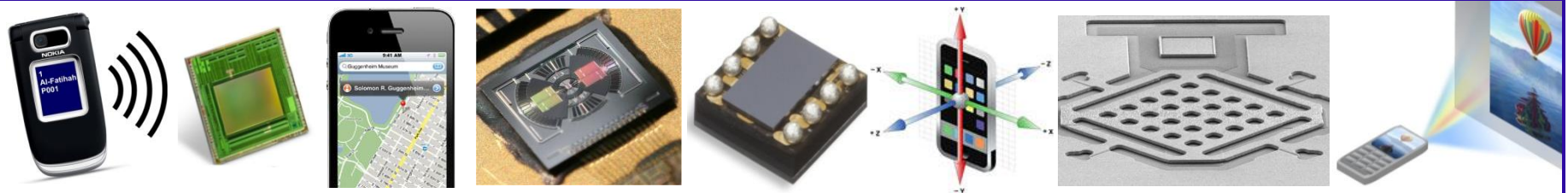


MEMS & Sensors for Smartphones

Sample Report



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Objectives of the report

- **In order to be exhaustive, the scope of this report covers:**
 - **All sensors integrated on mobiles phones** => not only MEMS technology
 - Images sensors are also covered as well as ALS,...
 - **All MEMS devices** integrated on mobiles phones => not only sensors but also actuators
 - BAW (and thus SAW – without the market metrics - because it is the same final market) filters are covered, as well as switches, micromirrors, oscillators...
 - Not only smartphones (despite the title of the report) but **all mobile phones, from low-end to high-end**
- **The objectives of this report are the followings:**
 - To provide market data on MEMS & sensors for mobile phones → key market metrics & dynamics:
 - **Unit shipments, revenues and average selling price** per type of MEMS & sensor
 - **Market shares** with detailed breakdown for each player
 - To provide **application focus** on key sensors that are changing the mobile phone industry: new features, technical roadmap, insight about future technology trends & challenges:
 - **Packaging roadmaps** (size of the sensors)
 - **Integration roadmaps** (multi-sensors, integration of processing...)
 - **Performance roadmaps** with functionalities (e.g. for gyroscopes: from current devices used for stabilization, gaming and user interface to very low-drift gyroscopes used for true pedestrian navigation)
 - To provide a deep understanding of MEMS & sensor value chain, infrastructure & players for the handset business:
 - Exhaustive **list of players** for each device under consideration
 - Analysis on who are the **key suppliers and emerging players** to be considered
 - What **business model** is the most successful and how will it evolve?

Who Should be Interested in this Report?

- **MEMS & sensor suppliers**
 - Evaluate market potential of future technologies and products for new applicative markets
 - Understand the differentiated value of your products and technologies in this market
 - Identify new business opportunities and partners
 - Monitor and benchmark your competitor's advancements
- **R&D centers**
 - Understand the impact of new optical assembly technologies such as wafer level cameras for your business
 - Evaluate market potential of future technologies and products for new applicative markets
 - Identify the best candidates for technology transfer
- **MEMS & packaging foundries**
 - Understand what are the applications that will drive the volumes in 2015
 - Identify new business opportunities and prospects
- **Mixed-signal companies & ASIC manufacturers**
 - Spot new opportunities and define diversification strategies
- **Mobile phone OEMs**
 - Evaluate market potential of future technologies and products for new applicative markets
 - Screen potential new suppliers for introducing disruptive features such as low-drift gyroscopes and IMUs, secondary microphones, MEMS oscillator, tunable RF components...
 - Evaluate the benefits of using these new technologies in your end system
- **Network operators**
 - Understand what will be the future services that can be offered by taking benefit on the new sensors
- **Financial & strategic investors**
 - Understand the potential of new devices & MEMS technologies such as gyroscopes, RF switches, oscillators, speakers...
 - Get the list of main key players and emerging start-ups of this industry

