MEMS' Trends

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Magazine on MEMS Technologies & Markets

INDUSTRY REVIEW
MEMS everywhere: opportunity moves from devices to ecosystems

ANALYST CORNER
Pace of growth for MEMS in mobile devices may moderate, but pace of change will not

COMPANY INSIGHT
Texas Instruments: Non-contact temperature sensors come down in size and cost

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EDITORIAL

Towards the ultimate step of MEMS and sensors integration for the functional enabling of our everyday devices...

Dear readers,
While strolling around your favorite tourist spots this summer, you should ask yourself the following question: are there MEMS or sensors here? In most cases, you should not be surprised that the answer is a definitive yes...

Yole Développement forecasts that the MEMS market will see 13% compound average annual growth in revenues, going from $11.5 billion in 2012 to $21 billion in 2017 - with almost a quarter of this attributed to cell phones and tablets. Sensor combination and fusion will become mandatory in order to provide the end-user with the expected level of environment/content awareness, and augmented reality and immersive experience will be possible in every-day consumer electronic products.

Our recent report "MEMS for Cell Phones and Tablets - 2012" well illustrates this trend. First, the list of MEMS-based components that have either been implemented, introduced as a sample or are in the process of emerging in consumer mobile devices is impressive from accelerometers to touchscreen sensors.

Secondly, combination and fusion is omnipresent. It started with motion sensing for navigation and human interfaces, where increasingly adaptable hardware sensors were mixed with software platforms for data fusion. After this came 3 axis accelerometers, gyroscopes, and magnetometers working closely with GPS for accurate outdoor pedestrian location-based services. Now, pressure sensors are entering the field for indoor (GPS blind) navigation with floor determination. It's inevitable that after the commoditization era of single MEMS devices comes the era of higher functional extended value through combination.

It's inevitable that after the commoditization era of single MEMS devices comes the era of higher functional extended value through combination...

Motion sensing is, in fact, not the only domain to be impacted by sensor fusion for advanced human machine interfaces. By having a look at our industry review article, you will see that MEMS Microphones and Speakers are also on the list of innovative interfaces based on sensors & actuator fusion.

For most applications, it's now more a matter of ease of integration through digitalization and software embedding location strategies (microcontroller, microprocessor or locally on sensor combo boards) than of chip acceptance.

In order to expand beyond the mobile consumer industry, MEMS manufacturers will have to consider full-usage ecosystems built around the multi MEMS sensor platform. The DIRHA research and development project highlighted in our industry review is a great example of this topic.

In addition to Yole Développement's well-known activities, our company is highly involved in the issue of "full-usage ecosystem building" through COWIN - and we are happy to say that forty-five new European Commission-funded miniaturized smart systems technologies are supported by the "COWIN for Business Case" service. In the "Company Insight" section of this current issue, we will highlight a few examples of supported technologies, with articles pertaining to CSEM, IMEC and BiFlow Systems.

Wherever you are, be sure to enjoy your holiday along with a paper or electronic version of *MEMS' Trends* summer issue!

Dr Eric Mounier
Senior Analyst, MEMS Devices & Technologies
Yole Développement
mounier@yole.fr

EVENTS

- **MEMS in Motion**
September 12 to 13 - Palm Springs, CA, USA
- **Inertial Sensors & Systems - Symposium Gyro Technology**
September 18 to 19 – Karlsruhe, Germany
- **MEMS Executive Congress**
November 7 to 8 – Scottsdale, AZ, USA
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- Omron develops super-sensitive thermal detector for smartphones
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- STMicroelectronics unveils ultra-compact multi-sensor MEMS module with programmable motion-recognition capabilities

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FINANCIAL BUZZ

H1 2012: continuous activity in MEMS fund raising, IPOs and acquisition rather quiet

Again, we observed many transactions in the last quarter...

Laurent Robin,
Activity Leader,
Inertial MEMS Devices
& Technologies,
Yole Développement

There are still major fund raisings in MEMS, with large rounds for Sand 9, Qualtre and OrthoSensor in the first half of 2012. The IPO side is quiet so far in 2012, the major event was InvenSense follow-up offering (in Q1).

On the M&A side, while we observed many large transactions in 2011 (six acquisitions over $100M), no big MEMS acquisition has been observed so far in 2012. Acquisition of Sensonor is perhaps the most important one.

New investments (VC rounds, IPOs)

Company	Type of product	Type of investment	Level of new investment	Investors	Yole Développement Comment
			Apr. 2012		
Wasatch Microfluidics (US)	Protein analysis equipment for the drug discovery and research market	3rd round	$0.47M	Pasadena Angels Inc.	Wasatch Microfluidics has been founded in 2005 and licenced a Continuous Flow Microspotter™ (CFM) technology from the University of Utah.
			May 2012		
Micropelt (D)	Thermoelectric generators	3rd round	$6.5M	Ludgate Investments Ltd. (lead investor), Mitsubishi UFJ Capital Co. Ltd., GoodVent Beteiligungs-management GmbH & C, KfW Mittelstandsbank, SHS Ges. f. Beteiligungs-management mbH	Spin out of Infineon in 2006, MicroPelt is the leading player in energy harvesting based on thermal conversion. Micropelt TEC generators are produced with wafer-based thin-film MEMS-like micro-structuring process. A production facility has been opened in 2011, this means that the company will now be able to manufacture devices with batch manufacturing and thus reduce cost. This new round will support the global expansion of MicroPelt business and help to secure sufficient volumes of production. In total Micropelt rose close to $20M so far.
OrthoSensor (US)	Orthopedic sensing solutions	Series B preferred stock financing	$15M	NA	OrthoSensor is working on innovative sensor electronics platforms which will integrate MEMS components for implantable biomedical applications. Orthosensors secured $21M in January 2011 as a first part of Serie B round. Total Serie B round now reaches $36M
Microvision (US)	Picoprojector based on scanning MEMS mirror	Equity investment	$5M	Lead investor: Shmuel Farhi, a Canadian-based real estate developer and the sole owner of Farhi Holdings Corp.	Microvision is still losing money each quarter, however Microvision should benefit from the availability of direct green laser in 2012. In the mobile devices market, 2012 is supposed to become a key year for ramp up start of embedded pico-projector (Samsung Galaxy Beam incorporates a projector based on TI DLP). Microvision is also deeply involved in the automotive market: a strategic partnership has recently be announced with Pioneer for HUD for the aftermarket. Those products will be released in July 2012.
Qualtre (US)	MEMS gyroscope	4th round	$10M	Equity financing from Matrix Partners and Pilot House Ventures + debt financing from Eastward Capital Partners	Qualtre is currently launching its first 3-axis gyroscopes based on BAW technology, and will use this new funding round to develop products for key applications. Qualtre primary targeted market is the consumer field, which is attractive but with high barrier to entry. Qualtre competes with big players in this area, such as ST, InvenSense and Bosch Sensortec (which recently entered the gyro market and which is designed-in smartphones that will be released in the market within a few weeks). However we note that Qualtre is also targeting industrial applications such as high-end IMUs - indeed Qualtre technology offers clear benefits in performance and robustness.
Lilliputian Systems (US)	Micro fuel cells	9th round - Bridge	$1.2M (over a $3.4M debt offering)	17 investors (undislosed)	Despite the hype on fuel cells a few years ago, many developments stopped. Lilliputian Systems is one of the only few companies that is still active in the development of micro fuel cells for cell phones and laptop applications. The company is currently preparing for the market launch of its first product

New investments (VC rounds, IPOs)

Company	Type of product	Type of investment	Level of new investment	Investors	Yole Développement Comment
June 2012					
Sand 9 (US)	Silicon MEMS timing devices	5th round	$23M	Intel Capital and Vulcan Capital (+ existing investors mmonwealth Capital Ventures, Flybridge Capital Partners, General Catalyst Partners, Khosla Ventures and CSR)	SiTime is expected to start production this year of TCXO-grade oscillators, for mobile devices. We note that the many newcomers are currently releasing products in this silicon MEMS timing market: NXP, IDT, Silicon Labs, VTI/Murata.

M&A

Company	Type of product	Type of transaction	Value of the transaction	Acquirer	Yole Développement comment
April 2012					
Sensonor (NO)	High-end gyroscopes and IMUs, pressure sensors	Acquisition	NA	3 private investors	Sensonor filed for bankruptcy in February. One of the largest factors is probably the high burn rate due to the run its MEMS production facility. Infineon was the main user of this fab but stopped to use Sensonor as a foundry for its TPMS in 2011. The new Sensonor has a great technology for high-end gyroscopes and thermal sensors, it was thus a good opportunity for the new investors which were able to move quickly after Sensonor bankruptcy
June 2012					
SigmaTech (US)	Metrology tools	Acquisition	NA	MicroSense	SigmaTech instruments are used in the MEMS area for Through Silicon Via and deep trench metrology, membrane thickness measurement…
MEMSCAP share in Intuiskin / Icosmeticals (FR)	Skin analysis sensors based on MEMS technology	Equity stake	Euros 2.9M (11.6% shareholding of Intuiskin / cosmeticals)	NA	Consolidated financial gain from this sale amounts to 1.3M euros for MEMSCAP. The company keeps some assets in this area such as the IOMA brand. MEMSCAP now refocuses on its core business such as pressure sensors for demanding environments or optical MEMS for communication

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Distant-speech Interaction for Robust Home Applications project focus and concept (Courtesy of Mirka Perseghetti and DIRHA)

MEMS everywhere: opportunity moves from devices to ecosystems

MEMS companies have made great progress on making the low cost sensors and actuators that enable the first wave of volume consumer applications in games and smart phones. Now comes the next step of integrating the sensors with other components and more sophisticated software, to make them easier for systems makers to use, and enable the next generation of context-aware applications.

"It's no longer really a question of the technology, but of proliferating and building the ecosystem, figuring out how to make it easy to use, and building awareness for more people," says Dave Rothenberg, Movea.

