Inertial MEMS

Inertial MEMS Manufacturing Trends 2014 – Volumes 1 & 2

The shift from stand-alone devices to integrated inertial measurement units and combos will come from optimization of current technologies and the introduction of disruptive approaches.

WHAT'S NEW

- More than 46 new MEMS components analyzed, including 10+ combos
- Deep analysis of disruptive approaches, including M&NEMS and BAW-based gyroscopes
- Evolutionary analysis of inertial MEMS devices from 2007 to 2013, including die size, manufacturing cost, component performance and more
- Detailed front-end process flow for a typical MEMS accelerometer and MEMS gyroscope
- Device's structure and manufacturing cost are analyzed

REPORT OUTLINE

- Title: Inertial MEMS Manufacturing Trends 2014
- Market & Technology report
- PDF & Excel file
- March 2014
- €2,490 - Executive summary (30+ slides)
- Full report: (550+ slides)
  Multi user license: €7,990
  One user license: €5,990
- For one volume:
  (270+ slides / 300+ slides)
  Multi user license: €5,990
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KEY FEATURES OF THE REPORT

- 2011-2018 market size in value, units and wafer shipments
- 2012 market share in value and wafer shipments, 2013 trends
- Cross-analysis of market drivers and technological answers
- Technology classification for inertial sensors that depend on detection principle
- Illustration of the reverse engineering trends of new commercially-available MEMS sensors
- Summary of main packaging trends
- Details on the physical structure and cost structure of 46 recent inertial sensors used in consumer, automotive and high-performance industries.

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6 AND 9-AXIS DOF SENSORS ARE CREATING A NEW PARADIGM IN THE COMBOS BUSINESS

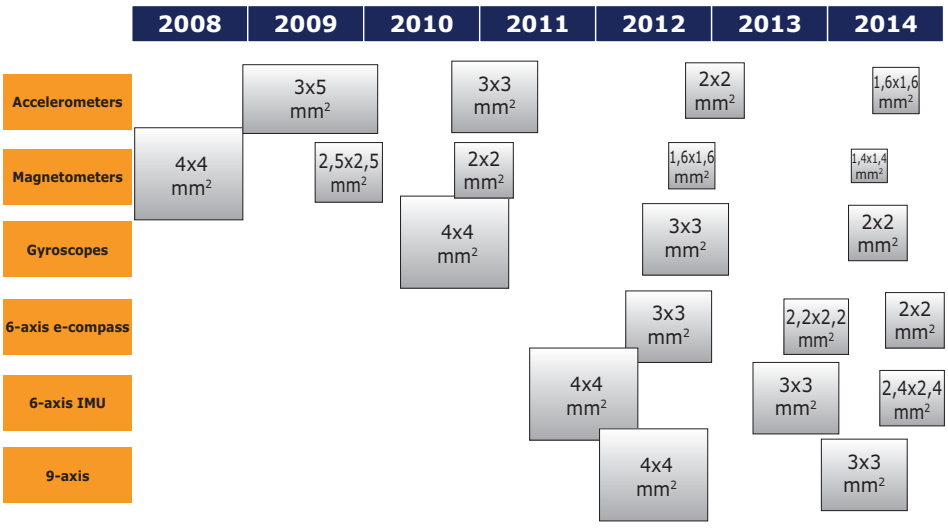
Current technological developments are motivated by several market drivers. For example, integrators for consumer products apply strong price pressure on component manufacturers, thus motivating die size reduction in order to lower manufacturing costs and change the manufacturing platform. Other industry requirements include low-power consumption for mobile applications, better performance and higher integration of functionalities.

These required improvements have been the same for some time now. The difference mainly lies in the way that technology adapts in order to meet these increasingly stringent specifications. Over the past several years, the tendency was to increase the number of axes for stand-alone components while decreasing size. Now, the industry favors complete integration of 9+ axis sensors and platform standardization.