Companies cited in this Report

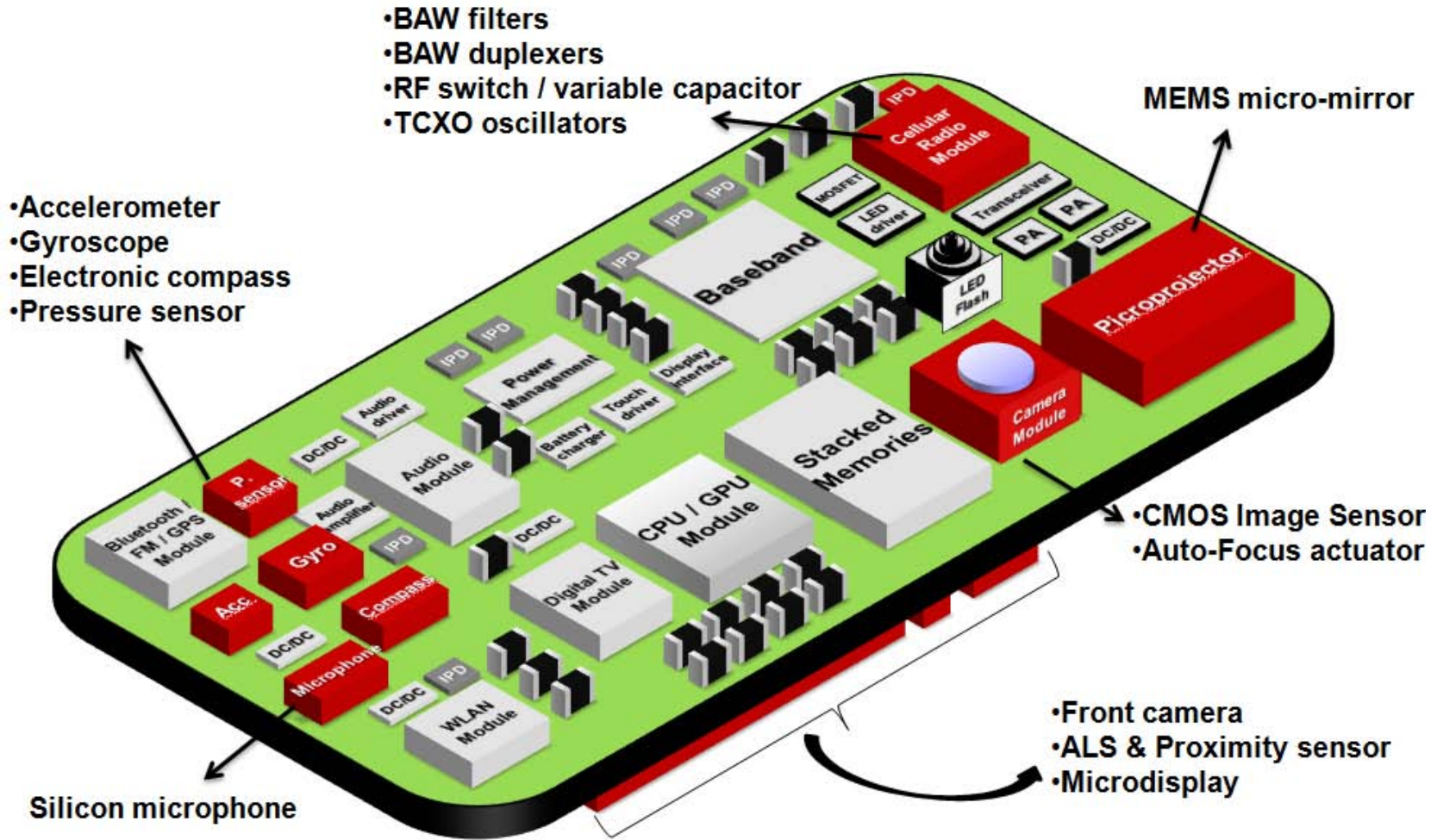


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Executive summary

Major findings – MEMS & Sensors

- The following MEMS & Sensors are under the scope of the report (in Red)



Executive Summary

Overview (1/3)