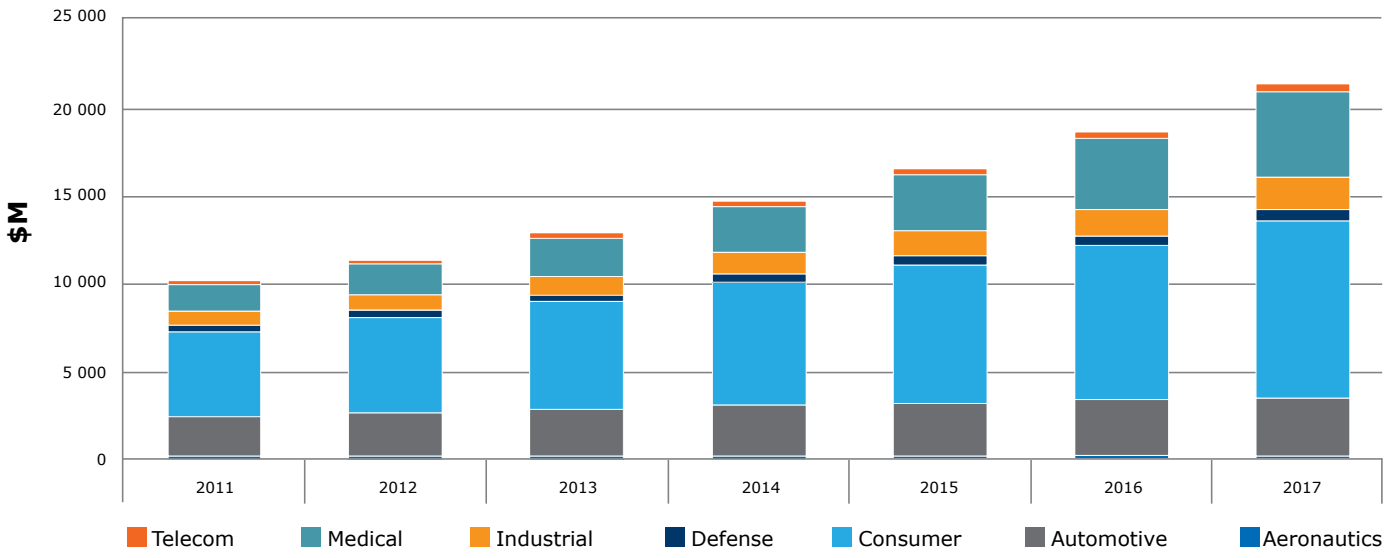
The mobile consumer market's adoption of relatively simple sensor functions has spurred explosive growth in sales of MEMS devices. Now the key strategies are moving to building the ecosystems that will make it easier for systems makers to add much more intelligent sensor functions to their products. This typically means collaborations across the supply chain, with much more focus on the integration and software needed to embed smart sensing in a much wider range of applications. In this issue we look at some of these innovative examples of such software-centric integration into ecosystems, at multiple levels along the value chain, ranging from a Freescale/Microsoft sensor platform, to Movea embedded inertial software on processors, to STMicroelectronics' multi-microphone software applications, to the European DIRHA project to develop voice-controlled home automation.

Collaborating on an integrated sensor platform

Whatever the other controversies about Microsoft's recently announced Windows 8 tablet, it looks like it will make a major effort to integrate hardware and software around a standard platform to ease development of sensor applications for Windows 8

MEMS devices forecast by application ($M)

(Status of the MEMS Industry report, July 2012, Yole Développement)



products. To simplify integration, Microsoft worked with Freescale Semiconductor and a major user to specify and offer a plug-and-play sensor hardware and software solution.

Microsoft wanted to set the base sensors for Windows slates and tablets and make them easier for developers to use, as well develop the foundation for the yet-to-be-defined Windows 8 phone, says Freescale's Stephane Gervais-Ducouret, global marketing director for sensors. So it worked with the sensor maker and system maker to identify the key features and how best to meet them. The result is a sensor platform and reference design, with 9 motion axes, plus a pressure sensor, temperature sensor and light sensor, and embedded sensor fusion firmware and developer interface, running on a microprocessor-based sensor hub, all mounted on a thin 4cm x 1cm sensor board, that calibrates and delivers the sensor data and sensor fusion in Windows 8 format. Gervais-Ducouret argues that local, distributed processing of the sensor data in an optimized MCU instead of the core processor is faster, can save power, and gets better quality data by fusing sensor data with effective time synchronization—and that approach is in fact required by Windows 8.

The platform delivers full position and orientation information, and a simple user interface, to make it easy to for users to do landscape/portrait selection, gaming interfaces, and gesture recognition, as well as making the sensor data easier to use for the more complex functions like navigation. "Sensor providers know how the sensor works, so it makes sense that we provide the high quality sensor data and first level fusion, but not much beyond that," says Gervais-Ducouret. "This reference platform for Windows 8 is about the ultimate example, in my opinion, of what the sensor maker can do. Then we need to collaborate more with software specialists like Movea and Hillcrest to build the more refined gesture recognition or custom features that will enable a wider range of custom applications, and work with navigation and GPS providers for the complete WiFi and positioning systems." Freescale expects Windows 8 certification shortly, and to start production of the module in Q3 this year, for a consumer product from an OEM for the holiday season.

Freescale's 12-axis Xtrinsic sensor platform. This complete hardware and software solution fuses accelerometer, magnetometer and gyroscope data using a Freescale ColdFire+ MCU for high quality. (Courtesy of Freescale)

Gervais figures these integrated sensor solutions will be vital for meeting the driving demand for next generation consumer devices that more conveniently serve the user by intuitive interfaces and sophisticated context awareness. Collaboration of many different players will be needed to build successful location-based information and advertising services, but basic to them all is accurate, low power location and navigation, which needs integrated sensors both indoors when GPS is not accessible, and outdoors to reduce power-hungry GPS usage so consumers will use the system and not turn it off to save the battery.

Broader types of context awareness could be an even bigger opportunity, he argues, noting Freescale is seeing increasing customer interest in a wide range of ways to adjust the system seamlessly to the environment, ranging from changing screen brightness according to the ambient light level, to changing the amount and type of information offered depending on whether a user is in a hurry or is browsing leisurely. "We're seeing more and more interest in things like mood detection," he says, noting development work on a gamepad where the game can change according to one's level of stress as measured by heart rate or palm moisture, and other parameters, possibly helping the user learn to control stress. "Or the information that you're stressed out and in a bad mood today could be sent to your social network, to let people know not to disturb you today, without your having to actively tell them so," he suggests. "We need software people to write this kind of software."

Integrating software in firmware and hardware

Motion processing software specialist Movea also aims to make sensors easier to use by working with partners towards tighter integration of software, looking to move its software on to processors as firmware in memory, or even hardware circuitry, as well as to supply tools to help developers more easily write their own software for specialty applications.

"As the market matures, money flows to the tools that enable makers to do their own development," says Dave Rothenberg, Movea's worldwide director of marketing, hypothesizing about chip design tools with sensor building blocks. "It's no longer really a question of the technology, but of proliferating and building the ecosystem, figuring out how to make it easy to use, and building awareness for more people."

The need for more processing power than on the processors typically included with inertial sensor modules, and the need to also process data from more sensors besides just inertial, is now starting to move more sensor processing away from the sensors towards processing on firmware in a sensor hub, he argues. So the company aims to offer firmware on common processor platforms for embedded gesture control interfaces for consumer electronics, and for tracking the motions required for a number of common sports. Movea motion processing software is now available as firmware in the memory of a microprocessor-based sensor hub from Freescale. The two companies plan to jointly promote an applications board with processor, sensors and software for handset makers to prototype and test motion interfaces, activity monitoring, navigation and augmented reality.

But longer term, for high volume production by more players at the lowest price and least power consumption, sensor processing may move to be integrated at the gate-level as a dedicated motion processing core, as one tiny part directly in the application processor. Movea is exploring selling its motion processing software solution—the basic sensor fusion plus much more data fusion-- as an IP block to chip makers, or ASIC designers or foundries, for integration into their products, to ease sensor integration for far more players. So far it's just talking about this solution with one chip maker, but such an off-the-shelf solution could considerably expand the sensor market if it became widespread.

Also highly useful to facilitate the use of sensors will be better tools for developers. Movea seems to be gradually rolling out software development tools and reference kits for application developers based on what it's developed for its own in-house use in doing custom software. The company has created a graphical development tool for its internal use that allows building up the signal processing by drag and drop blocks, which connect to show clearly what's happening to the data at each step, and is thinking about sharing it with some key customers. But meanwhile it has already introduced software development tools and reference kits based on some of its earlier work for creating gesture recognition and motion control for computer peripherals, TVs, and some sports.

Integrating multi-microphone processing

It's not just inertial sensors that can do more with more sophisticated software and integration. Multisensor systems of MEMS microphones are also enabling new applications and context awareness.

"Before the microphone was a stand-alone detector. Now we start to think about the unique capabilities of MEMS microphones for phase matching to do a lot more things without much signal processing overhead," says Andrea Onetti, director of the audio business unit at STMicroelectronics. "It's becoming a system game that requires access to a wide range of capabilities. Technology is not enough. Now the major opportunity is to offer an ecosystem that's immediately usable by major systems manufacturer, for new applications that people can understand."

He suggests a host of new opportunities this is creating for microphone applications, from systems that wakeup to voice commands, to front mics on TVs for Skype calls and speech controls, to mics than can cancel out the noise or the photographer's directions from the mic on the back, while the mic on the front records the audio to go with the video. More complex integration and processing could bring context awareness to earphones, eliminating the annoying occlusion effect that interferes with comfortable speech and makes wearers feel closed off from the world, by a system of noise cancellation and microphone matching. The user could switch between modes, or the smart context aware system could switch to phone or speech as needed, or could let in important sounds for safety, or use input from inertial sensors or location to determine what the user is looking at, to focus on the sound from that, or overlay a layer of audio augmented reality.

"It's important to cooperate with different universities and research institutes, to learn what the components need to do in real functions—the performance they need besides just being small, good and cheap," says Onetti. "ST is looking at all the possible partners we need to do new things, as we aim not just to design components, but to enable new technologies."