Indeed, in term of detection principle, and in terms of physical concepts in general, we haven't seen many disruptive approaches reach the market, aside from Qualtré BAW-based inertial sensors. Nevertheless, strong efforts have been made to develop standardized platforms - for example, Teledyne DALSA now offers a generic platform for accelerometers and gyroscopes, as does STMicroelectronics via its THELMA process. Moreover, a very innovative approach in terms of standardization can be seen in CEA-LETI's M&NEMS platform, in which the company intends to use silicon nanogauges as detection principle for their accelerometers, gyroscopes and magnetometers. The concept lies in using nanoscale gauges for detection, thus increasing sensitivity and reducing size, while keeping a microscale mass for better detection reliability. M&NEMS technology allows for the integration of 9-axis sensors with small form factor. This process is expected to enter production through Tronics Microsystems within the next few years.

Innovation also comes from back-end processing. Packaging issues had to be leveraged in order to attain the high integration required by advanced inertial combos. Key packaging developments and innovative front-end approaches are analyzed in this report.

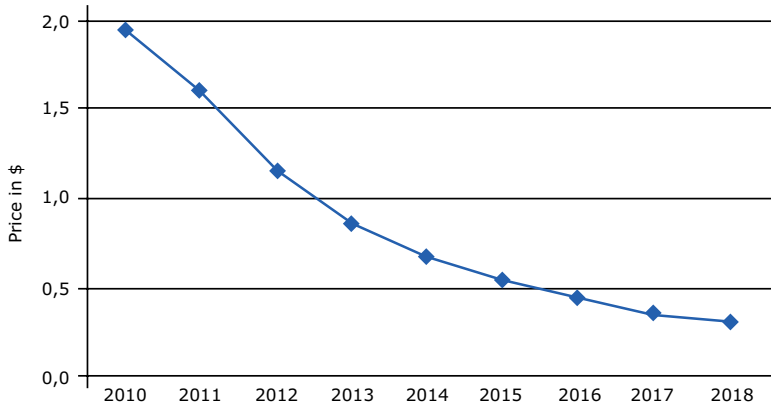
Continuous MEMS size decrease (typ. package footprint for sensors in mobile)



(Yole Développement, March 2014)

FOR THE FIRST TIME EVER, OUR ANALYSIS IS ILLUSTRATED BY MORE THAN 40 REVERSE ENGINEERING STUDIES OF DIVERSE COMMERCIAL COMPONENTS!

Price decrease over years for gyros in mobiles



(Yole Développement, March 2014)

46 inertial MEMS components have been reverse engineered to provide insights and data regarding accelerometers, gyros and combos. In our report, a reverse costing simulation of the MEMS, ASIC and packaging parts of these devices has also been made. These tasks were performed by System Plus Consulting, Yole Développement's sister company. The report compares performance, cost, size (MEMS, ASIC and package), ASIC lithography node and manufacturing approach results. This factual analysis well underlines the previously mentioned trends, and permits a concrete visualization of different companies' current status in terms of integration. This analysis is complimented by the 23 devices that were reverse engineered for our previous report in order to visualize general trends over a five year timeframe. One noticeable evolution shown in our report is that sensor die size has stabilized over the last few years, while prices continue dropping. Our report also shows how die size reduction has been achieved through new packaging approaches (i.e. new sealing bond).

Example of reverse engineering/reverse costing analysis

Package:
- Dimensions: 3mm x 3mm x 0.95mm)
- Type: LGA 16-pin
- Cost: $0.165 (includes final test & yields losses)

ASIC accelerometer:
- Die area: 1.38mm²
- Process: CMOS 0.18µm 2P 4M.
- Cost: $0.098

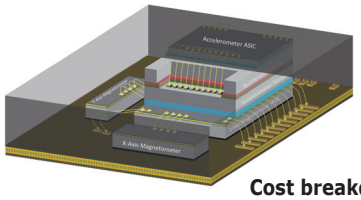
MEMS accelerometer:
- Die area: 1.96mm²
- Sensing axis: Three axes (X, Y and Z).
- Process:
  - Cap: Bulk micromachining (Isotropic etching).
  - Sensor: Epi-Poly Surface Micromachining.
  - Bonding: Glass-frit
- Cost: $0.059