- **Integration of MEMS components and sensors is not new to the mobile phone industry. For example, FBAR RF filters and silicon microphones have been integrated on our mobile phones since 2002. More recently, MEMS accelerometers have been established as a “must-have” feature for many smartphones and feature-phones. And other types of sensors, like CMOS image sensors, have experienced a large success in the recent years.**
- **But the mobile phone market is changing extremely quickly. It appears that in 2010 we are at a turning point in the history of MEMS & sensors for handsets: the market for MEMS & sensors will experience double digit growth, from \$3.55B in 2009 to \$7.91B in 2015.**
- **We have identified several factors explaining why MEMS & sensors will experience this tremendous growth over the next few years:**
 - **Share of smartphones is rising faster than ever: 44% of the mobile phones will be smartphones in 2015. Success of smartphones is leading to an increasing amount of MEMS & sensors in mobile phones to provide new features/services to end-users, to reduce cost through more integration or to improve hardware performance**
 - **GPS integration is not limited to high-end phones anymore. Nearly one phone in three will incorporate GPS in 2010. This is an additional driver to integrate motion sensors : when combined with compass, accelerometers or gyroscopes, this enables new services to be deployed**
 - **The RF part of cell phones is currently changing very quickly, with more and more multi-band multi-mode mobile phones. The incoming deployment of new standards (LTE network in particular) has a direct impact on RF components and will open new doors for online services using an increasing amount of sensors**

Executive Summary

Overview (2/3)

- One striking illustration on how quickly things can happen in the mobile phone industry is the recent release of iPhone 4, the first mobile phone to integrate a MEMS gyroscope, followed a few days later by the announcement of InvenSense IPO. The gyroscope business is now expected to boom very quickly: we believe that the gyroscope market for mobile phones will be more than \$80M in 2010 already. We believe strongly that the impact of gyroscopes on the user experience will be as high as the accelerometer case. Only 3 years ago the first accelerometers were integrated on mobile phones, at a price level similar to gyroscopes today. Now accelerometers are viewed as commodity products in some platforms and their penetration should be above one third of cell phones in 2010. Total motion sensor market for mobile phone will reach 1.19 B\$ in 2015, with a 25.3% CAGR.
- Gyroscopes are not predicted to be the only “killer app” in handsets for the years to come. Many other significant changes are also expected:
 - While the accelerometer and compass try to offer differentiating features, gyroscopes are now entering the mobile phone business, and efforts are also put on pressure sensors. Combo of motion sensors with an increasing processing part are now in development
 - RF filters, variable capacitors and silicon MEMS oscillators should benefit from the changes occurring at the radio-front end level, from the increasing market for duplexers to the LTE impact on multi-mode phones.
 - Silicon microphones are being accepted by the handset market. The cost benefit of ECM tends to decrease, and silicon microphones offer many other advantages. The emergence of dual-microphone solutions for ambient noise cancellation is going to push this business.

Executive Summary

Overview (3/3)

