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

Executive summary

Major findings – MEMS & Sensors

• The following MEMS & Sensors are under the scope of the report (in Red)
  - BAW filters
  - BAW duplexers
  - RF switch / variable capacitor
  - TCXO oscillators
  - Accelerometer
  - Gyroscope
  - Electronic compass
  - Pressure sensor
  - CMOS Image Sensor
  - Auto-Focus actuator
  - Front camera
  - ALS & Proximity sensor
  - Microdisplay
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

First navigation services in Japan

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, Tatoo, Bravo; Motorola Calgary; i-mate 810-F; Samsung B2700
Motion Sensors for Mobile Phones

General segmentation

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

  - Basic user Interface → Low-resolution accelerometers
  - Basic gaming • Compass assistance → High-resolution accelerometers
  - Advanced HMI & gaming • Image stability → 3-axis gyroscopes
  - GPS assistance: pedestrian navigation... • Location-based services → Low-drift gyroscopes → Cluster of motion sensors
  - Map orientation (in complement to GPS position) → Electronic compass

Added value

Motion complexity
Analysis: Evolution of the Radio Front-End Module

FEM evolution

RF architecture evolution for multi-mode mobile phones

TODAY

Baseband (Multiband)

Multiband Tranceiver (emerging)

Multiband FEM

4 PA (GSM)

Filters (GSM)

PA + Duplexer

PA + Duplexer

PA + Duplexer

Antenna Switch Module

Antenna

TUNABLE architectures (long term view)

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)

Tunable tranceivers are in development

1 tunable PA at long term

TOMORROW

Baseband (Multiband)

Multiband tranceiver

Multiband FEM

PA module

Filter bank / Tunable filters or duplexer

Antenna Switch Module

Broadband antenna

Antenna tuners are in qualification
MEMS Switches and Variable Capacitors for Mobile Phones
Product roadmap for tunable components

- **Antenna tuner & impedance matching networks**
  - Q4 2010: Antenna tuners (Wispry, then Epcos) → feature phones then smartphones
  - End Q4 2010: Market introduction by Paratek / ST
  - Q3 2011: Impedance matching networks → high-end smartphones at first (in addition or replacement to antenna tuner)

- **Tunable filter & duplexer**
  - Q3 2010: Market introduction by Peregrine

- **Tunable PA**
  - SOS → for smartphones (multimode multiband)
  - BST → for smartphones (multimode multiband)
  - MEMS → for smartphones (multimode multiband)

**Timeline:**
- **2009**
- **2010**
  - Sampling & qualification
  - Market introduction
- **2011**
- **2012**
- **2013**
- **2014**
- **2015**

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CMOS Image Sensors for Mobile Phones

Technology drivers: New challenges to face!

- **Front-end**
  - BSI (Backside illumination)
  - New color filters, AR coatings
  - Pixel isolation, substrate technolo
  - HDR (High Dynamic Range)
  - eDoF (Extended Depth of Focus)
  - NIR (Near IR Capability)

- **Packaging / Assembly**
  - WLP (Wafer Level packaging)
  - 3D TSV interconnects
  - Wafer Level Camera & Molding

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

- **Optical module**
  - 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 ...
About the Authors of this Report

• Laurent Robin:
  – Laurent is in charge of the MEMS & Sensors market research at Yole Developpement. He previously worked at image sensor company e2v Technologies (Grenoble, France). He holds a Physics Engineering degree from the National Institute of Applied Sciences in Toulouse, plus a Master Degree in Technology & Innovation Management from EM Lyon Business School, France

    Contact: robin@yole.fr

• Jerome Baron:
  – Jerome is leading the MEMS & Advanced Packaging market research at Yole Developpement. He has been involved in the analysis of the CMOS image sensor industry at the sensor, packaging, assembly & test levels. He is also involved in the research linked to new equipment and materials for image sensor manufacturing. He was granted a Master of Science degree in Nanotechnologies from the National Institute of Applied Sciences in Lyon, France

    Contact: baron@yole.fr