

# MEMS EXECUTIVE CONGRESS 2009

## KEYNOTE AND PANEL NOTES

THURSDAY, NOVEMBER 5, 2009

OPENING KEYNOTE: DR. SHOICHI NARAHASHI, EXECUTIVE RESEARCH ENGINEER, NTT DOCOMO

Key points:

- Mobile market is rapidly expanding and consumers demand more multimedia services from their phones
- Mobile communications have evolved beyond just voice and are moving to high speed data (4G IMT-Advanced will have speeds of ~100 MBps to 1 GBps; 4G rollout coming soon, but not yet determined)
- Future “mobile terminals” must have:
  - **Low power and high performance**
  - Multi-band operation
  - Multi-function capability
  - Integrated RF circuits
- Triple-band mobile terminal (902iS) example
  - Multiband RF design direction needs to be “reconfigurable” while also keeping it small and low power
  - Looking to MEMS to remedy this situation!
- NTT DOCOMO’s prototype
  - Reconfigurable Power Amplifier – uses MEMS switches to provide multi-band operation
  - MEMS has much promise here, but the hurdle is that it may take several years to make the MEMS switches commercially feasibly at necessary volumes
- Performance: MEMS RF switches have very good stats for low power; low insertion loss when on-state, high isolation when off-state, low distortion generation
  - Issues: size, cost, durability, reliability, power
- Expectations for MEMS technology
  - Integration would be ideal, but it’s hard to design
  - Is it really cost-effective (with respect to implementation/packaging)? – reduce cost through integration BUT volume efficiency would be required
  - Characteristic deterioration by reconfigurability?
  - Functional devices with ultimate characteristics

## BIO/MEDICAL MEMS DEVICES PANEL

Panelists: Doug Lee, founder and CEO, OrthoMEMS; Junji Adachi, senior vice president, BEANS; Per Slycke, chief technology officer and founder, Xsens Technologies B.V.; Thijs Vieggers, chief technology officer, Philips Applied Technologies

Moderator: Brian Wirth, global product manager, MEMS, GE Sensing

Market report: Biomedical device market for 2009 about \$200B, including MEMS diagnostic and microfluidics

### Challenges to MEMS implantable and factors for MEMS vs. non-MEMS

- MEMS provides inexpensive alternative but development costs are very high, so only applicable if at high volumes
- Develop MEMS for readily available foundry processing
- Challenges and path are different for small startup versus an established player – foundry vs. fabless
- **The clinician is the other critical partner!** The devices/sensors are extensions of the surgeon's hands so the clinician must be involved with the implementation of the device. You can't think of this from a pure technology point of view.
- Integration is the big challenge to Lab-on-chip functions. Need more integrated functionality so that one MEMS device is performing multiple performances. First step is to combine devices and then move to integration.
- Have to look at the healthcare system as a whole and find an integrated solution: top 1% of population consumes 30% of health services, 30% consumes 70%
- Ultimate goal is to integrate into the body, but getting approval for invitro is difficult
  - Have to be very careful, but we can't reduce healthcare costs if we don't do this
  - In Japan a large part of the population is over 65 years old seeking care from a doctor is very difficult – therefore sensing for home healthcare is a critical challenge
- **Integration is critical**

### MEMS devices are consumer-oriented but are being used in medical field. What's the connection to bio/medical and BioMEMS?

- Wii and the Wii Fit are one example, but professional healthcare needs more predictable and reliable performance
  - Xsens applications are based on automotive sensors because of their higher requirements for reliability
  - You can reuse technology: try to extend and apply existing technology.

### Lots of opportunities are out there – but what are technical hurdles and barriers to entry in BioMEMS?

- Biggest hurdle: FDA – they put out guidance documents for what's required for approval. Also, all the big medical device companies don't understand MEMS. Customers (surgeons) have to say, "This device changes the world" to influence medical device companies.

**What is the liability of putting MEMS into an implantable? Is the technology able to meet the needs of the FDA, related to liability?**

- There is high risk, but also high reward (80% margin)
- Materials need to be proven safe – like silicon in the body. Especially in Japan, where the government is even stricter than the FDA.