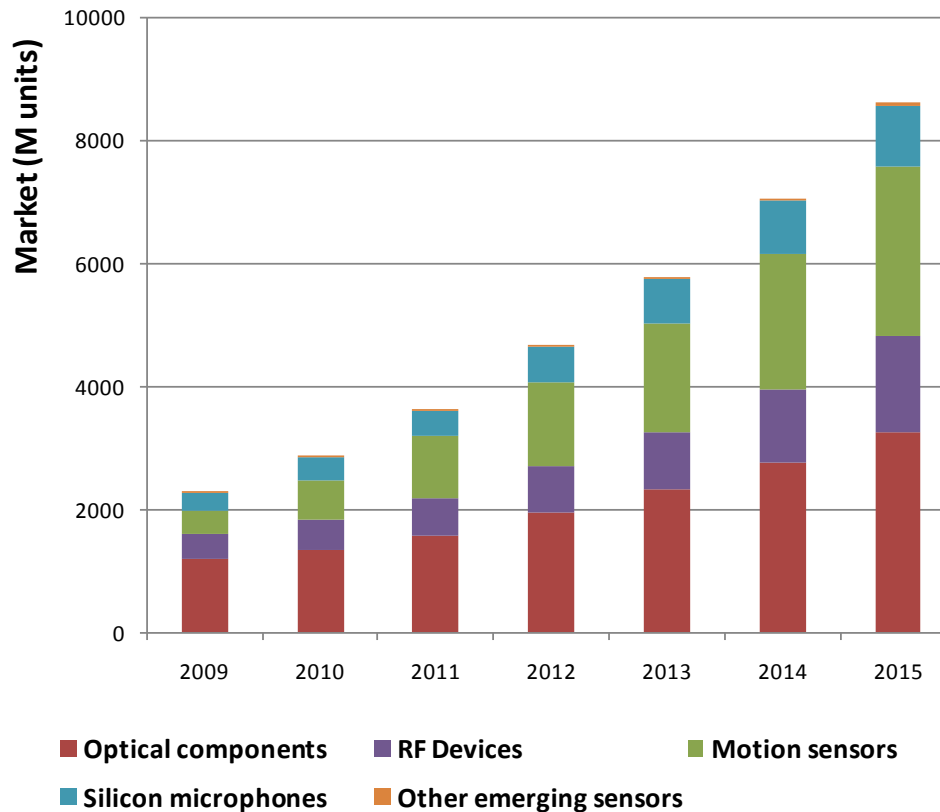
- Many innovative developments in the optical MEMS area are observed. Integrated picoprojectors could make the micromirror market take off, while new microdisplay concepts expect to widely decrease power consumption.
 - CMOS image sensors are already a very big business. The battle is intense between the competitors to develop the next key features such as BSI, WLO, autofocus solutions or stabilization.
 - Many other emerging sensors have been identified, with the potential to become new killer applications in 5 to 10 years: microspeakers, environmental sensors...
- Such an attractive market brings with it intense competition between players. We can observe very quick changes in the supply chain since 2 years with the emergence of new players, the alliances between companies and regular fundraising / acquisitions, in particular when it comes to start-ups. IDMs such as ST Microelectronics have been established as business leaders, by offering reliable components, high level of customer support, an extensive product portfolio and huge price reduction. However few fabless companies have been successful and many innovative fabless start-ups are expected to impact the market within a few years.

Global MEMS & Sensor Market for Mobile Phones

Breakdown by product category

- Motion sensor market is the most dynamic in units

2009-2015 Market for MEMS & Sensors in Mobile Phones (M Units)
- By product category -



Digital Compass for Mobile Phones

Market dynamics: penetration in cell phones

2009: Nokia N97 & Apple iPhone 3GS

- AKM gained design wins for those high-volume selling cell phones
- T-Mobile G1 model in USA (fall 2008) has adopted a 3M + 3A solution

2010-2011: LBS expected to propel compass into the mainstream market

• Telecom carriers and application developers are pushing hard to develop Location-based or augmented reality services

• Ex NTT Docomo "auto-GPS" service started in Winter 09 in Japan → provides location service depending on the user's position and heading

• Leading smart phone providers all have plans to introduced magnetometer-featured phones in 2010:

• Google Nexus One; Nokia E72, Thresher, 5530 XpressMusic; LG GW990, HTC Hero, Tatum, Bravo; Motorola Calgary; i-mate 810-F; Samsung B2700

2004-2007: digital compass integrate in many Japanese handset platforms
First navigation services in Japan

