The MEMS Revolution

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As a pioneer in MEMS technology, ST has led the MEMS Consumer and Mobile Market since 2008, with Market share > 50% for Motion Sensors.

Sources: iSuppli January 2012, iSuppli H1 2011
MEMS in ST: A Success Story

- **90’s:** Inkjet
- **2005:** Accelerometers
- **2010:** Gyroscopes
- **2012:** 9-Axis Modules & Sensor Fusion SW, Dual Core Gyroscope

- Augmented Content
- Smart Phones & Tablets
- PCs, Gaming consoles
- Printers

Sensor Fusion
2011 MEMS Top Players Ranking

Source: IHS iSuppli, Competitive Landscape H1 2012

Leading the MEMS world of Micro-Actuators and Sensors
2011: The Year of Doubling

ST MEMS Revenue

- $30M in 2006
- $650M in 2011
- Growth > x20 in 5 years

Gyroscope Market Share

- ST #1: Gyroscope
- Market Share ~60%
- Achieved in only two years

• ST #1: MEMS Motion Sensors for consumer electronics & mobile handset market
• ST #1: Accelerometers, Market Share ~50%

Source: IHS iSuppli, January 2012; Yole Developpement
5.5 Billion MEMS in the Market

Outstanding Global Manufacturing Capability with Dual Sourcing

2.5 Billion units of Motion/Environmental MEMS

+ 3 Billion units of Thermal Inkjet Printheads
Motion Sensors: A Look from the Inside

- MEMS take advantage of the electrical and mechanical properties of silicon:
  - an **Advanced Analog Chip** with embedded smart functionalities
  - **Micron-sized Transducer** realized through a specific process called Micro-Machining

- Dedicated **package** and **calibration** features
Accelerometer and Gyroscope System Approach

Stacked Configuration

Accelometer MEMS

\[ A \text{ mg} \]

\[ \Delta C \]

Analog or Digital Output

mV digits

Gyroscope MEMS

\[ \Omega \]

\[ \Delta C \]

Analog or mostly Digital Output

mV digits

ASIC

Analog or mostly Digital Output

mV digits

ASIC

Analog or Digital Output
The Most Popular MEMS Gyroscope

Drive mode

\[ F_{\text{Coriolis}} = -2m\Omega z \times v \]

Yaw mode
Pitch mode
Roll mode

SINGLE DRIVING MASS

The Beating Heart
THELMA/Smeraldo Technology

ST First to Use Through-Silicon Vias in Volume Production for Smaller and Smarter MEMS Chips
Thelma/Smeraldo: Tru-Si-Vias for MEMS
High performance Accelerometer and Gyro on the same chip
The Dawn of MEMS Consumerization Wave

Accelerometers
- Nintendo 3DS Accelerometer

Gyrosopes

Compasses

Intuitive Interface

Smart Phone Gyroscope
Your gateway to the network…

…Wherever you are
LIS331DLH and AP3GDL8B inside iPhone4S

- A5 dual core Processor
- iOS5
- HSPDA up to 14.4 Mbps
- Up to 64GB memory
- 8MP camera

ST Accelerometer & Gyro
ST MEMS: official partner of M’Soft for Win8

Sensors

ST solution is WHQL certified

Sensor Fusion

Gyro
Accelerometer
Magnetometer

Near Field Communication (NFC)

www.buildwindows.com
LIS3DH in the shoes...
New Applications Enabled by MEMS

- Navigation & LBS
- Remote Monitoring
- Image Stabilization
- Fitness/Wellness and In-House Tele-health
- Indoor Navigation and Dead Reckoning
- 3-Dim Tagging
- Augmented Reality
- Location Based Services (LBS)
Optical Image Stabilization

With OIS enabled, the optics tilt inside the camera but remain still to the subject – giving a sharp image.

Both pitch & yaw tilt are measured by a gyroscope and compensated by the OIS actuator.

The lens and sensor are tilted together with SMA wire on all 4 sides of the camera.
The 920 employs a "floating lens," which, in layman's terms, translates into hardware image stabilization and also packs impressive low-light capabilities.
LBS and Indoor navigation
(Joint Demo with CSR show at CES - WMC)

Accel + Gyro + Magnet + Pressure Sensor
+ WiFi (indoor) / GPS (outdoor)
Indoor Navigation @ MOCA TAIPEI

STMicroelectronics and Museum of Contemporary Art in Taipei Use Indoor Navigation on Mobile Devices to Guide Visitors

The future of indoor navigation is available today in your mobile phone or tablet

Taipei, Taiwan, August 01, 2012 - Many people have experienced getting lost at shopping malls, stores, airports, parking lots - or when wandering through museum exhibitions. STMicroelectronics (NYSE: STM), a global semiconductor leader serving customers across the spectrum of electronics applications and the leading supplier of MEMS (Micro-Electro-Mechanical Systems) for consumer and portable applications¹, has worked with the Museum of Contemporary Art in Taipei to enrich the experience of visitors to Taiwan-based Chinese film-director King Hu’s works exhibition through the use of indoor navigation. This technology transforms mobile phones and other smart consumer devices into the most convenient source of real-time information about the exhibition, overcoming the limitation of satellite navigation in indoor spaces.
Indoor Navigation @ MOCA TAIPEI

- Started inside museum with no GNSS
- Walked around in room 108
- Walked around in room 202
- Up the stairs
- Down the elevator
Indoor Navigation @ Tokyo Station

- Lower level at Tokyo station
- Google indoor maps for each level
- Environment has no GNSS signal, lots of magnetic anomaly sources (tracks, elevators, escalators), and many people causing signal variations
- Red flags mark the route walked
- Blue dots mark the position from the ST-SiRF demo

Starting point determined using Wi-Fi only
The iNEMO platform enables New Applications through sensor fusion.