Microphones could even be used for low cost gesture recognition with the right software. Microsoft is showing a simple system that analyzes how microphone signals are disrupted by reflected ultrasound signals by hand movements. Researchers use standard off the shelf speakers and microphones already in most electronics systems to sense

The MP34DT01 is an ultra-compact, low-power, omnidirectional, digital MEMS microphone built with a capacitive sensing element and an IC interface. (Courtesy of STMicroelectronics)

in-air gestures to generating an inaudible tone, then measure with the mics how its frequency shifts (the Doppler effect) as it reflects off moving objects like the hand to infer gestures. Researchers have demonstrated using the technology to scroll through the screen, or move around Tetris blocks, even in a noisy coffee shop environment.

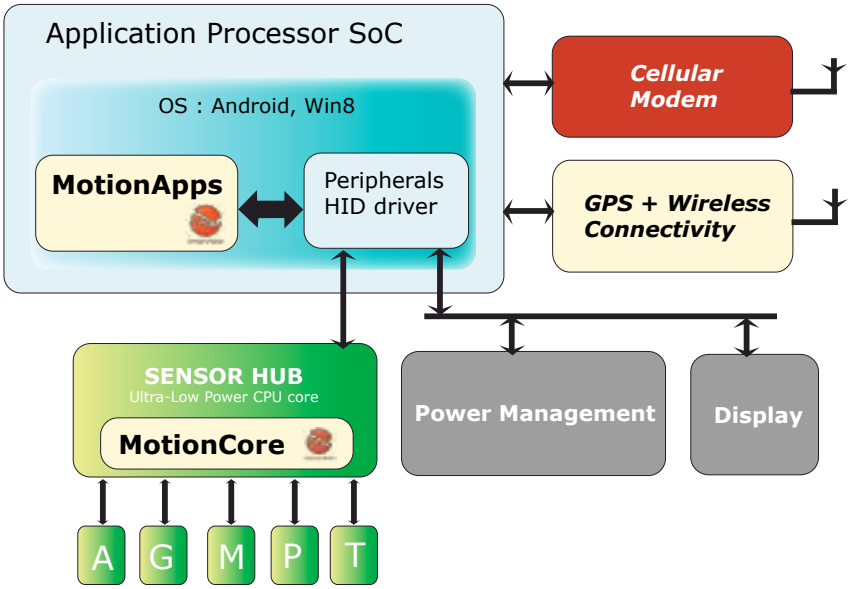
Integrating a full ecosystem for smart acoustic processing

An example of collaboration across multiple parties towards a complete sensor ecosystem is the European Commission's Distant Speech Interaction for Robust Home Applications (DIRHA) project, which brings together components makers, software suppliers, systems makers and end users to develop the multisensor processing to enable voice controls in a complex environment for home automation.

"Speech recognition has serious problems when the speaker is more than some two meters away from the microphone, and a further challenge is to develop solutions that don't require push-to-talk activation, but operate in always-listening mode," notes project manager Maurizio Omologo, head of the SHINE research unit at Fondazione Bruno Kessler (FBK), noting that a voice controlled home automation system would need to process input accurately from anywhere in the house, locate the speaker, distinguish speech from background noise, distinguish live speech from television or radio speech, distinguish two people talking in different rooms at the same time. "The system also needs context awareness to be able to manage information smartly, and recognize when it is being addressed," he notes.

And to do all this well will take collaboration among a lot of folks. FBK and Italian home and building automation company DomaticArea, had worked together earlier on a small voice activation home system for a motor-impaired user, and decided to undertake a larger project, recruiting STMicroelectronics, man-machine interface supplier NewAmuser, and several universities and research institutes for project that won some $3.5 million in European Commission support to develop a demonstration prototype of a voice controlled home automation system that works in different dwellings and different languages, tested to meet the needs of users with limited mobility. The project will use off-the-shelf hardware, but plans to evaluate what kind of microphone quality and embedded or central processing power is needed.

Future applications of better acoustic processing could include smart spaces, environmental or security monitoring systems, video conferencing, and voice control for robots and automotive features, notes Omologo.



Motion core for mobile. (Courtesy of Movea)

We think these kinds of collaborations to better integrate the sensor and much more sensor processing software into the system are the key to enabling the future of MEMS everywhere.

Paula Doe for Yole Développement

Stéphane Gervais-Ducouret, Global Marketing for Sensors, Freescale Semiconductor
Stéphane has 19 years of experience in the semiconductor industry as global marketing, business development, project management, and product designer. He has worked for multi-national companies in Europe and in Asia in the consumer and mobile phone segments. Stéphane also has experience in emerging technologies and markets. His current position is global marketing for sensors at Freescale Semiconductor and he is focusing on consumer and mobile phone market development. Stéphane holds a Doctorate degree (Ph. D) in Electronics from the University of Bordeaux (France) and an MBA degree from Newcastle University, Australia. He holds a European and US patent in MEMS application.

Maurizio Omologo, Project Manager of FP7 STREP project, DIRHA
He received the laurea degree with honours in Electrical Engineering, in 1984, from the University of Padova, Italy. He is responsible for research on acoustic scene analysis and distant - speech recognition at FBK - Center for Information Technology - irst, Trento, Italy. Between 2006 and 2009, he was Project Manager of DICIT (Distant-talking Interfaces for Control of Interactive TV) European Project. Since January 2012, he has been acting as Project Manager of FP7 STREP project DIRHA.

Andrea Onetti, Senior Director of Audio and Sound Business Unit, STMicroelectronics
He joined STMicroelectronics' R&D Lab in Castelletto, Italy, in 1990 as designer of mixed signal audio IC's for both consumer and car radio applications. After five years of successful activity in design with several patents in Audio field, he moved to Product Management, in charge of Marketing for Consumer Audio and then appointed of full responsibility of design, marketing and application for Audio Systems products. In 2005, Onetti's organization was transformed into a Product Division and his scope was subsequently enlarged to include management of Planning, Operation and Quality of Audio products. In 2011, ST regrouped Audio activities under Analog, Mems and Sensors Group by the creation of Audio and Sound Business Unit: Onetti is now in charge of Audio business across all the different applications, covering the whole Audio chain.

Dave Rothenberg, WW Marketing Director, Movea
Dave heads WW Marketing and Communications for Movea and has over 14 years of Go-To-Market experience productizing and commercializing new technologies for companies in Silicon Valley and Europe. He takes an interdisciplinary approach to business having held senior management roles in Marketing, Business Development, and Engineering, across a range of markets including: Enterprise Software, Wireless and Mobile, Consumer Electronics, Health and Fitness, and Web Services. Dave holds dual degrees in Aerospace Engineering and Physics from the University of Colorado, Boulder.

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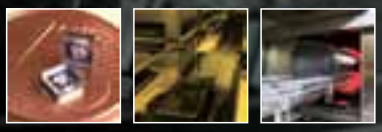

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COMPANY INSIGHT

Non-contact temperature sensors come down in size and cost

Smaller, lower cost IR thermopile sensors that read the temperature at distance instead of by contact open new applications for integrating MEMS sensors.

Add another MEMS sensor to the toolkit. Texas Instruments says it's seeing interest from a wide range of potential users in its non-contact temperature sensor, for applications ranging from better performing laptops and servers to smarter home thermostats and industrial controls. Omron has also recently introduced an IR thermopile sensor, targeted at occupancy sensing and automation control.

Seeking a product where its MEMS technology could add a disruptive advantage, TI's R&D lab came up with a CMOS-based MEMS thermopile infrared sensor that can be integrated on a single chip with the CMOS signal conditioning. Cost and size are also reduced by using very minimal wafer-level chip-scale packaging, taking advantage of silicon's transparency to IR to essentially use the wafer itself as the cover window. The die with the control circuitry and the thermopile structure released over a cavity is flipped over, and the unprocessed wafer remaining below the cavity then becomes the cover window. The change in temperature of the thermopile to the IR in its field of view is converted to a change in voltage.

Such IR thermal sensors, which allow temperature measurement at a distance without the need for the usual direct contact with the measured surface, have typically been multichip units packaged in metal cans or relatively large surface mount packages and costing several dollars to several tens of dollars each, limiting them to industrial and automotive uses. TI's single chip solution reduces the size to 1.6mm x1.6mm, and the cost to $1.50 in 1000-unit volumes. TI says the devices also uses 90% less power than the competition. It claims +/-1°C accuracy, with a range of -40°C to +125°C.

"We've seen interest from makers of almost every sort of equipment, from laptops to trains and heavy equipment," says Daniel Mar, product market engineer for sensing products. "Almost everyone turns out to have thermal issues."

The device is in now testing at potential customers. "Laptops will probably be the first to ramp, because it's the easiest problem to solve," says Mar. The limiting factor now is not the heat of particular components, but the heat of the case, as more powerful processors and radios are crammed into ever smaller space without active cooling. Cases can easily get hot enough to cause skin damage, which Mar notes can start at as little as 43°C when against the skin for extended periods. Systems designers are currently limited to estimating the temperature of the case based on the temperature of the hottest part of the board where it can conveniently put a sensor, which can be quite different from the actual temperature of the case in the outside environment's heat or cold. Better thermal data would allow designers to push the design for better performance or speed.

Omron meanwhile targets first applications of its recently introduced MEMS IR thermopile sensor at occupancy sensing, as the temperature of an area can indicate more reliably if someone is in the room than motion sensors can, to switch off lights and air conditioning to save energy. The company also sees possible uses in factory automation from sensing unusual changes in temperature. Its multi-die unit remains packaged in a metal can.