Penetration of magnetometers in cell phones



2007

2008

2009

2010

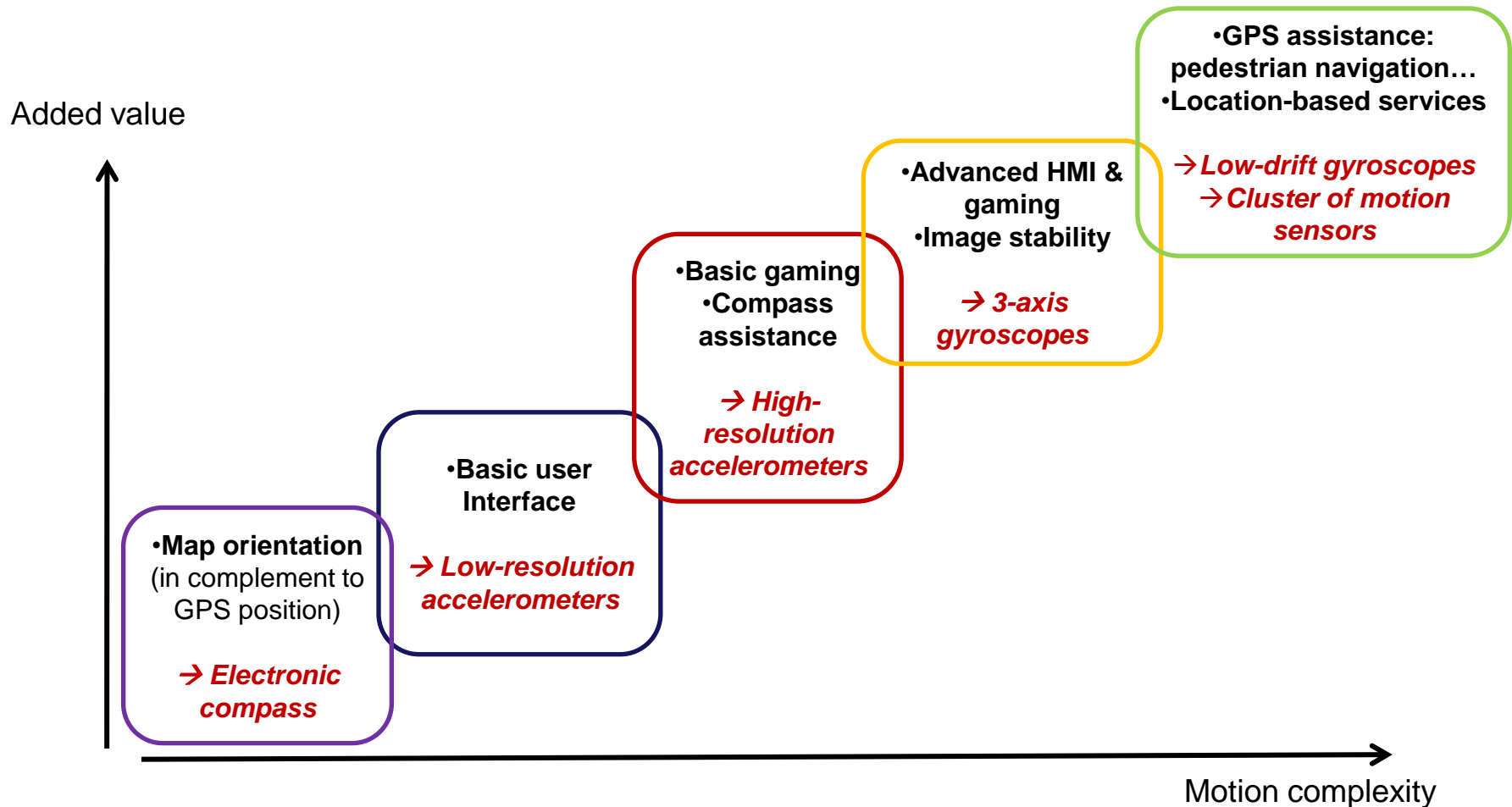
2011

2012

Motion Sensors for Mobile Phones

General segmentation

- 5 groups of motion sensing functions are distinguished for cell phones:

