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Prospects for MEMS in the Automotive Industry

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Abstract: An automotive sector as a growth market for MEMS sensors is analyzed in the article. The automotive sector accounted for \$1.6 billion, making this the second biggest opportunity after IT peripherals and inkjet print heads. By 2011 the market will top \$2.2 billion, a CAGR of around 7%. The main applications in revenues terms are, in order, pressure sensors, gyroscopes, accelerometers and flow sensors and this will remain so for the foreseeable future. Automotive companies are forced to innovate as a result of competition and price pressures. *Copyright © 2007 IFSA.*

Keywords: MEMS sensors, Automotive industry, MEMS, Pressure sensors, Gyroscopes, Accelerometers, Flow sensors

1. Introduction

The automotive sector has long been a growth market for MEMS sensors. However, the industry continues to change and face new opportunities and challenges—regulations, saturation in some applications and price erosion issues, to name a few.

Today's high-end vehicles feature up to 100 different sensors. About 30 these are now MEMS (see figure). The market is made up of accelerometers, gyroscopes and inclinometers (shown in green) and pressure and flow sensors (blue). Emerging applications include IR sensors for air quality, microscanners for displays, etc. (yellow) and further out, MEMS oscillators and energy scavengers for TPMS (those shown in red).

2. 2nd Biggest MEMS Market

Our estimates show the automotive sector accounted for \$1.6 billion, making this the second biggest opportunity after IT peripherals and inkjet print heads. By 2011 the market will top \$2.2 billion, a CAGR of around 7%. The main applications in revenues terms are, in order, pressure sensors, gyroscopes, accelerometers and flow sensors and this will remain so for the foreseeable future.

