
Lab on chip (microfluidic)
Co-development, ST supplies the chip
2009: development and design
2011: successful deployment

SENSIMED
Smart contact lens
Co-development, ST supplies components (pressure sensor + WLP)
2010: production

→ 8 inch MEMS foundry in Italy

Component sourcing

Honeywell
Inertial combo (6+ freedom degrees)
Honeywell supplies magnetometer wafers
2010: commercialization

OMRON
Microphone, gas meter flow sensor
Co-design, OMRON supplies key component
2009: collaboration for microphone
2010: microphone release, collaboration for gas meter

Technology providers (software licensing / production tools)

CEA-LETI
R&D collaboration
Started before 2000

PNI Corp
(not announced, not verified)
Software license from PNI for sensor fusion

Sounchip
High precision personal audio system
Full production & commercialization, ST licenses Soundchip technology and gives access to design software
2011: beginning of collaboration

SPEA
Test bench development collaboration
2003: Beginning of collaboration

Customers / Partners for reference designs

CSR
Indoor navigation
Co-development, sensors by ST, fusion application by CSR
2012: application demonstration
…

FOXCONN
Camera stabilization
Co-design, ST supplies components
2011: beginning of collaboration

Microsoft
Motion sensor software for windows 8
Co-development of software
2011: release of software

The Final Word …

- **The MEMS market is on a growing curve again and many changes are happening on the technical side, business model side and supply chain side.**
  - **20% CAGR in units**
  - **13% CAGR in revenues**
  - **To become a $21 billion market by 2017.**
- **Every year brings new business to the MEMS landscape.**
  - **Today, combo sensors are reshuffling the cards in the motion sensing business**
  - **But the MEMS market is still very fragmented, with a number of high volume MEMS applications still limited today**
- **However, a whole range of new MEMS devices has now reached the market and new "emerging MEMS" devices are coming as well:**
  - **Some of them have the possibility to ramp up to large volumes quickly: those that can be applied to mobile devices (RF MEMS switches, oscillators, auto-focus…)**
  - **Both sensors (humidity, touchscreen,…) and actuators (switches, energy harvesting…) are driving future growth**
  - **In addition to those emerging MEMS, growth of the MEMS market will come from existing sensors that are expanding into new market spaces, sometimes using new types of integration: e.g. pressure sensors for consumer.**

- **Please give me your business card if you want to get an electronic copy of this presentation.**

- **If you have questions, please come and discuss with us!**

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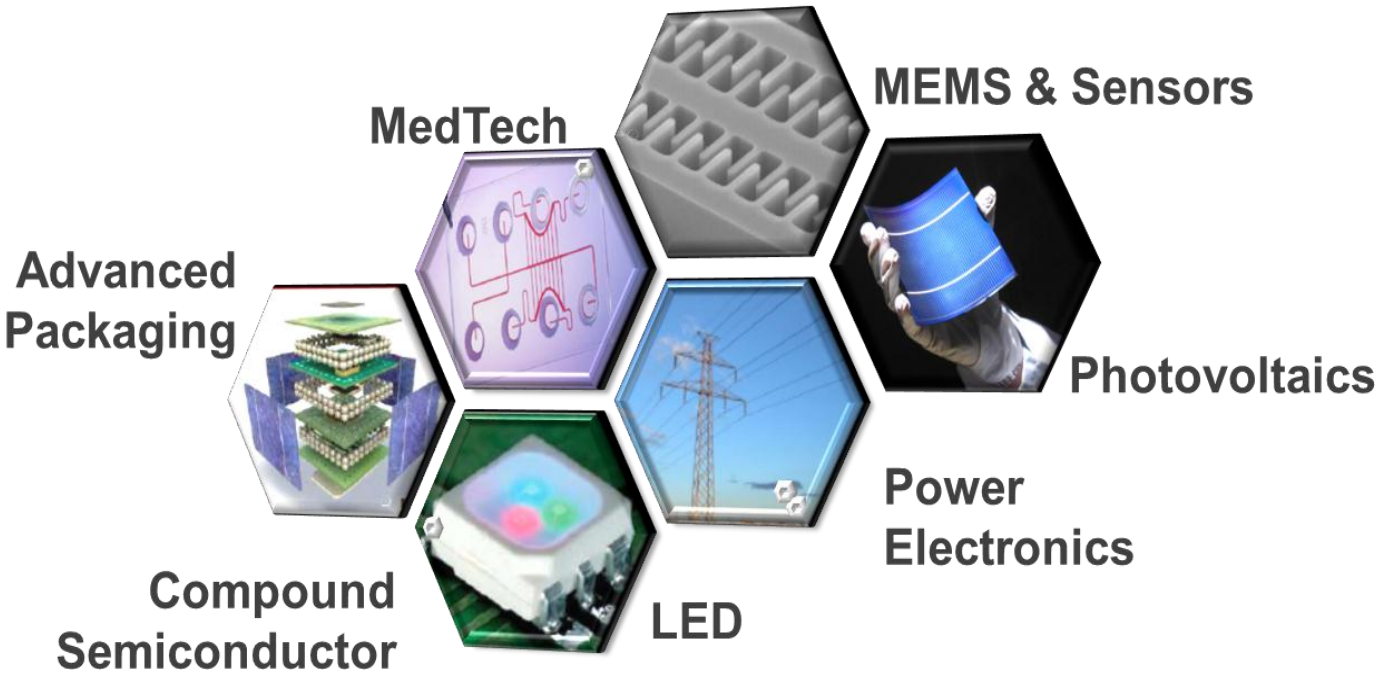
About these markets: www.i-micronews.com



About our company: www.yole.fr