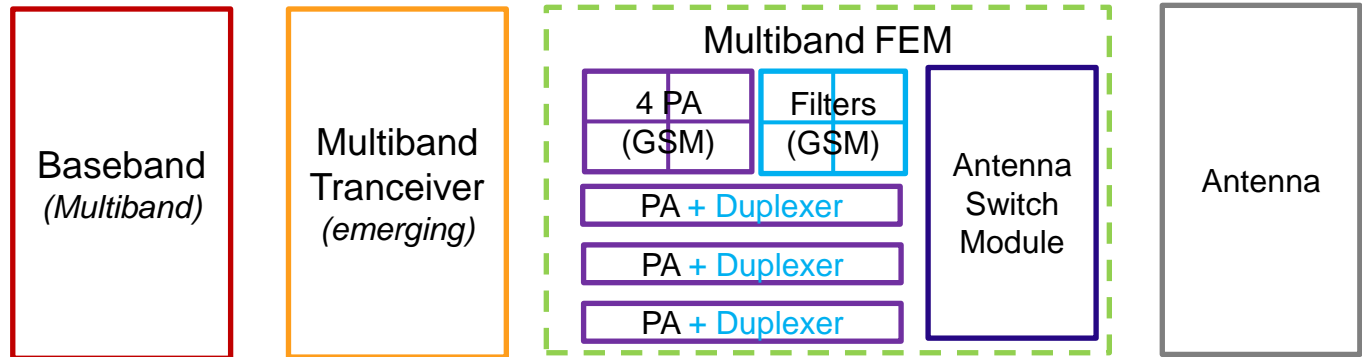


Analysis: Evolution of the Radio Front-End Module

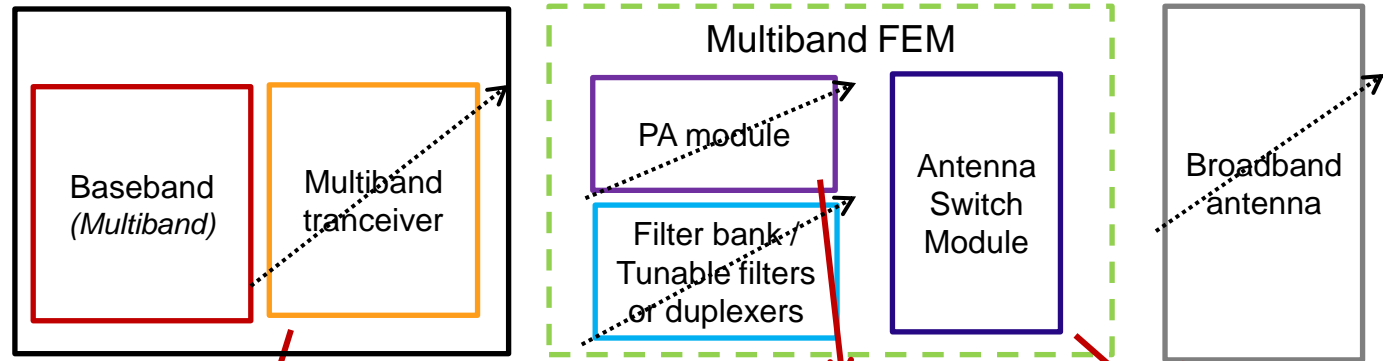
FEM evolution

RF architecture evolution for multi-mode mobile phones

TODAY



TOMORROW



Tunable tranceivers are in development

2/3 PAs inside PA module:
 → low band / (medium band) /high band
 → or 3G PA / LTE PA (optimized by linearity, not by frequency)