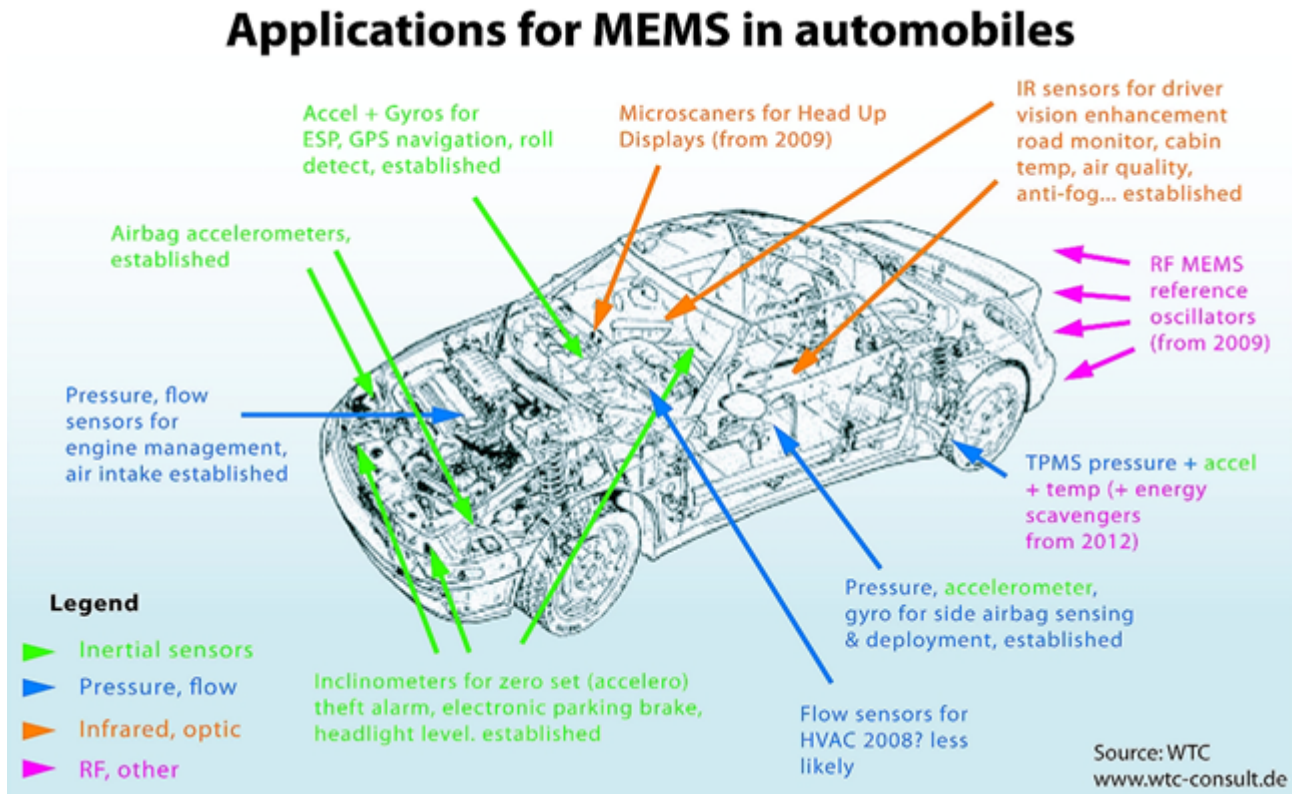


Fig. 1. Industry Quote: On sensor fusion: "There are so many new sensor functions on the horizon that will continue to create need for MEMS sensors." — Dr Peter Ernst, Robert Bosch.

The total number of sensors will grow from over 430 million units in 2006 to 780 million in 2011, an annual growth of 13 %. This outstrips the dollar growth due to price erosion running at 4-5 % per year. It can be higher depending on the component (see section on airbags).

Leading markets are ESP gyroscopes (\$ 272 million), airbags (\$ 260 million), followed by pressure with MAP and BAP (total \$ 192 million), side airbags and tire pressure monitoring (TPMS). The market for TPMS systems will grow at 50% this year due to a US mandate (described later) before leveling off in 2008-2010 to under 10 %.

Suppliers to this industry include 13 companies from the top 30 MEMS sensor producers (see last issue of Think Small! for full breakout). Ten of these make considerably more than \$100 million. Robert Bosch leads the field and is the 4th biggest MEMS supplier overall with \$374 million, up there with giants like Hewlett Packard and Texas Instruments.

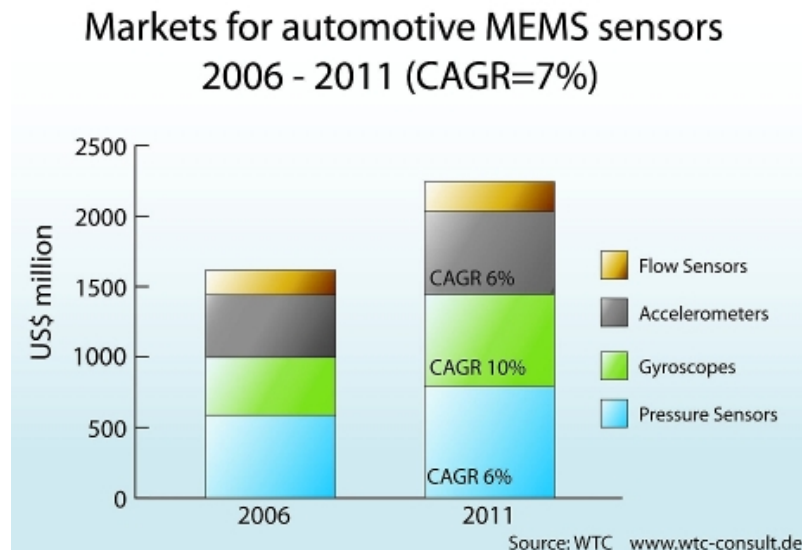


Fig. 2. Markets for automotive MEMS sensors 2006-2011.

3. Airbag Sensors Commodities

Contrary to our thinking 2 years ago, the airbag market is not stagnating and continues to provide impressive unit growth, driven for example by new markets in Asia.

In fact integrators like Autoliv expect airbag penetration to increase from 40 to 60 million vehicles over the next five years (i.e. 80% of cars worldwide).