**Where's biggest bang in biomed?**

- Cost reduction and increase speed
  - Need to integrate process steps into tools; technology platform makes the shift possible;
  - Integrate wireless, sensing, wearable electronics
  - The breakthrough will come through in lab-on-chip and complex integration!
- Trend towards home healthcare monitoring will continue, especially for elderly as in Japan.
  - Wireless tech is the enabling tech for home health monitoring (heterogenous integration) – this will change the doctor/patient relationship
- Critical to make existing healthcare more efficient and reform medical reimbursement for MEMS devices (reimbursement process called “fundamentally broken” by one audience member)
- Objectifying the results is very important (which treatments work, which don't); also need to be more reliable and cheaper and don't forget the software!
- Decisions are really made by \$\$ - but they can drive the FDA – some major corporations are trying to reduce healthcare costs and push the FDA
- What MEMS healthcare apps don't require approval or reimbursement?
  - Yes, in high-end segment, new tech can be a differentiator – added value, certainty of treatment, result of the treatment.
  - Those with plastics – “we should talk”

**MEMS for drug and delivery? What do you see?**

- Already have an electronic “pill” sensor that help with dosing medication in the right place. These devices contain a combo that includes MEMS and we are just at the start of using these types of applications.
- Great potential!

**What's the biggest challenge?**

- Time! Takes forever! Rapid prototyping is a killer in this business.

**What's the outlook for 2010? Where should we invest?**

- OrthoMEMS: waiting for a big win in MEMS. CardioMEMS has late-state products going through efficacy testing. Would like to see buyers step in and ask for MEMS.
- Philips: More customers for Philips.
- Xsens: We will introduce some nice products early next year.
- NEDO: We are asking major funding agencies in Japan for more money!

## ENERGY HARVESTING & GREEN MEMS PANEL

Panelists: Keith Abate, director of business development, Perpetuum; Chris Van Hoof, heterogeneous integrated microsystems director, IMEC; Eric Young, general partner, Canaan Partners; Robert Andosca, President and CEO of MicroGen Systems

Moderator: Paul Werbaneth, VP Marketing and Applications, Tegal Corporation

### Which region is best in energy efficiency?

- The US market only usefully uses 30% of the energy consumed (Lawrence Livermore Laboratory stats). Study looked at sources and uses of energy and how meaningful renewables are versus non-renewables.
  - Change consumers' behavior by providing them with more information on energy consumption
  - Need energy monitoring to save energy. The problem is how to power all those sensors? Energy harvesters save significant money (e.g. 18% a year in energy costs in industrial buildings)
  - Every dollar invested now can create \$2 in savings
  - SmartGrid has hit a few roadblocks
    - Some progress has been made with smart meters, but large public utilities are still looking to grow their revenue stream
    - For example, sensing has opportunities in security
    - MEMS-type apps could be a key enabler for cost, power consumption, etc.

### Monitoring infrastructure (bridges, roads, etc) could be a big market. Can infrastructure be monitored through energy harvesting?

- Infrastructure disrepair is a big problem in the US: an estimated 33% of bridges are in disrepair
- MicroGen is one company submitting a proposal for monitoring civil infrastructure. Looking to create an autonomous power sensor that requires little power but can send out an alarm if there's a problem with the piece of infrastructure.
- MEMS allows sensors to be mass produced and cost effective
- For structural monitoring "fit and forget" needs to be "embed and forget" power for life-cycle performance....for structural monitoring – that's something that needs to be "embed and forget"
- Software is important to manage and interpret the data that sensors pick up

### Why not stick to batteries?

- There's only so far you can go.
  - If sensors keep using less power wouldn't batteries last forever?
  - Maybe if you stayed at the same level but you'll want to do more with sensors.
  - Still need to reduce power consumption and boost power creation/levels
  - If you have to go wireless, harvesting may be the only route.
- Startups in batteries?
  - More of the interest has been in smart grid at larger scale

### What investment apps have you seen in energy harvesting or energy scavenging?

- Work on energy storage to make renewables more predictable

- Server manufacturers – very concerned about how much power these consume? They are becoming power limited? Looking to reduce memory power requirements that the box consumes...MEMS can help solve that problem

#### What's perspective on hype vs. deliverables for green MEMS?

- It comes down to educating the public
- Energy harvesting not there for fun -- it's for lower power and cost reduction!

### MEMS AUTOMOTIVE PANEL

Panelists: Reiner John, senior manager, Infineon; Gary O'Brien, director, Advanced MEMS Design Group, Robert Bosch LLC Research and Technology Center; Pietro Perlo, director, technology division, FIAT; and Jeanne Krayer-Pitz, sensor interface/power products technologist, Mixed Signal Automotive, Texas Instruments, Inc.