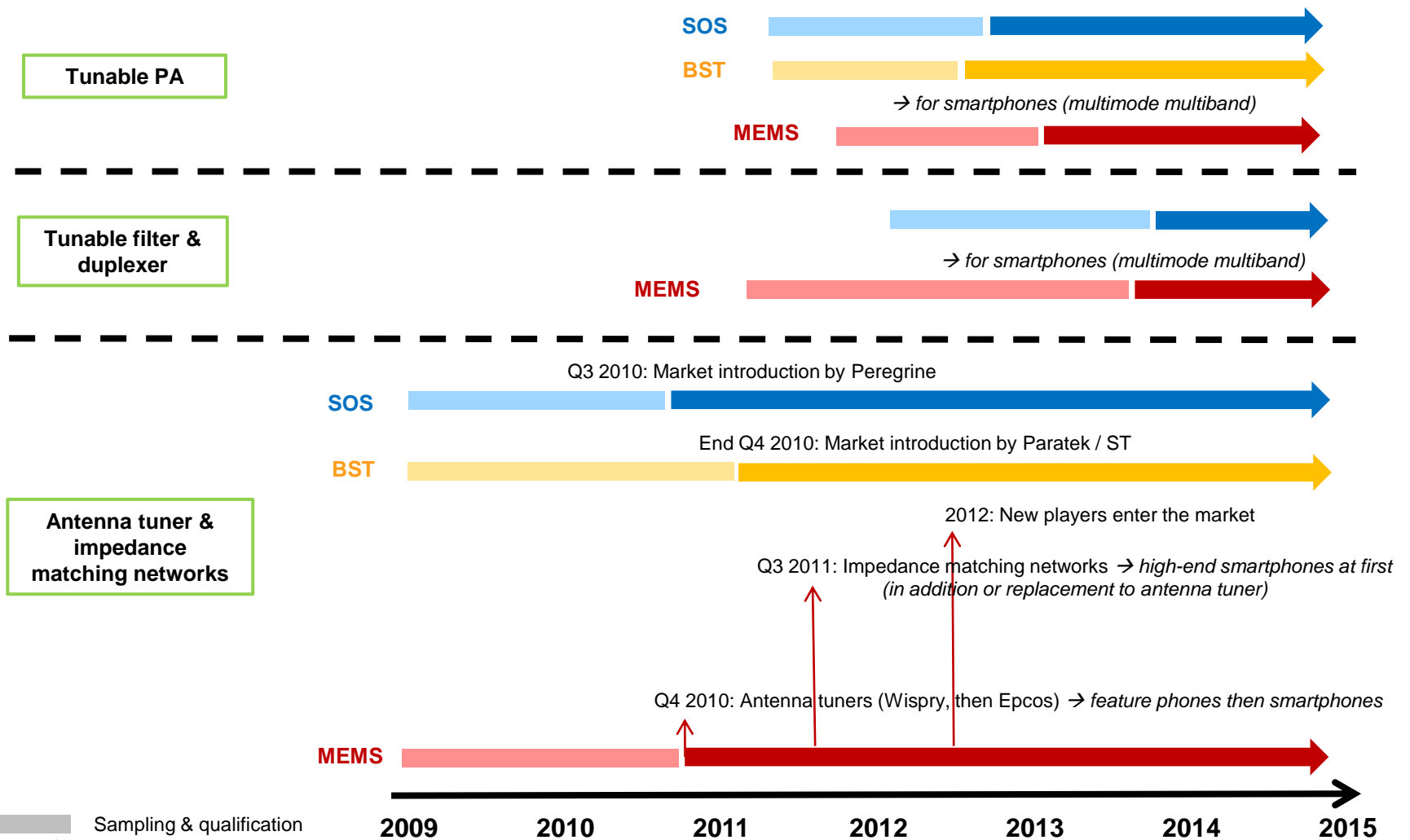
Antenna tuners are in qualification

1 tunable PA at long term

↗ Tunable architectures (long term view)

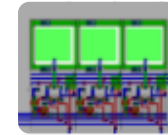
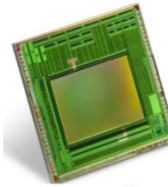
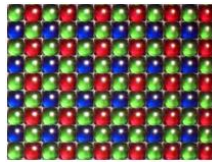
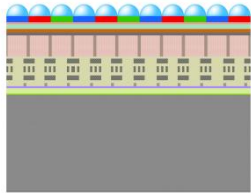
MEMS Switches and Variable Capacitors for Mobile Phones

Product roadmap for tunable components



CMOS Image Sensors for Mobile Phones

Technology drivers: New challenges to face!



- BSI (Backside illumination)
- New color filters, AR coatings
- Pixel isolation, substrate techno

- HDR (High Dynamic Range)
- eDoF (Extended Depth of Focus)
- NIR (Near IR Capability)

Front-end

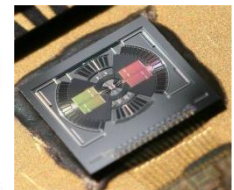
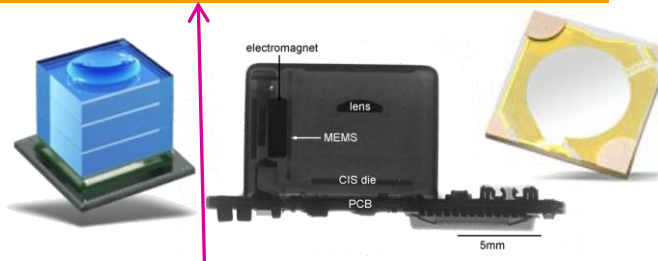
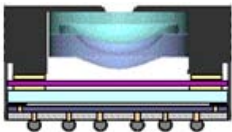
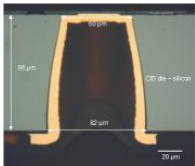
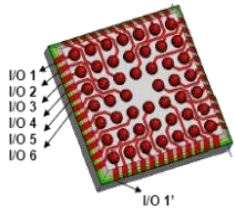
Software / Design

Packaging / Assembly

Optical module

- WLP (Wafer Level packaging)
- 3D TSV interconnects
- Wafer Level Camera & Molding

- WLO (Wafer Level Optics)
- Image stabilization (MEMS inertial...)
- Auto-focus (VCM, Liquid crystal, MEMS...)