We estimate this will equate to insertion from 200 million accelerometers today to 350 million in 5 years, with as many as 8 accelerometers per electronic control unit (ECU). Major players in this space include Bosch, Infineon, Analog Devices, Denso, and Delphi.

More sophisticated solutions are being developed as a result of passenger occupation detection and combined pressure/accelerometer side airbags. However, in coming years the market will suffer from price pressures reminiscent of consumer electronics (10 % per year).

4. ESP to Ride US Regulation

Today ESP systems make up 2/3 of the revenues for gyroscopes. This amounted to around 16 million units in 2006. Systron Donner Automotive (part of Schneider Electric), Robert Bosch, Silicon Sensing Systems and Panasonic dominate this market space (see Fig. 3).

We have now updated our data to take account of the mandatory introduction of such systems in the USA in 2010. Penetration of ESP was below 20-25 % in 2006 in the US compared to over 40% in Europe. The US mandate will rapidly accelerate the market for ESP. This is stimulating interest from potential future suppliers; among these are Freescale, Honeywell, Infineon, Sensor Dynamics-Fraunhofer, and Microcomponents, a Swatch group company with a quartz gyroscope. While not all will succeed we believe there is room for about 7-8 players in total.

On one hand, the market transparency brought on by the mandate brings potential risks of commoditization and price erosion. This will precipitate an interesting battleground as prices are driven down by increased competition, and tier one suppliers have more options.

However, gyroscopes are still challenging to manufacture and remain relatively speaking expensive. They require 100% testing—a major contributor to cost.

We predict the number of ESP units will reach 28 million in 2011 or 40% of cars worldwide. ASPs will drop at a rate of 3-4% in the first few years and more sharply after the US law comes into effect prior to 2010. Growth in ESP systems will continue to benefit accelerometer companies like VTI, which supplies low g sensors needed to measure lateral acceleration in a curve, or vertical acceleration in roll detection systems.

2006 ESP market breakout in units (Total = 16 M units)

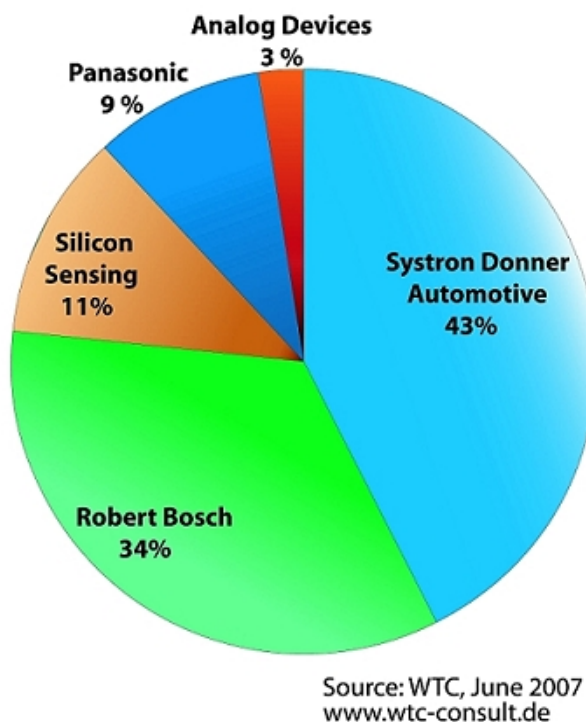


Fig. 3. 2006 ESP market breakout in units.

The attractive market conditions for ESP systems will affect the supply chain as integrators look for lower cost units. We expect Panasonic, a company that currently dominates navigation gyroscopes with well over 80 % market share, to increase its share in ESP.

Technology changes could be on the cards for Systron Donner, which is not ruling out a silicon solution. The company current has a quartz offering. Bosch is looking to reduce size and cost through consolidation of ESP and roll over detection gyros in the same package, either hybrid or single die.

Earlier this year Silicon Sensing Systems introduced its 4th generation vibrating ring gyro, which has been changed from an inductive to capacitive drive to reduce costs and size. The ASIC is now on the same piece of silicon in this single axis design.