Z-Axis magnetometer + ASIC:
- Die area: 2.19mm²
- Sensing axis: One axis (Z)
- Process: CMOS 0.18µm 2P 4M.
- Cost: $0.126

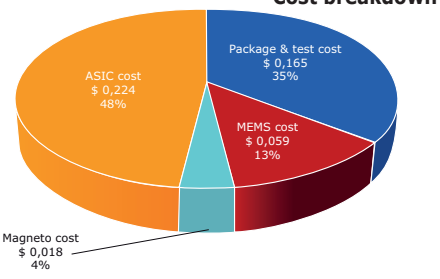
X/Y-Axis magnetometer:
- Die area: 0.61mm²
- Sensing axis: One axis (X or Y)
- Process: Thin film deposition
- Cost: $0.009

(Yole Développement, March 2014)

Bosch Sensortec BMC050



Cost breakdown



BY 2018, THE INERTIAL SENSOR MARKET WILL REACH ALMOST 1,000K 8" EQUIVALENT WAFERS

The inertial sensor market has been very active over the past few years, and innovation is ongoing. Today these sensors represent the largest MEMS market (accounting for more than $3.5B in 2012) and we don't see this changing any time soon. Stand-alone inertial devices (1 - 3 axis accelerometers, gyroscopes and magnetometers) have matured over the last several years, and they will soon start to decline. In terms of value, this decline has already begun in the consumer accelerometer market. Nevertheless, the inertial sensor market can rely on combos for its future growth. Currently, accelerometer/gyroscope combos, e-compass and 9-axis sensors are penetrating consumer applications. For example, 9-axis combos are expected to be an $850M market in five years.

The consumer market remains the main opportunity for inertial sensors. Also, the automotive industry will benefit from the integration of gyroscopes and accelerometers on the same components for ESC applications, representing a $625M opportunity for gyroscope/accelerometer combos by 2018.

OBJECTIVES OF THE REPORT

Over the last years, inertial MEMS have been subject to dramatic market & technological evolution. This has been driven by a large increase of the consumer market. Along with "stand-alone" MEMS devices, inertial combo sensors – a combination of several inertial sensors in a single package - are also coming. Main applications are consumer – e.g. accelerometer with magnetometer or accelerometer with gyro – and automotive for ESC and rollover functions first.

To give clues about the differences in cost, size, package, structures … of the different inertial MEMS, Yole Développement has released this report in order to:

- Provide an understanding of the market drivers for inertial MEMS
- Give trends about packaging and test strategies
- Provide in-depth analysis for 23 MEMS devices in terms of cost, size, package type, performance
- Have a comparative analysis in terms of performance, cost, MEMS size, ASIC cost, ASIC size, package size, year for market introduction.

A second report "Front-End, Assembly & Test Trends for Inertial MEMS & Magnetometers – REVERSE ENGINEERING/COSTING" depicts photos for each device: Package view / MEMS & ASIC dimensions / close-up MEMS structure / specific process steps / cost breakdown

RELATED REPORTS

- 6 and 9-Axis Sensor Consumer Inertial Combos
- MEMS Gyro Patent Investigation
- MEMS Front-End Manufacturing
- Reverse Costing of mCube 3-Axis Accelerometer
- STMicroelectronics LSM9DS0 9-Axis MEMS IMU
- Bosch Sensortec BMX055 - 9-Axis MEMS IMU
- InvenSense MPU-6500 6-Axis MEMS IMU

COMPANIES CITED IN THE REPORT (non-exhaustive list)

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- Power Price+for any power component or module
- SYS.Cost forelectronic boards and systems

Cost Simulation Tools, process flow based

- MEMS CoSim+ / Power CoSim+ / Sapphire CoSim+ / LED CoSim+ / TSV CoSim+ (thru silicon vias)

Other costing models can be developed according to customer specifications.