Moderator: Moderator Mark Martin, vice president and general manager, Micromachined Products Division, Analog Devices

- Efficiency of automotive components – power electronics and the sensors behind it are critical
- Industry wide initiatives for developing automotive: energy efficiency and “sensor fusion”
- Sensor fusion or sensor confusion?
  - For electric vehicles sensor fusion is about additional sensors – an evolution from what we have now, not radically different
  - Need to reduce size while increasing functionality
    - But power is important: increasing functionality means more power is needed, so MEMS is a good solution for sensor fusion
    - Need more processing power to make sense of all the data, therefore we need to dramatically change the way we do system design – **needs to be looked at holistically**
    - Pietro Perlo (Fiat) disagrees with term “sensor fusion”; it's smart system integration. We can't continue to add more functions for safety and comfort without integrating them. It's much more than fusion, it's optimization.
    - A problem with a sensor in an automobile is a BIG problem. In terms of complexity, the automobile is the mother of all platforms.
  - We should add intelligence where we need it, not just to add complexity.
  - The level of control that needs to be processed on a single platform is amazingly detailed – almost hard to believe how much detail is required.
  - Reliability and control are the most important things! How fast can your system do these functions?

#### Future trends: How can MEMS play a role in the electric car?

- Pure electric, hybrid-electric – which one will win out?
  - Hybrid is not going to be the solution in Asia
  - Hybrid is a transition to full electric
  - Need to let electric power plants catch up if everyone is going to plug their car in at night. A lot of electric energy is still created from burning coal.

- Don't forget about more public transportation!
- 2010 will be first year in history of mobility that electrical will overtake combustion-based mobility (if you take into account electric bicycles)
- EMF levels a concern to consumers – need to develop a low-cost magnetic sensor (not available today) to let consumers know that EMF levels are safe
- Need to let electric power plants catch up if everyone is going to plug their car in at night. A lot of electric energy is still created from burning coal.
- Lithium ion batteries are still too expensive, but if you look inside there's really no reason it should cost anymore than a regular battery
  - In China alone, 40 companies are working on lithium-ion batteries, not for automotive but for renewable energy
- "You have to break your paradigms to solve these problems. Open your mind to solar panels on cars or whatever the solutions might be."
- The whole world is coming together, speaking of energy harvesting and lower power (convergence with other panel discussions)

## CONSUMER ELECTRONICS PANEL

Panelists: Frank Bartels, founder and CEO, Bartels Microtechnik; Bryan Hoadley, executive vice president and general manager, Movea; Chad Lucien, vice president of Freespace® products, Hillcrest Labs; Becky Oh, CEO, PNI Corporation

Moderator: Benedetto Vigna, vice president and general manager, MEMS and Healthcare Division, STMicroelectronics

- More visible applications such as Wii have made technology popular with consumers
- MEMS technology has become more affordable and software has become easier to develop – functionality provided by MEMS device coupled with software is critical
- Difficult to see the next big area, but once you create an idea many applications will be created – we are going to see an explosion in the adoption of these MEMS devices

**Does consumer need to be high volume? Is cost the key issue? What really exploded the adaption of MEMS is the success of Apple iPhone, Nintendo Wii, Nike, etc. – not until the Wii happened**

- Combination of all of this being accessible and affordable is why we're seeing the success

**What team sold Nintendo on the use of accel's in their product?**

- Gyration worked with Nintendo in 2001 which was the premise for the Wii – it's what they started with...

**Healthy for foodchain to have a lot of new players in the CE market – keep the big guys honest...**

- But the big guys help with supply chain
- Bringing all the sensors into one piece of silicon is critical – integration is KEY

### Price of accelerometers

- Can the software take care of issues of integration of accelerometers and gyros?
  - There are a lot of applications that don't need that type of reliability – but yes you need it in automotive
  - Yes can use software but it may cost more because you need to calibrate which outweigh the savings
- You need to make a tradeoff
- There are places where can do high volume, but places where you can't (because of complexity of the system)

### Seeing a blurring of application of MEMS – we see great convergence of sports, consumer and bio/medical markets

- Elderly patients (fall detection), obesity, in-home patient rehab to track patients and their progress; signif learning in these markets
- When you start to combine them – flow-through systems; you'll see more and more applications for the same MEMS devices