Portable navigation devices  Service robots  Unmanned aerial toy  Automotive  Advanced video games

Note: AHRS = Attitude Heading Reference System
A Modular & Complete Platform for iNEMO™

- Standalone Gyroscope
- Accelerometer + Gyroscope
- Accelerometer + Gyroscope + Compass + uController
iNEMO Successes: System to Module or SiP

- **INEMO V2**
  9-Axis/10-axis System
  AHRS Algorithm introduction
  (4.2x3.8 cm)

- **INEMO M1**
  (13x13x2mm)

- **iNEMO V1**
  9-Axis/10-axis System
  (4.3x4.8 cm)

**INEMO-M1: 9-axis Module**
(Accelerometer + Magnetometer + Gyroscope) + 32-bit MCU

**INEMO: 9-axis System-in-Package**
(Accelerometer + Magnetometer + Gyroscope) in a few mm² Package

Industrial

- **INEMO: 9-axis System-in-Package**
  (Accelerometer + Magnetometer + Gyroscope) + 32-bit MCU in a few mm² Package

Consumer

- **INEMO: 9-axis System-in-Package**
  (Accelerometer + Magnetometer + Gyroscope) in a few mm² Package

**In development**

Available now

- **Wall Street Journal Technology Innovation Award**

- **Nominated for Computerworld award**
Sensor fusion combines the signal from multiple sensor and compensates the non idealities of standalone sensors.

The SW provides also advanced features such as:
- Dynamic signal distortion (hand jitter) from inertial components
- Magnetic distortions correction
- Full calibration support
NEW

iNertial Modules – iNemo

LSM330D – 6-axis inertial
Ready for Mass Production

3x5.5x1mm

LSM333D – 9x Module
Ready for Mass Production

3.5x6x1.1mm

3x3x1mm

LSM303D - eCompass
Mass Production

SoB for Reference Design

3x5.5x1mm

4x4x1mm

Luxor – 9x Module
Samples Available
What’s Else?
LPS331AP

- Compact solution 3x3x1 mm
- Pressure range 260-1260 mbar
- Overpressure: > 20 bar
- ADC resolution: 24 bits
- Power consumption: 30 µA high res. @ 1Hz ODR
- Pressure noise: 0.020 mbar
- Accuracy: Linear: 2 mbar
- Based on patented VENSEN MEMS technology

30 Million sensors already in the market since April 2012
A New Entry: MEMS Microphones

- **Top-Port uPhones = Bottom-Port uPhones**
  ST PATENTED technology allows placement of the MEMS sensor adjacent to the inlet in both top and bottom port microphones achieving the same performance.

- **Application Segments:**
  - Mobile phone
  - Digital camera/camcorder
  - Laptop PC
  - Gaming

... Analog or Digital microphone
ST’s Microphone Already in the Market
MEMS Around the Body

Disposable Insulin Pump

MEMS Pressure Sensors on Flexible Plastic Substrate close to Eyes for Glaucoma Detection

24-hour disposable contact lens with pressure sensor – ST and Sensimed

Source: Debiotech, www.jewelpump.com
MEMS - Disposable Insulin Pump

• Diabetes is a Pandemic and accelerating WW (250M in 2010, could double by 2032)

• Applications:
  • Diabetes Type I Therapy
  • Drug Delivery for multiple applications
  • Microfluidics for Biosensors

Debiotech, ST

Low Cost
• Disposable

Reliable
• Embedded error detection
• Occlusion Detection

Small
• Size smaller than any pump
• 6-day treatment

Precise
• Nominal Accuracy ±5%

FDA under review
www.jewelpump.com
Electrostatic actuation: MEMS μMirrors

Pico-projector
- Two uni-axial mirrors
- Electrostatic actuation

Resolution:
SVGA (800x600)
The heart of bTendo's technology is comprised of an innovative pair of uni-axial, MEMS-based scanning mirrors arranged to reflect the combined laser beams efficiently.

The optical engine scans orthogonally (horizontal, vertical) at the right pace and angles to achieve the required resolution and aspect ratio.
Electrostatic actuation: MEMS μMirrors

- **Horizontal Resonant μMirror**
  - Opening angle: +/-12deg
  - Operating voltage =180/220V
Electrostatic actuation: MEMS μMirror

- **Vertical Linear μMirror:**
  - Vertical comb drive
  - Opening angle: +/-9deg
  - Operating voltage =180/190V
Conclusions

• STMicroelectronics, the leader in Motion Sensors for consumer electronics and mobile handsets; the one-stop supplier of choice for Accelerometers, Gyroscopes, Magnetometers, Pressure Sensors and Microphones

• MEMS have driven the revolution of the User Interface in mobile terminals and game consoles and are now paving the way to Image stabilization and indoor navigation

• HW and SW are increasingly working together, moving the model from sensor-offer to solution-offer

• “Thinking beyond the chip” is the key to opening new markets and new applications
Thank you

www.st.com/mems