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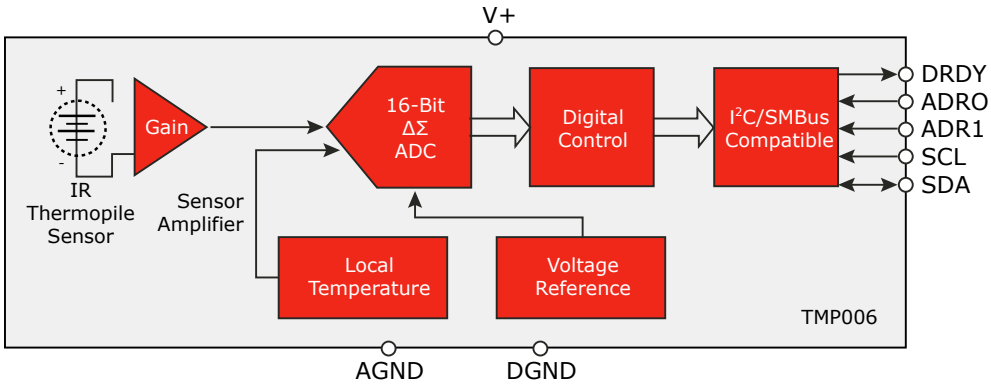
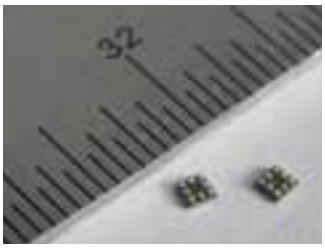


MEMS IR Thermopile TMP006 block diagram. (Courtesy of Texas Instruments)

Daniel Mar, World-Wide Product Marketing Manager, Texas Instruments

"Texas Instruments suggests its non-contact temperature sensor will see wide application," says Daniel Mar.



MEMS IR thermopile TMP006 chip (Courtesy of Texas Instrument)

Daniel Mar, World-Wide Product Marketing Manager, Texas Instrument's AIP group

AIP group covers temperature and current sensors, and gamma buffer product lines. With TI since 2000, he has worked as a program manager, product engineer, and characterization engineer for IEEE-1394 and High-Speed USB (2.0) products before transitioning into marketing. Daniel received his MBA with a focus on strategy from Southern Methodist University, and a BSEE from Colorado School of Mines.

csem

WiserBAN: Medical equipment makers and wireless researchers cooperate on next generation body-area-networks with low power RF MEMS resonators

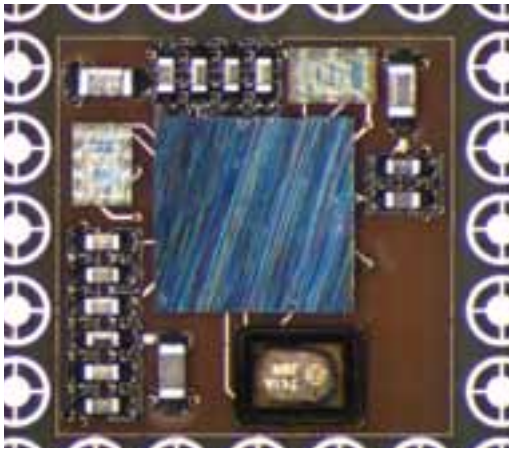
Smarter medical devices that communicate data are a big potential market for sensors, but need much smaller and lower power solutions than the current generation of consumer fitness products. The European Commission funded WiserBAN project brings together major medical device makers, research institutes and chip makers to create an ecosystem to enable this market, based on heterogeneous integration of low-power but high frequency RF MEMS resonators.

Vincent Pieris, Head of the RF and Analog IC Program, CSEM

Tiny and ultra-low-power wireless communications are a key enabler for networked sensors everywhere, and particularly for healthcare applications, to smartly communicate changes in conditions and adjust treatments from tiny in-body or on-body devices, for things like heart and cochlear implants, or hearing aids and insulin pumps. The ~$13 million, 3-year European project brings together players from across the varied fields of expertise needed to create such systems, aiming at developing the technology for a higher bandwidth single-chip radio that fits the footprint, power budget, and performance specified by the participating medical device makers for their next generation products.

The target is a 2.4GHz radio in a 4mm x 4mm x 1mm package with mW power usage, based on small MEMS resonators and compact SiP integration, for a system some 50x smaller and 20x lower power than existing consumer fitness products largely based on Bluetooth. Researchers aim to show the proof-of-principal prototype can work to user specs in the real environment of inside these small medical devices on and in the moving body, and show a fairly clear path towards development of commercial medical and lifestyle devices using existing sensors and batteries that can send and receive data within a meter or two range.

"The target is 2.4GHz radio in a 4mm x 4mm x 1mm package with mW power usage, based on small MEMS resonators and compact SiP integration," says Vincent Pieris.



WiserBAN 2D-SiP before prepreg is being laminated. The chip in blue is the WiserBAN SoC (~2mm x 2mm), other components are BAW resonators, SAW filters and a few capacitors, the module is 4mm x 4mm. (Courtesy of CSEM)

Key to the low power wireless technology is tuning the resonator frequencies with CMOS electronics, allowing use of very low power but fixed frequency BAW and silicon resonators, explains Vincent Pieris, manager of the project, of Centre Suisse d'Electronique et de Microtechnique (CSEM). Temperature compensation is also done electronically, avoiding use of power-hungry PLLs. The silicon resonator is piezo-driven AlN, for lower impedance and noise than electro-statically actuated parts. Power usage is further reduced by processing the signal at the source to detect deviations from the norm, so power is only used to send a signal when there is something important to send.

For compact, low cost packaging, the components are embedded inside very thin epoxy laminate. Chips are attached by adhesive to copper substrates, then laminated in epoxy prepeg. These flat, 2D SiPs can then be stacked together by solder bumping. "It's fairly simple, fairly modular technology available today, using standard low cost PCBs and assembly tools, but tailored to the miniaturization requirements of WiserBAN," says Peiris.

Now slightly more than halfway through the three-year program, the first prototypes of each of the technical modules are completed, and researchers are starting on improved second iterations. "Making the low power radio and digital signal processor in 65nm CMOS was ambitious but worked right the first time," he notes. "But vacuum packaging of the silicon resonators was more challenging."

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Wiserban benefits from COWIN support for commercial exploitation.
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One goal of the project was that co-design among the parts from the beginning would enable the best systems. But integrating the parts developed by the thirteen separate research groups has also proved to be one of the biggest challenges. Each group regularly had to make tradeoffs among the different requirements for its component, and these tradeoffs could impact the neighboring technology modules. "But if you can clearly identify the advantages and drawbacks of your components, you can intelligently balance across them by co-design," notes Peiris.

Partners in the project include the biomedical companies SORIN, Siemens Audiologische Tecknik, MED-EL, and Debiotech; European research institutes CSEM, CEA-Leti, VTT and Fraunhofer IZM; the University of Bologna and the Technical University of Berlin; digital signal processing provider SignalGeneriX, and BAW/SAW resonator and packaging provider EPCOS.

For SORIN's cardiac implants the device would allow higher data rate transmission of data from the heart, and integration with data from other, non-implanted devices, with smaller size and lower energy consumption. Siemens aims at wireless streaming of sound between the hearing aids in the two ears to improve focus on an individual speaker in a noisy room by acoustic beam forming, as well for audio streaming from telephones and music players. MED-EL sees using the higher bandwidth for better audio transmission from the behind-the-ear unit to the cochlear implant, and potential as well for sound from media players some distance away, and for remote control units. Debiotech sees potential for remote control of its MEMS-based insulin pump, and for sending information to a PC or smart phone to track glucose levels.

www.csem.ch
www.wiserban.eu

WiserBAN. (Courtesy of CSEM)

Vincent Pieris, Head of the RF and Analog IC Program, CSEM
Vincent Pieris holds a PhD from the Swiss Federal Institute of Technology in Lausanne, and has been the Head of the RF and Analog IC Program at CSEM since 1999. His research interests and expertise are in the area of RF CMOS microelectronics and low-power transceiver design for wireless sensor networks and wireless body area networks. He has been project leader for several large size RF transceiver developments involving Swiss and European industrial partners.

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New sensors: IMEC develops MEMS-based electronic nose for cell phones

Low cost system uses common absorbent polymers to change resonant frequency of micro-beams

Jan Van Der Kam, Program Director for sensors and energy harvesters, IMEC

"e-nose can be designed to recognize the characteristic frequency patterns," says Jan Van Der Kam.

IMEC researchers report high sensitivity and low power usage for their small MEMS vapor detector, aimed at turning the smart phone into a tool for monitoring health, by detecting symptoms of disease in the breath or toxic vapors in chemical industries. Ultimately the sensor could potentially also be used to monitor the freshness of food or the quality of wine, says program director Jan van der Kam. The e-nose can be designed to recognize the characteristic frequency patterns generated as the target chemicals are selectively absorbed by polymer-coated MEMS bridges to change their resonant frequency.

Researchers have identified common industrial polymers with openings in their molecular structures suitable to match the molecules of target compounds. The target compound can then settle in between the polymer molecules, so the polymer expands, and stresses a MEMS fixed-fixed beam to change its resonant frequency. "It's like a sponge," explains van der Kam. "If it absorbs a lot of water its mechanical properties change a lot. If it absorbs a little oil, it changes differently." They have so far screened a number of common IP-free polymers to find those with an appropriate molecular structure to absorb or not absorb particular target compounds in vapors, although custom polymer molecules could also be specifically designed if required.

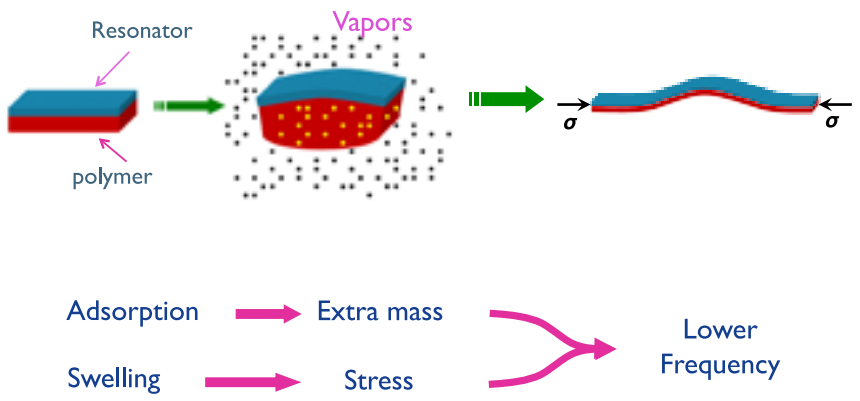
Researchers have shown results detecting ethanol, acetone and water vapor with 200x better sensitivity than similar sized systems. They are now in the process of testing different coatings and thicknesses, trying to optimize trade-offs between sensitivity, speed, size and power consumption.