5. US Mandate for TPMS in 2007

US regulations (TREAD) governing tire pressure monitoring this year will accelerate the pressure sensor market. Undergoing rapid technology iterations, TPMS systems will eventually evolve into smaller, lighter batteryless “intelligent tire” systems that attach to the tire, not the rim.

Tires provide a high vibration environment that allows sensor engineers to consider energy harvesting solutions. At the same time this gives tire makers a chance to add intelligence and move up the value chain. Intelligent tire systems could conceivably add new functionalities such as force, friction/grip, ID and wheel speed to feed ESP systems and other sensor fusion scenarios. We expect intelligent tires with a battery in 2010 and from 2012, intelligent tires powered by MEMS vibration energy scavengers. Such systems will probably start with ID functionality.

The new regulations will also commoditize the market as many players try to gain entry and challenge the likes of Infineon, Freescale, Texas Instruments and GE NovaSensor. Contrary to ESP, TPMS is a technically easier challenge that—at least in current generations—is a question of integration of a range of different technologies into a compact low-power system.

As a result, many new suppliers including Melexis, Bosch, VTI, Kavlico, Continental... target the estimated \$190 million market expected in 2011 (based on sales of 90 million units). Therefore some will fall by the wayside.

Other solutions could also come to the fore and indirect systems should not be completely discounted. Common to Europe, these systems make up by far the smallest part of the current market. Indirect sensor solutions use sensor fusion from existing ABS and speed sensors to extrapolate tire pressure, although would not provide additional information such as ID.

6. Data Clusters = Less Sensors ?

Clustering of sensors is a buzz word in the industry now. Broadly speaking the issue is that additional functionality leads to higher numbers of more complex electronic control units (ECUs), increased bus load and adding more wiring. One approach is to incorporate more types of sensors in the ECU, thereby reducing the overall number of such units. This does not affect the overall number of say, inertial sensors, but influences the bus load and weight.

Currently there appears to be no consensus on how best to integrate disparate sensor elements for no loss in performance or reliability, which requires a full view of architecture. Sensor suppliers like Honeywell and Systron Donner Automotive integrate accelerometers into IMU modules. However, we believe that tier 1 suppliers like Bosch, Denso and Siemens VDO will find this activity easier due to inherent systems-level knowledge. Systron Donner Automotive, which integrates VTI accelerometers into an IMU, could find itself competing with its major customer Continental Automotive at module level.

So far, Analog Devices has combined roll-over detection and ESP functions (which feature gyros with significant resolution differences) used in TRW’s systems employed for SUVs. Bosch is



accommodating ESP active safety systems with passive roll-over sensing with a new gyro with increased measurement of 240°/s. This ultimately leads to fewer gyroscopes.

7. The Role of R&D

One of the major challenges is the continued pressure on prices. Suppliers generally agree that a healthy rate of R&D investment (typically 12-15 %) is needed to maintain and innovate in order to keep their margins. This is being achieved as follows:

- In the back-end through smart packaging as well as wafer level test instead of component testing;
- At the front-end to increase process stability, e.g. to relax effort on test, gain on yield and to ensure long-term product reliability;
- Through new front-end processes such as a shift away from bulk to surface micromachining to lower costs;
- New or larger (8") substrates.

8. Limited Foundry Outsourcing

We believe, contrary to the view given by other analysts, that there is no obvious trend to outsource manufacturing to big CMOS foundries such as TSMC. An exception is the relationship of Freescale with the Dalsa foundry, although this is confined to lower value devices like some types of pressure sensor. Freescale retains in house manufacturing of high-value technologies such as accelerometers and gyroscopes.

In fact the requirement of an "in house" capability is still perceived as critical in MEMS. Bosch provided a clear demonstration of the "make or buy" decision with the recent investment in a new 8" fab in Reutlingen.

In some cases MEMS foundries could play a role after acquisitions or restructuring or new products needing 8" fabs. One such foundry betting on automotive is Silex. Also tMt is currently cooperating with a well-known automotive MEMS manufacturer wanting 8" for a new product, though most others look to higher volume CE opportunities.