### Two years from now – what will see in the next 24 months?

- Convergence – sports fitness, gaming, medical, “taking stuff home”, size, usability...these things are really going to change the opportunities for apps in the motion-markets and feasibility of MEMS technology
- Data collection – will see new products evolve – this is a really exciting time! Of course there are privacy issues –
- Smart houses – we haven't tapped this market yet (close to what has happened in the car)
- Mass market adoption for remote controls (CHAD); b/c broadband connectivity has reached the living room – internet connected TVs – standard remote controls aren't effective enough to handle the content, etc. – pointing technology and gestures will bring along with it motion-based gaming – will enable new interactive services

### AFTERNOON KEYNOTE: DR. MAURO FERRARI, PROFESSOR AND CHAIRMAN OF THE DEPARTMENT OF NANOMEDICINE AND BIOMEDICAL ENGINEERING AT THE UNIVERSITY OF TEXAS MEDICAL SCHOOL AT HOUSTON

- Started off at UC Berkeley working on MEMS
- We should care about and think of silicon as a medical material; also think about integration and functionality – integrated device components – that is critical for MEDICAL applications
- Started with biological applications – they called it BioMEMS to bring MEMS into medical (very early days ~ 1993)
- He moved to nanofluidics to apply to medicine
  - Initial focus on filtration of viruses from biological fluids (diabetes)
  - Immune-isolation of cell transplants
  - Surface tailoring/bio and hemo-compatibility
- Current focus – personalized therapy implants based on silicon in animals
  - Smart implants – using silicon to fight disease
  - Used nano-channel technology to address this challenge

- Key to the nano-channels: passive release, active release, active pre-programmed, remotely and self-regulating the objective
- Working towards development of silicon nano-channeled devices (with many, many channels) for passive AND active drug and nanoparticles release from implants, over a long time (6-12 months) – need a controlled release.
- Nanochannels experiment is going to space – first experiment to be flown in space in a private sector aircraft
- Created new company, NanoMedical Systems, for commercializing nanochannels
- Now we go weirder – definition of nanotech in nature – “It ain’t nano if it ain’t got the math to back it up.”
  - Market for nanodrugs = \$5.4Billion
  - Nanotech has the opportunity to address the biggest issues in medicine (and curing cancer): early detection and individualized treatment
  - We don’t need magic bullet drugs to cure cancer: if you can detect it early enough and cut it out before it metastasizes, cancer is solved
    - Curing cancer is fundamentally a prevention and technology problem
  - National Cancer Institute – research programs focused nanotechnology on cancer
  - Current research programs of his lab: regenerative cancer medicine, cardiovascular medicine and infectious diseases
    - Multistage drug delivery system
    - Proteomic nanochips
    - Fracture putty with nanotechnology – nanoporous silicon
    - Early detection – looking for markers in the bloodstream
    - Looking for proteins and protein fragments, peptides that are in very low concentrations (low molecular weight) – very hard to find
  - 3 generations of nanotech in medicine
    - First generation – passive targeting, in clinic
    - Second generation – biomolecular targeting, in pipeline
    - Third generation – higher functions, combinational nanotechs, sequential actions, biobarrier focus
- Key to their approach: Nanoporous silicon totally degrades and you can control the degradation – can be made to degrade in days, hours, or never. Other nanoparticles do not degrade and thus the FDA will never approve them.

FRIDAY, NOVEMBER 6, 2009

## MEMS MARKET ANALYST PANEL

Panelists: Jérémie Bouchaud, principal analyst, MEMS, iSuppli; Jean-Christophe "JC" Eloy, president and CEO, Yole Développement; Roger Grace, president, Roger Grace Associates; Steve Ohr, director of research for analog semiconductors and power management devices, Gartner

Moderator: R. Colin Johnson, technology editor, EE Times

### **Steve Ohr, director of research for analog semiconductors and power management devices, Gartner – focusing on analog RF, power and MEMS**

- “The semiconductor industry went off a cliff last September.” In our forecasts, we said it’s going to be an awful year – down 25% -- but then we had a decent Q2 – with a revised forecast. Q3 was better than expected.
- Latest consensus is that in 2009, we’ll finish the year down 11-12%.
- Automotive down 30.1%, etc.
- Growth rates for non-optical sensors – need to see presentation
- Top 15 non-optical sensor companies – Robert Bosch is bigger consumer of non-optical sensors – Continental, Denso, etc. other consumers – and Apple is now on the list with 13 million.
- In non-optical sensors – increasing pressure sensors, temp sensors, GPS and more.
- Acceleration sensors by market share – Robert Bosch is #1, ST, ADI, Denso, Freescale, VTI, Mitsubishi, Omron is 9, Toyota is 10
- Also forecasting accelerometers/gyro revenue in game controllers – we’ll see continued growth
- MEMS microphones – Akustica, Knowles – seeing penetration rates and they will follow pricing. Can you get 75% penetration into smart phones? Not without severely lowering your price! If a MEMS mic costs \$.55, ECM is closer to \$.35. Need to show cost reductions in other places – can put mic into a low profile package to reduce cost of manufacturing.