The polymers are applied to fixed-fixed MEMS beams, which are released not by etching a cavity, but by etching all the way through the wafer, leaving an open grill-like pattern. A different polymer can then be inkjet printed on the underside of each beam. When a target molecule is absorbed, the polymer expands and stresses the beam, changing its resonant frequency. By using thin-film piezoelectric elements integrated on the MEMS beams, the resonance frequency is excited and tracked with an oscillator-based read-out circuit, which counts the time between oscillations to accurately record the frequency.

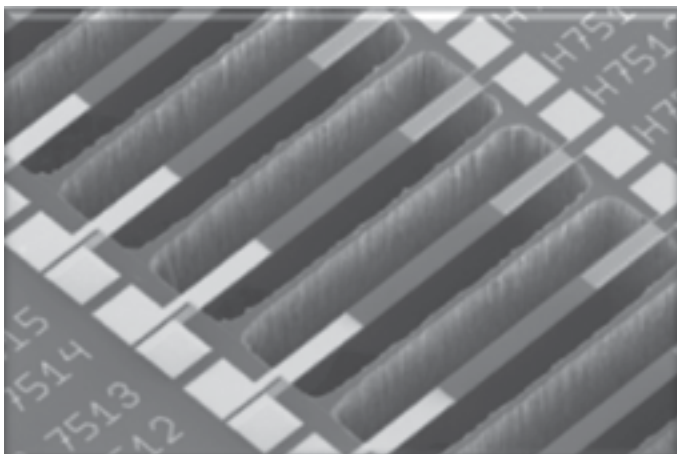
Researchers say the oscillator-based readout limits continuous power consumption to less than 1 milliwatt, so it would not make major demands on a mobile phone battery. Project manager Mercedes Crego Calama notes that because change in frequency is a much more sensitive measure than currently used capacitive and conductive detections, and because the system is looking only for relative frequency shift in a particular frequency band, the system compensates for some variability in manufacturing tolerances.

Van der Kam says they've seen great interest from potential users, first for things like detecting toxic gases for industrial safety or detecting BTX or volatile compounds to adjust ventilation systems. But longer term there is probably more potential in applications for remote monitoring of health, checking acetone levels in the breath for diabetic or fat metabolism issues, or isoprene levels to monitor cholesterol, for example. "There are lots of people who want to apply it with the results we have now," van der Kam asserts. "I am completely convinced that in due time this will become a high volume consumer market."

However, first the research institute needs an industrial partner to take the sensor platform to volume production, which will take some further work, as well as partners with the appropriate medical or other expertise to specify the chemical



IMEC/Holst Center MEMS resonator array gases sensor principle. (Courtesy of IMEC/Holst)



e-nose sensor MEMS array. (Courtesy of IMEC/Holst)

indicators and concentrations for particular applications. IMEC has prototyped a first generation single-bridge device, has fabricated the second generation array of 8 to 10 beams, and is now working on identifying gases from the more accurate frequency pattern fingerprints from multiple beams all with different polymers, and expects more robust results in the coming months.

Crego Calama argues that the MEMS sensor platform, with the specific reactive polymers printed on at the final step, is easier to manufacture consistently than nanowire and nanotube approaches, is smaller and lower power than the metal oxide approaches, and is more sensitive than cantilever solutions that measure changes in weight. The IMEC MEMS technology also provides a more integrated and therefore a smaller and cost effective solution to detection of volatiles when compared with using discrete component crystal resonators.

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Mercedes Crego Calama. Sr. Principal Researcher and Program Manager, imec-nl/Holst Centre
She received her PhD (Cum Laude) in Chemistry (1995) on artificial enzymes. In 1995, she moved to the University of Pittsburgh, USA (NATO fellowship). In 1997 she was awarded with a Marie Curie European fellowship and she moved to the The Netherlands. In 2000, she won an entry KNAW fellow working on sensor fabrication. She held a tenured position as associate professor in the University of Twente. She is author of more than 135 per review international publications, book chapters and patents. In 2006, she started to work in wireless autonomous transducer systems at imec-nl/Holst Centre as Sr. Principal Researcher and Program Manager in the sensor and energy harvesters group.

Jan van der Kam, Program Director for sensors and energy harvesters, IMEC
He joined the Holst Centre / Imec in December 2011 as Program Director for sensors and energy harvesters. Jan gathered experience during 31 years with Philips Electronics in several senior product and business development positions in the Netherlands, Singapore, Austria and Belgium. He holds a master degree in EE from the Technical University Eindhoven.

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COMPANY INSIGHT

BiFlow Systems integrates low-cost active control for microfluidic pumps

Microfluidic sample preparation unit aims at easy integration with bio sensors.

German startup BiFlow Systems is supplying a microfluidic device with built in active electronic control of membrane pumps, for sample preparation for developers of low cost diagnostics solutions. The simple system puts a flexible membrane under the polymer microfluidic reservoirs, and reactive gel and electronic circuitry under that. Current to the gel produces a reaction that creates gas, causing the membrane to deflect and push the liquid out of the reservoir to flow into the channels.

"The goal is low cost microfluidics with active control for sequenced and controlled delivery of liquid reagents," says company founder Joerg Nestler, who developed the technology at Chemnitz University. "Most other approaches still need external actuation, which can be harder to integrate and more expensive." Most competing low-cost cartridge systems put the pneumatics that move the valves and pumping membranes off board into the cartridge reader. The company is working with Fraunhofer ENAS on integrating the sample preparation system with some biochemistries and on some contract work for companies in validating biomarkers.

BiFlow targets development labs, who will integrate their own custom biologic testing unit with the standard microfluidic sample preparation unit, often by simply connecting their particular biosensor or flow cell on top of the outflow channel of the microscope-slide-like sample preparation device. The company offers a development kit of its standard microfluidic slide with the pumping mechanism and six reservoirs, with a control unit and Windows software, but its main business is in then developing the custom versions with the right sizes and numbers of reservoirs for particular bio sensors or bio assays, so developers can quickly turn their biosensors into workable integrated systems.

Nestler says the gas-activated membrane pumps can work with liquid volumes from tens of microliters up to several milliliters, though deflecting the membrane pump for a larger reservoir will take longer. Cost is competitive with other disposable cartridge technologies, but integration should be easier, he argues.

Building an ecosystem for automated diagnostics of tropical disease

BiFlow is also working with Fraunhofer and researchers and companies across the value chain to develop a complete system for low-cost, point-of-care diagnostics for the devastating parasitic tropical disease Chagas, under a 30-month collaborative project funded by the EU and Brazil. Testing for Chagas is particularly challenging since it requires identification of both proteins and DNA, often in areas with very limited access to medical facilities, requiring integration of components from a wide range of players to build a diagnostics system.

BiFlow's contribution is the microfluidic sample preparation, which has remained one of the key challenges to do outside the laboratory. So far it has developed a process to isolate the DNA from lysed material with its microfluidics, and is working on the next steps.

The actively controlled microfluidics will be integrated with a range of other components, including a real-time PCR chip from STMicroelectronics, and a SAW-based biosensor and control ASIC from VTT. FioCruz (Brazil) and CEA-Leti are developing the bio assay chemistry, Brazil's CERTI Foundation is making the readout instrument, and Hacker Automation will build an automated assembly line for precision production of the units. Partners on the Brazil side also include the government's science ministry unit Centro de Tecnologia da Informacao Renato Archer (CTI), and major research institutes and universities contributing sensor, assay and disease expertise. Goal is a fully integrated proof-of-concept demonstrator for easy-to-use, low cost, point-of-care diagnosis that can identify a parasite by its DNA, and tell how far the disease has progressed. "All of the components are close to being mass producible," says Nestler, who believes it will be possible to offer the integrated cartridge for a few euros.

www.biflow-systems.com

Dr. Joerg Nestler, Founder and CEO, BiFlow Systems

Flex.flow microscope slide, with 6 reservoirs and integrated micropumps. (BiFlow Systems)

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Dr. Joerg Nestler, founder and CEO, BiFlow Systems
He has been working on microfluidic integration technologies for some 10 years, developing lab-on-chip devices with integrated pumps, valves and heaters at Chemnitz University and Fraunhofer ENAS for various applications. He received his Ph.D. in Electrical Engineering in 2010 and has nine patents and patent applications in the field of microfluidics.

ANALYST CORNER

Pace of growth for MEMS in mobile devices may moderate, but pace of change will not

Growth rates for MEMS in mobile phones and tablets will calm down a bit--from explosive to merely strong going forward. But there will be no let up in the lightning pace of change, as the high profile market opportunity next moves to more integrated solutions and to a much wider range of new applications, to expand to more than $5 billion over the next five years.