9. Consolidation

As the automotive MEMS branch is maturing, it is also consolidating. Continental Automotive Systems (CAS) is the most active player in this process, having acquired Motorola's automotive group (pressure sensors and Telematics) and subsequently VTI's module business. We also know that Siemens VDO turned down Continental's recent overtures.

CAS is clearly a Tier 1 integrator of MEMS. This situation changed with the Motorola acquisition, which now adds now in-house production of pressure sensors. However, this does not fit the company's business model and it is not yet clear if the pressure sensor fabrication will remain in house.

Worthy of note is Delphi. Although it filed for chapter 11 (bankruptcy) in October 2005, it remain a very active MEMS supplier, even investing in new products.

10. Opportunities for Newcomers

We believe that the automotive sensor market will prove too tough for many startups or consumer-market oriented companies looking to enter this space. Opportunities will exist but largely for non-safety critical sensors used in GPS navigation or infrared sensors. STMicroelectronics is an exception, leveraging strong connections in the industry through its existing IC business. We know that several suppliers of ASIC to the automotive market are also looking at widening their offering to include sensors.

It remains to be seen what effect companies like STMicroelectronics, Kionix and MEMSIC will have on the market. While each acknowledges the challenging automotive specifications, they point to the stable process that comes from high volume manufacturing for CE applications.

11. Conclusion

In the automotive industry, companies are forced to innovate as a result of competition and price pressures. New regulations drive new markets and precipitate competition for existing suppliers, potentially producing excellent opportunities for a few newcomers to the supply chain.

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Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726- 5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In addition, some special sponsored and conference issues published annually.

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- Theory, principles, effects, design, standardization and modeling;
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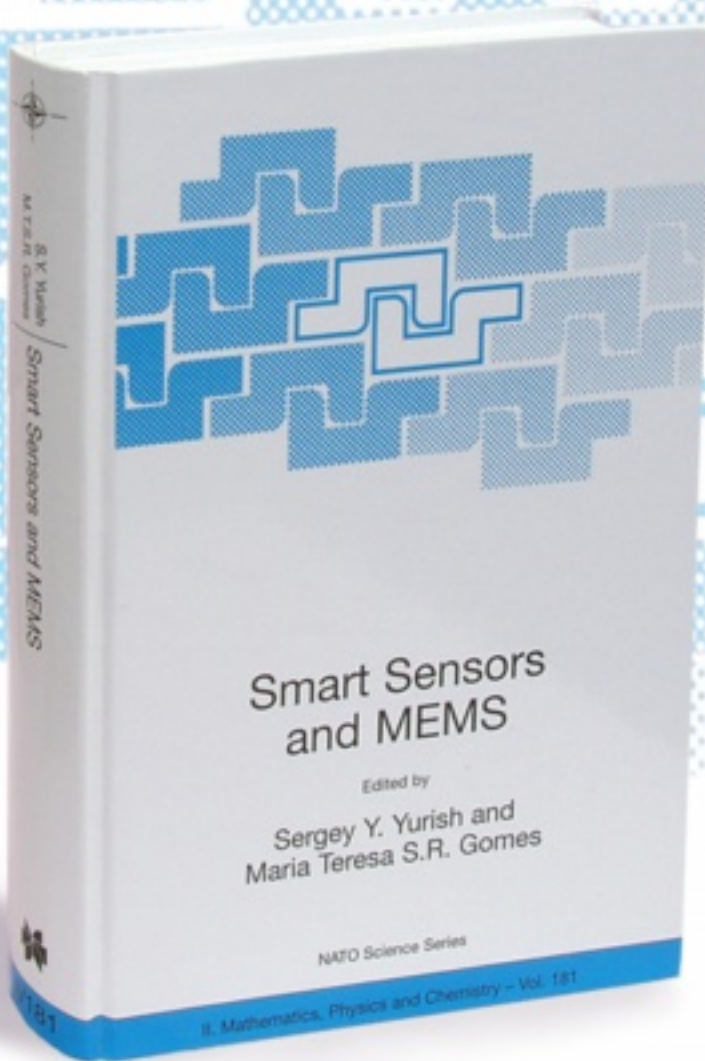
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