This is where MEMS technologies could play a role!

Some more slides extracted from the Report ...

Global MEMS & Sensor Market for Mobile Phones Breakdown by application

Image sensors, filters, microphones and accelerometers are the largest part of the market!

2009-2013 Market for MEMS & Sensors in Mobile Phones (M Units)

Global MEMS & Sensor Market for Mobile Phones Diffusion model

- The diffusion model has been compared for Si Microphones, SAW filters and MEMS accelerometers
 - SAW filters: replacement market (to SAW or ceramic displays and RF filters)
 - Si Microphone: replacement market (to ECM)
 - MEMS accelerometer: new function
- The new function offered by the MEMS accelerometer has seen an extremely quick market adoption
 - Faster than for Si Microphones or SAW filters
 - Si Microphones and SAW filters penetration has been slowed down during the 2008-2009 downturn

Global MEMS & Sensor Market for Mobile Phones Top player ranking - Breakdown by product type

Cliquez pour ajouter du texte

Top MEMS & Sensor Suppliers in the Mobile Phone Market - 2009 Revenue (2M\$) - Breakdown by Product Type

Global MEMS & Sensor Market for Mobile Phones 2009 market shares per product

Global market shares by company in the MEMS & Sensor Revenue by Company in the Mobile Phone Market

Motion Sensors for Mobile Phones Winners and Losers

Successful companies

Big ICMs with difficulties to develop multi-axis solution and to meet price requirements

Japanese players (Altera, Renesas, Fujitsu, Ztek, ADI)

US start-ups with successful management

Other developments (low involvement & low investments)

HEK Robotics, MEMS, MicroSensors, etc.

Motion Sensor Modules for Mobile Phones Focus on GPS assistance

Yole believes that GPS is now next driver for the motion sensor market

GPS problematics

- Large power consumption (up to 200mW)
- Performance is not continuous (due to urban canyons, tunnels...)
- Navigation is not possible when no GPS or RF signal
- Position alone is not sufficient for location-based services and augmented reality

GPS assistance

- Precise heading & acceleration measurement

MEMS Gyroscope for Mobile Phones Structure of InvenSense gyroscopes

MEMS Gyroscope

MEMS Gyro - 170 2200 3-Axis Gyro - 2008 version

- The Cap
- Minimum size on top side
- Carried etched by DRIE
- The Base

MEMS Switches and Variable Capacitors for Mobile Phones Market forecasts (1/2)

MEMS is considered as a viable solution at long-term

SOS solution should take the largest part of the tunable market at first

Market for tunable components in mobile phones (M Units)

MEMS Gyroscope for Mobile Phones Which functions can justify it?

Yole sees 3 "killer features" which could justify the gyroscope integration:

Gyroscope penetration in handsets

- Image stabilization
 - more friendly user interface
 - advanced gaming
- Dead reckoning navigation (tunnels, urban canyons...)
- True pedestrian navigation (long periods inside buildings...)

Implementation: Ultra low cost gyroscopes (10\$) not existing at low cost today! Combined with accelerometers in IMUs and with compass for more accuracy

MEMS AF for Mobile Phones Overview of camera phone AF technologies

Camera phone manufacturers are challenged by emerging technologies for new generations of camera modules, emerging technologies such as liquid lenses, electro polymer, SMA, MEMS technologies attractive specifications while some developments have reached the market introduction stage, others still have to demonstrate reliability and manufacturability

	VCM	Press AF SMA	MEMS AF	Liquid Lenses	EODF	WL Auto-Focus
Volume	***	***	***	***	***	***
Volume %	***	***	***	***	***	***
Cost	***	***	***	***	***	***
Reliability	***	***	***	***	***	***
Manufacturability	***	***	***	***	***	***

About the Authors of this Report

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