Laurent Robin,
Activity Leader,
Inertial MEMS Devices
& Technologies,
Yole Développement

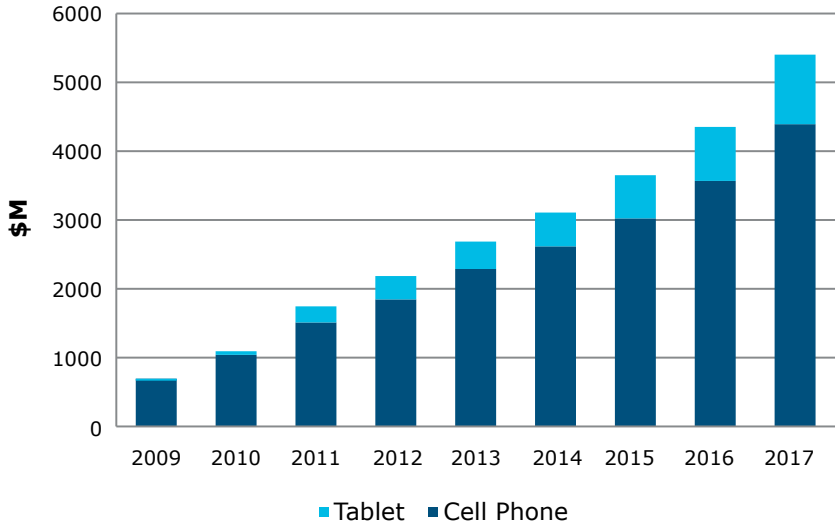
The fast adoption of MEMS sensors into mobile phones and tables drove a 3X jump in unit volume from 2009 to 2011, and a whopping 60% growth in revenues last year, as BAW duplexers, then accelerometers and MEMS microphones, then low cost consumer gyroscopes quickly became must-have components. Now that the market is more established, we expect the on-going rate of growth to ease a bit, but to still average a robust ~20% annually over the next five years. That will drive sales of MEMS for mobile gear past $2 billion this year, and to $5.4 billion by 2017. By then each of the world's 2.9 billion mobile phones and tablets will average 5 to 10 MEMS devices.

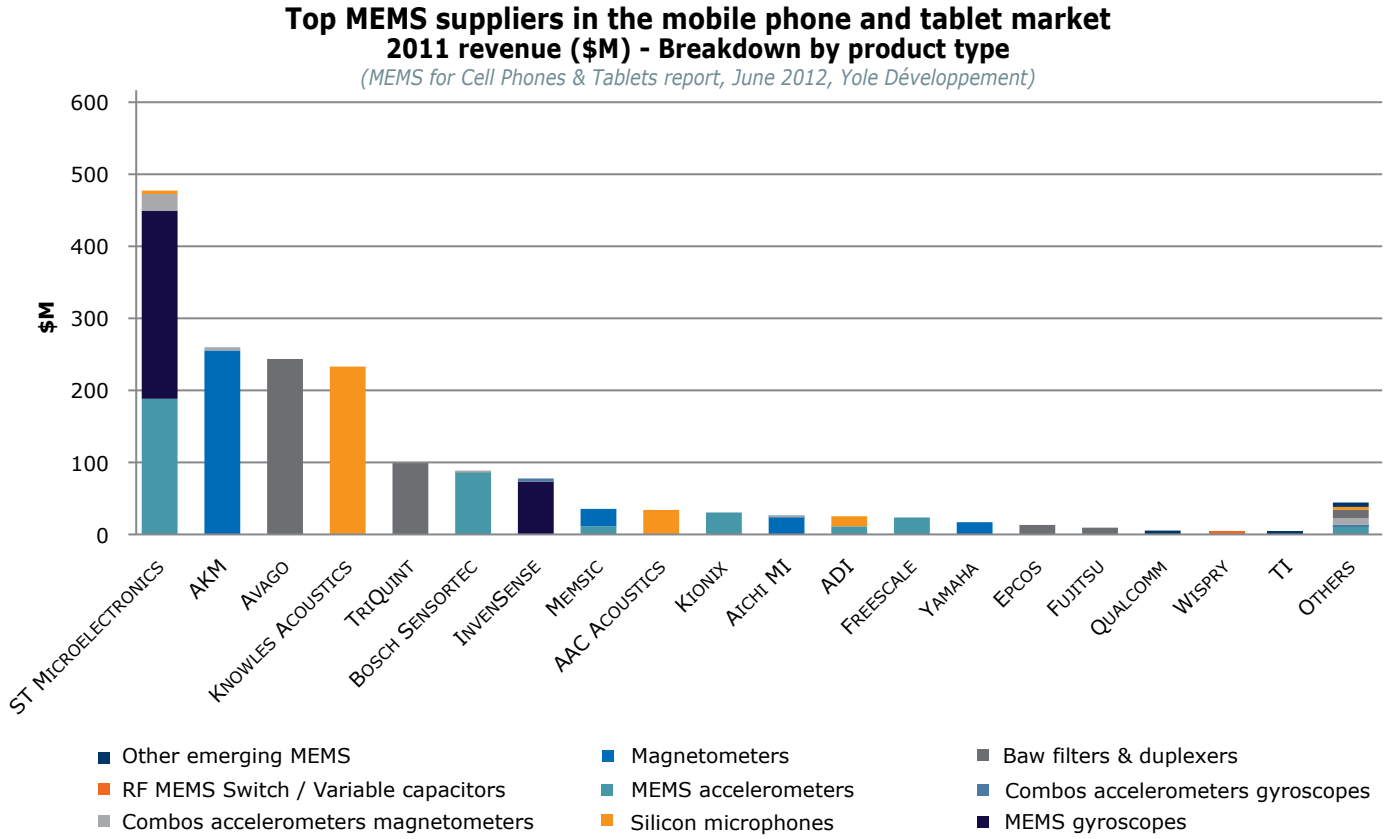
The market has ramped up roughly 20% faster to date than we foresaw in our last report two years ago, as innovations in Apple products, and by suppliers to reduce die size and cost, spurred faster than anticipated adoption. Most of the fast ramp of initial demand has been highly concentrated so far among a few device types from a few leading suppliers. Inertial sensors, microphones, and BAW filters and duplexers account for almost all the MEMS devices used in handsets and tablets to date, and the vast majority of those were sold by a handful of large players who were first with key intellectual property for a device, early volume production capacity, and initial design wins with the dominant systems makers. STMicroelectronics captured more than 50% share of the motion sensor market. Knowles Electronics commanded some 80% share of the MEMS microphone market. Avago controlled over 60% share of the BAW component market. AKM dominated some 75% of the magnetometer market.

But we see expect to see a widening range of opportunity in this fast changing mobile market. With its large volumes, its intense competition for differentiating features, and its fast churn out of new models, any new sensor-based feature or hit application that takes off can get adopted very quickly to a mass market—and very quickly reach high penetration and level off, while prices get driven rapidly down. Though clearly a tough market for newer, smaller companies, the potential opportunity for innovation is attracting lots of investment for a wide range of players – from startups to large IC companies--in disruptive technologies, new sensor applications, and new

Global MEMS market for cell phones & tablets (in $M)

(MEMS for Cell Phones & Tablets report, June 2012, Yole Développement)





business models to enter all parts of the fragmenting sensor value chain, with focused solutions for particular steps, integrated solutions for complete subsystems, or whole ecosystems enabling context aware performance.

Motion sensor growth will climb sharply, then level off, while microphones and BAW components see more stable increase

The inertial sensor sector has seen dizzying change and will continue to see more as it moves towards more integration of sensors. The motion sensing market can expect several more years of stellar revenue growth in mobile phones and tablets, to approach $1.8 billion in five years. Healthy unit growth will continue longer, but total sector revenues will level off within two to three years as the savings from combo sensors drive prices down. Accelerometers are becoming a commodity product already, and the market is moving towards integration of the accelerometer and magnetometer, sharing one ASIC and one package to reduce size and cost. Though it's been less than three years since the introduction of the first low cost consumer gyroscope, big users are increasingly already starting to demand combo sensors of gyros with accelerometers. We expect that by 2014—only four years after first introduction in the phone market—revenues from discrete gyros for this application will start to decline, as growth moves to the combo sensors instead. Sensors will increasingly be sold integrated into easy-to-use modules of some sort. That means more functionality, but also more complex software for sensor management, and more processing power to run it, bringing more makers of microcontrollers, software and subsystems into the MEMS supply chain.

Sales of MEMS microphones will continue to increase steadily, as phones and tablets add multiple microphones, higher-priced digital models, and more sophisticated software for better sound quality. Challengers will likely gain share, as companies in this sector have been particularly clever in devising new business models that take advantage of their particular core competencies, focusing on selling bare die, or on packaging others' die, or on capitalizing on their existing microphone distribution networks as they can do best.

BAW duplexers will also see continued steady growth, as the move to 4G and LTE drives explosive demand for more filters and duplexers. As more bands will be used, part of them will be covered by SAW and temperature-compensated SAWs, but a significant opportunity will exist for BAW as well.

Lineup of new applications headed for the market

Many more new mobile sensor applications are also in the pipeline and will likely hit the market in the next several years. First to be adopted will be established MEMS devices finding new applications in the mobile gear, but new types of devices will also likely be reach commercialization. We expect about 25% of MEMS sales to mobile phone and tablet makers in 2017 will come from these new sensor categories. Meanwhile, even in the established categories of motion sensors and RF devices, the types of product will change significantly, from discrete to combo sensors, and from BAW duplexers to timing devices and switches or variable capacitors.

Pressure sensors should start to see rapid uptake in consumer mobile devices this year, driven by the need to aid the GPS for more accurate pedestrian navigation by identifying a location on indoor floors in high end phones, and to potentially save on power consumption. The Samsung Galaxy Nexus and Motorola Xoom devices already include pressure sensors.

Micromirrors may also be on the verge of adoption for picoprojectors in phones. Samsung has a Galaxy phone model with an embedded projector based on TI's DLP out now, testing user enthusiasm for the feature. The current generation module is still rather expensive at $30-$50, and image quality is limited, but we expect rapid progress this year as green lasers may become widely available and could be a trigger for better performance at lower cost from suppliers like Microvision, Maradin and bTendo.

MEMS autofocus could see fast adoption if it can in fact offer much faster response and lower power consumption than current technology. Suppliers Tessera and Polight have working prototypes and reportedly plan to start production early next year. We expect rapid uptake after the first of the major phone players add the feature.

Temperature and humidity sensor chips from the likes of Texas Instruments and Sensirion are available, should anyone come up with a popular application beyond reminding the user to drink more water when it's hot, perhaps for tracking system temperature to maximize component performance. Operating system makers clearly see possibilities, as Android has added an API for using temperature sensor data, and not to be outdone, Microsoft's Windows 8 sensor hardware module specified with Freescale, includes temperature as well as, along with those for sensing light, pressure, and 9 axes of motion.

Next generation 4G LTE high speed wireless data communication standards, with its less space between transmit and receive bands, will require more sophisticated tunability and stronger filters, giving a push to RF switches and variable capacitors. WiSpry's tunable antenna capacitor array is in production today for a Samsung phone, but competing non-MEMS technologies could turn out to be a lower cost alternative.