### **Jérémie Bouchaud, principal analyst, MEMS, iSuppli**

- MEMS is not immune to the global downturn – down 8% in 2009
- Price erosion in cell phones, consumer electronics, automotive
- CE and mobile phones are driving MEMS market
  - Brightest spots: accelerometers in cell phones and multi-axis gyros for DSCs and gaming
  - MEMS mics down in 2009
- Attractive opportunities in high-margin MEMS: high-end gyros, microbolometers, professional inkjet, drug delivery
- Cards are being re-shuffled
  - Some automotive OEMs take stakes in MEMS fabs
  - TI and HP build new MEMS businesses
  - More M&As
  - See lots of newcomers – like wireless semiconductor companies
  - Limited impact of TSMC, UMC, etc.

### **Jean-Christophe "JC" Eloy, president and CEO, Yole Développement**

- Strong growth in MEMS – accelerometers, gyros, microfluidics for diagnostics.
- RF MEMS is promising as are silicon mics, MOEMS and microbolometers/thermography.

**Roger Grace, president, Roger Grace Associates**

- Single... MEMS-based system solutions
- Double... Magnetic MEMS
- Triple... Point of care bio, Energy harvesting/storage
- Home Run... Integrated IMU... startups/traditional players
- Strikeout... Accelerometers, Gyros, Microphones
- The jury is still out on
  - Oscillators
  - Pico projectors/displays

**What should companies do in tough economic times?**

Ohr – accelerometers in air bags, almost saturated, except side-impact implementations. Acceleration sensors, gyros, rotational sensors will have impact in location-based services and cell phones.

- Is there a billionaire \$ market to break into? Going to be tough with companies like Analog, ST, etc. in this market? How about silicon mics – are their other opportunities for the cell phone market? How about noise-cancellation devices to hook up to multiple mics?
- Are we building a bubble? Companies are shipping above demand – TI, esp. – filling end customer needs but replacing inventory – so number is inflated.
- Bouchaud – Not normal growth yet, there are still some inventory issues. 2010 will be more back to normal.
  - Survival tactics – partnerships have helped!
- Eloy – Big opportunity for analog and mixed-single to acquire MEMS companies. Rohm acquired Kionix, Bosch acquired Akustica & there is more on the way. This is close to what they are doing – and they can re-enter the area by acquiring companies that are still VC-backed. Very strong M&A.
- Grace – believes that we'll see 3-5% increase in MEMS next year.

**What's your forecast for MEMS units in 2010 and are financial projections based on a general recovery?**

- Bouchaud - Number of units will increase because cell phones growing so much. We see 100's of millions of units of new MEMS devices in cell phones.
- Ohr - Units depend on apps such as automotive – you'll see fixed and console GPS and portable navigation systems. Automotive has had an awful year for semis in 2009 – down 30% in 2009. But smart phones showing growth. 50% of smart phones will have rotational sensors in phones.

**Who's driving the growth in microfluidics? And can silicon replace glass as a material?**

- Eloy – Medtronic and other drug-delivery systems are moving market. Big players are driving it. Materials – 35% is glass (still quite new) and only 2% is silicon. Silicon makes sense if you are working with liquid materials. Silicon will remain very small percentage of materials. Microfluidics on top of CMOS sensors also happening.
- Bouchaud – PCI chip from ST – an expensive chip, targeted for specific monitoring applications. Cost is tough because silicon cannot compete. Still with 2B vaccinations a year, there is some potential.

#### **WHAT PERCENTAGE OF MEMS WAFERS WILL BE PRODUCED BY FOUNDRIES?**

- Eloy – 6-7% now up to 10% in 2012. Today business is dominated by ST and TI. New players – TSMC, UMC are trying to enter the market – but these companies don't care about MEMS. "What's important is the process."

#### **CONSUMER INERTIAL SENSORS – seem dominated by a few companies. Is this a trend or is it winner take all?**

- Bouchaud – it's a trend – Rohm is getting bigger – and they have a chance to compete with companies like Analog.
- Grace – InvenSense – in the gyro biz, relatively small (Steve Nasiri) – pretty successful in camera stabilization.