MEMS oscillators will likely take over the mobile timing market at some point, but to date few make products for this market, which requires both TCXO-grade performance and low power consumption. Intel is betting on MEMS startup Sand9 for this market, as Intel Capital led the recent $23 million financing round reportedly targeted at ramping production, joined by other technology heavy weights including Paul Allen's Vulcan Capital, tech VC Khosla Ventures and wireless supplier CSR.

Some more radical developments are a little further out, including MEMS speakers, joysticks and touch screen sensors. Audio Pixels has found support from Sony and a foundry partner for developing its potentially disruptive MEMS speaker technology. Meanwhile, Knowles is working on a joystick integrated into the mobile phone to navigate around the screen. And an Atlanta startup is developing a MEMS touch screen based on an array of small pressure sensors, that it says can cost less and use less power than conventional capacitive touch screens.

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Laurent Robin is in charge of the MEMS & Sensors market research. 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

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MEMS for Cell Phones & Tablets

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WHAT'S INSIDE

Mirasol® display, first MEMS IMOD from Qualcomm

Newcomer on the display market, Qualcomm promises a revolution with its Mirasol display, the first MEMS display, halfway between the LCD and e-ink.

Sylvain Hallereau,
Project Manager,
System Plus Consulting

Most of today's mobile electronic devices use an LCD display. On the plus side, LCDs offer a color display for static pictures and an interface for movies, sometimes at a very high resolution; on the down side, LCD displays require a backlight to function, and they also consume a lot of energy, which is a problem for a battery-powered device. Another weakness is that LCD displays are difficult to read outdoor in direct sunlight.

Several years ago, the E-ink technology was introduced for use mainly in eBook readers. E-ink is a bi-stable technology, so it consumes less energy and offers a contrast high enough for use in sunlight. However, the graphic performance of the E-ink is poor, and color and video are not available yet.

The Qualcomm Mirasol® offers another solution for portable display, and its characteristics place it between the LCD and E-ink technologies. The Mirasol® display is based on a reflective technology called IMOD (Interferometric Modulation), which has MEMS structures at its core. Each pixel contains reflecting micro-membranes. The technology is bi-stable, meaning it is very low power and highly reflective. The display can be seen in direct sunlight and eye strain is lower than LCD, though similar to E-ink; but with color images and a high refresh rate (30 FPS video), Mirasol® offers more possibilities than the E-Ink technology.

System Plus Consulting has studied the Kyobo eReader, the first eBook with a Mirasol® display. It features a 5.7-inch display with a definition XGA (1024 x 768 pixels, 223 ppi), and has a battery life between 1 - 2 weeks. Also, the Kyobo eReader integrates a backlight system for night reading. The electronic is on two boards, and the main IC uses a 1 GHz Qualcomm Snapdragon processor -- but the presence of a Xilinx FPGA and a Microchip microcontroller suggests that the electronic is not as integrated as it is in mobile phones. Completing the electronic is an internal Flash memory of 4GB, and WLAN. Eight drivers (22.8 mm² = 20.9mm x 1.09mm) are bonded to the Mirasol® display glass, and four Flex connect the display to the electronic. The absence of TFT on the screen increases the need for drivers and flex.

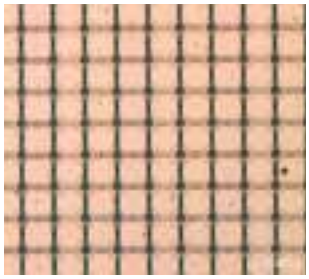
Main electronic board.
(Courtesy of System Plus Consulting)

Technology analysis

The interferometric effect is generated by the variable thickness between the movable mirrors and the stationary glass panel.

(Courtesy of Qualcomm)

Each pixel is a micro MEMS of 38µm x 38µm. The air gap thickness is controlled by a voltage between two electrodes. The display reflects the exterior light. 1 color = 1 air gap thickness. One pixel is specified for one color, while the other colors generate destructive interference in the pixel. To make three colors, three thicknesses are necessary. The air gaps are manufactured thanks to a sacrificial layer principle. Three vanadium layers (with three different thicknesses) are deposited before the manufacturing of the reflective membranes and etched at the end of the process, sacrificial oxide. The thickness of the reflective membrane is a function of the gap thickness to allow the same actuation voltage for collapsing the reflective membrane with three different gap sizes.



Pixels matrix.
(Courtesy of System Plus Consulting)

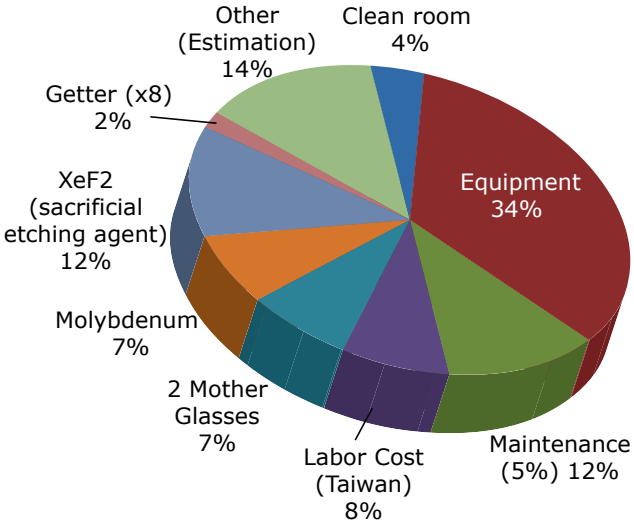
The following picture shows a cross-section of one mirror and its support:

Mirasol® pixel Cross Section. (Courtesy of System Plus Consulting)

Supply chain and cost structure

The Mirasol® displays represent the first MEMS-manufactured LCD technology. Today the display is assembled in an old 4G LCD plant by Foxlink, Qualcomm's production partner. The plant has had some problems delivering enough screens, and the yield is disappointing; but in 2010, Qualcomm invested $1 billion to build a dedicated plant for the Mirasol® display. This new plant should deliver its first screen in mid-2012. It is a 4.5G mother glass factory (730mm x 920mm) in Hsinchu, Taiwan. The capacity of this new plant is 50,000 mother glasses per month, and we estimate there are thirty 5.7" displays on a mother glass of 4.5G.

Display Mirasol manufacturing cost 600,000 displays per month



Display cost breakdown. (Courtesy of System Plus Consulting)

Today, the manufacturing cost is high due to low yield and low production volume, but we suppose that Qualcomm is testing the market before reaching good yields and high-volume production with the new fab unit. The simulated cost at medium term should be more competitive with the actual cost of LCD and E-ink displays.

www.systemplus.fr

Sylvain Hallereau, Project Manager, System Plus Consulting
Sylvain is in charge of costing analysis of Integrated Circuits, Power Semiconductors and Packaging. He has significant experience in the modeling of the manufacturing costs of electronics components. Sylvain has a master's degree in Microelectronics from the University of Nantes, France.

MEMS in Japan: What will be killer applications for MEMS devices for the next?

A few players dominate the inertial sensor market with high growth, but what other players are doing for sustainability in the market ?

Motion sensors for smart phone and tablet PC applications are booming, but small Japanese MEMS players are struggling to sustain their success

In April 2012, Yole Développement released its "Top 30 global MEMS companies of 2011" ranking. One of the big topics was STMicroelectronics achieving a dramatic 42% increase in growth, thanks to massive success in motion sensors for consumer applications. STM's growth increase was also due to the leveraging of its several years-long collaboration with Nintendo, specifically on the company's Wii gaming system, for new applications in smart phones and Tablet PCs, leading to additional revenue in the area of accelerometers and gyros.

A look back at the evolution of MEMS motion sensors in JAPAN

The silicon accelerometer developed by Stanford University in 1979 is regarded as the first MEMS motion sensor. The accelerometer (or high –g shock sensor) used in MEMS devices was adopted for the automotive air bag systems that were mass-produced in the early 1990s, and its volume increased exponentially because these systems were supported and mandated by the government. Meanwhile, low –g sensors appeared in the mid-1990s; they were first used for chassis control in cars, and then spread into consumer applications such as motion sensors, vibration detection, and tilt detection. Though many ideas were generated for additional applications, very few went anywhere. As such, MEMS device makers faced a dilemma; how could they differentiate the low g sensor and make it valuable enough to be a driving force in the MEMS business? On top of this, developing a software algorithm was another challenge that took a long time for system validation.

10 years later, in 2006, things changed significantly when Nintendo developed the Wii and adopted the low –g sensor for its game controllers. The Wii revolutionized video games and ushered in unprecedented high-volume production of low g MEMS sensors, with more than 60 million units produced per year. In this unprecedented fusion of gaming ideas and MEMS, Nintendo's novel concept of using motion sensors for the Wii's user interface not only created a new gaming world, but also a new world of possibilities for MEMS accelerometers.

A closer look at this big success story

Collaboration and highly-integrated engagement between MEMS device manufacturers and customers, with both sides sharing new ideas for the end product, is what defines new technology challenges. Indeed, one technological challenge for MEMS manufacturers was developing a 3 axis function that featured high integration, small plastic package size and capping technology for sensor elements, combined with high quality and reliability in the short term. Everyone said that there was no market for 3 axis accelerometers in Japan, and that 2 axis was fine for every application. However, the reality, as we have come to see, was different. STMicroelectronics and Analog Devices quickly responded to customer requirements and pursued development capability of 3 axis ahead of other competitors; this was done by listening carefully to what each customer had to say. As a result, these two manufacturers got in at the initial stage of the game business. Though Japan is a small country, sometimes technology challenges and the resulting outcomes in the consumer market can help penetrate other markets and industries more easily, by removing entry barriers. Also, these challenges and outcomes might create secondary products as well. In the case of the gyro, something like this has already happened in Japan. Invensense built upon the first Wii design and is now extending its business into another high-volume business: smart phones and tablets.

Japanese MEMS device makers are struggling to find new markets for future business

Japanese MEMS makers are currently suffering from lack of continuous growth, and some are getting out of the business - as opposed to overseas MEMS suppliers, who are strengthening their position thanks to competitive technologies, performance, capacity and price. The path to sustainability lies in securing return on investment with good profits, even in small volume applications. Currently, the MEMS industry is very fragmented, with a lot of small applications; however, there is a new wave of activities and arguments amongst industry/government/academic research groups who are each trying to identify new applications where MEMS devices can deliver big advantages and solutions.

After the nuclear disaster in eastern Japan, a safer and more comfortable environment is essential to urban development. The "smart city" approach, which links energy management, automotive safety, smart building, medical systems and sensor networking with new technologies, will be one key area for the MEMS industry. Additionally, new efforts and activities with diversified ideas will hopefully lead to more new positions for MEMS suppliers, and bring continuous growth to the entire MEMS world.

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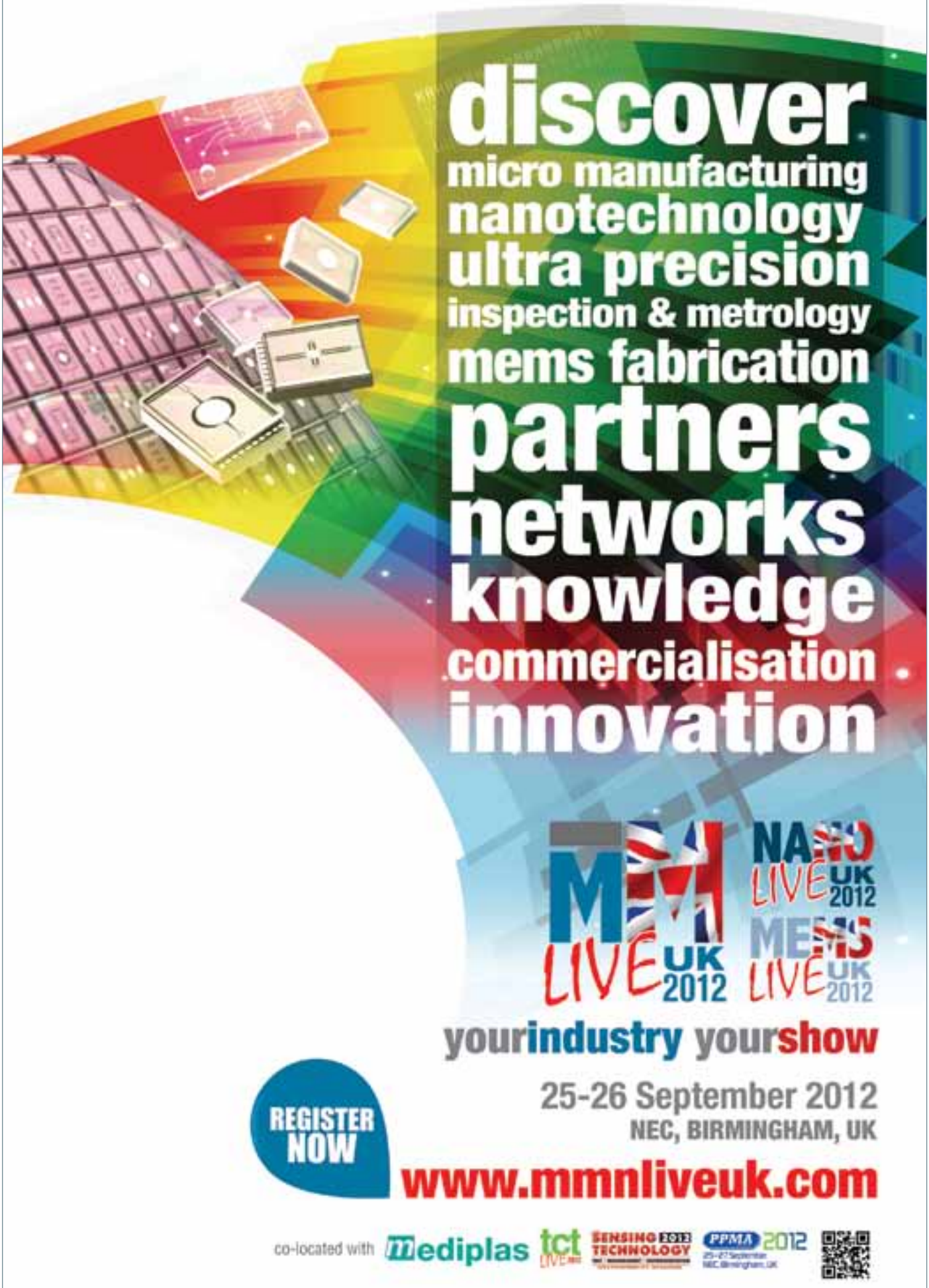
Yutaka Katano, General Manager, Yole Développement, Japan Office.

Yutaka Katano, General Manager, Yole Développement, Japan Office.
Yutaka joined Yole Développement in February 2010 to open the Japan Office, as a General manager responsible of the business development and customer engagement for business expansion. Before joining Yole Développement, he worked for Analog Devices of US semiconductor company (ADI) and dedicated to the Consumer, Wireless and Broadband communications, Automotive and MEMS business as segment director. Before 2009, he worked at ADI, and succeed in the design of 3 axis accelerometers for Nintendo, Sony game systems and mobile applications. He received an Executive MBA at Temple University Japan campus in 2011.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EVENTS REVIEW

Sensor+Test: the infrared sensor and camera market is booming!

This year's Sensor+Test show took place from May 22th to 24th in Nuremberg. Yole Développement participated as usual, in order to bring our readers the most valuable information and news in the sensor world.

Wenbin Ding, Technology & Market, Analyst MEMS Devices & Technologies, Yole Développement

We noticed that infrared detector and camera products are very hot topics this year. Dias infrared, Infratec, Heimann, Excelitas, FLIR, and others showed visitors their latest products and newly-developed technologies. Yole Développement is looking closely at this promising market, and our analysis of it indicates huge potential.

For decades, infrared detectors have been used as motion detectors, and in our daily lives for lighting controls and alarms. With 150 million units sold in 2010, this business is very important in terms of volume, but the price of infrared detectors is very low (less than $ 1). Even if the motion detector business is mature, it will continue to grow at a significant rate (CAGR 2010-2016 in value: + 9 %), driven by the concern for energy savings. In the coming years it will be increasingly used to automatically switch off/on lighting and other items such as HVAC , TVs, kitchen appliances, etc.

Another common use for infrared detectors is in non-contact temperature measurement, for applications like the human ear thermometer, or industrial pyrometers. IR detectors can also be used to detect gas and fire, or to analyze materials. For these applications, the detector price can vary widely, from single dollars to tens of dollars each. These applications are growing as well, driven by interest in IR detection, which offers very robust non-contact measurement combined with a long lifespan. The technology behind these applications is quite mature - it uses small detectors of from one to four IR sensitive elements that can be made with two technologies: Pyroelectric sensors or thermopile sensors.

Not only is the low-end infrared detectors market growing, but the high-end infrared imaging market is as well; this includes Infrared/Thermal detection with microbolometers. Initially developed for the military by US defense companies, infrared (IR) uncooled cameras are now widely used in many commercial applications. High price erosion (-15% / year) is rapidly broadening the use of infrared cameras in many commercial markets, especially in the thermography and surveillance markets. In thermography, ultra-low end cameras were introduced with success by FLIR in 2010, and Dewalt will introduce a new model in 2012 for $ 999. In surveillance, FLIR and Axis are competing heavily on pricing, and DRS introduced a middle-end camera at the incredible price of $2,000 in 2012 - which is half the normal price!

Pixel size miniaturization is a key trend to further increase the resolution of the imager and decrease the cost of the optics. In 2012, 17µm pixel pitch has become a standard in new product release, approaching the 12µm physical limit. While the size of the pixel decreases, the sensitivity of new sensors increases to approach 30mK (SCD, ULIS). This evolution will enable manufacturers to broaden microbolometer adoption to high performance applications which thus far have been exclusively targeted by cooled IR detectors.

An increasing trend toward multispectral imaging at end-user level has driven several microbolometer developments. Image fusion aims at combining several spectral bands (MWIR, LWIR, Visible, etc.) to increase system performance and functionalities for thermal camera users. SCD has paved the way for dual-band imaging by releasing a wide-band imager realizing on-chip fusion of LWIR & MWIR.

We believe that the infrared detector and imager/camera market will keep growing in the future. The next Sensor + Test occurs in May 2013, and there will also be a focus on infrared sensors in the parallel conference IRS2.

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Wenbin Ding is a full time analyst at Yole Développement. She has worked for several technology and market analysis and has strong involvement in researches of Chinese market.
She holds a Microelectronics Engineering Degree from the National Engineering School in Caen, plus a Master Degree in Business Administration from IAE Caen, France.

Two Impeccable Reasons to Attend...

"I love MEMS in Motion. I will absolutely dedicate the time to make sure I attend next time."
Kevin Shaw, Sensor Platforms, MEMS in Motion 2011 Participant

"Overall, I was very satisfied with MEMS in Motion and I think I'll come away with some deals from this experience."
Mary Ann Maher, SoftMEMS, MEMS in Motion 2011 Participant

Industry leaders will gather for the second edition of the two-day MEMS in Motion event. Qualified attendees will enjoy exclusive plenary sessions; hours of one-on-one meeting opportunities, plus a variety of social activities. Register today, and help shape the future of inertial devices.

To watch a video featuring comments by 2011 participants, and to learn about the 2012 event and how you can participate, visit www.MEMSinMotion.com.

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Beginning in 1998 with Yole Développement, we have grown to become a group of companies providing market research, technology analysis, strategy consulting, media in addition to fi nance services. With a solid focus on emerging applications using silicon and/or micro manufacturing Yole Développement group has expanded to include more than 50 associates worldwide covering MEMS, MedTech, Advanced Packaging, Compound Semiconductors, Power Electronics, LED, and Photovoltaics. The group supports companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to develop their business.

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