MEMS Sensors for Smart Living: ITRI Solutions

Chris Chen, ITRI
• MEMS Sensors for Smart Living
  – Sensors are Everywhere
  – What MEMS Sensors are Most Required
  – Smart Living Megatrend Herald Next Wave of MEMS

• MEMS Technologies in ITRI
  – Total Solutions on MEMS
  – ITRI’s Smart Sensors
  – Roadmap toward Smart Living

• Summary
MEMS Sensors for Smart Living
Sensors are Everywhere!

- Power Management
- Home Security (IR Sensors)
- Air Quality Monitoring (Gas Sensors)
- Wearable Devices
- Consumer Electronics
- Smart Appliances
- Healthcare Anywhere

Categories:
- Entertainments
- Health Care
- Security
- Sports & Fitness
- Others
What MEMS Sensors are Most Required?

MEMS Sensors for Smart Living

Environment | Motion | Physiologic | RF & Others
---|---|---|---
✓ MEMS Microphone
✓ Barometer (P)
✓ IR Sensor (T)
✓ Moisture Sensor
✓ Gas Sensors, …
✓ Accelerometer
✓ Gyroscope
✓ Magnetometer
✓ IMU (Inertial Measurement Unit)
✓ Pressure Sensor
✓ Bio Sensors (ex. HbO2, ECG, EEG, Glucose, PPG etc.), …
✓ FBAR
✓ Oscillator
✓ MEMS Switch
✓ MEMS Varicap
✓ IPD, …

- Apparently, motion and environmental sensors play as the key roles for smart living applications.
Smart Living Megatrend Herald Next Wave of MEMS

MEMS market forecast 2012-2018 value (in M$)

CAGR 13%

Sensors for Motion & Environment

(Source: Yole developpement)
Huge Market Opportunities on Smart Living:

IMU, MEMS Microphone and Pressure Sensor

(Source: Yole developpement)
Inertial Combo will Dominate the Future Market!

- Smaller Size, Lower Cost, Higher Performance
- More Software
- New Process Develop.
- WLP
- TSV
- CMOS MEMS
- Low-drift Gyro.
- Low-res. Acc.
- 3-axis Gyro.
- Magnetometer
- High-res. Acc.
- 6-DoF
- 9 DoF/10 DoF
- Sensor Fusion
- Sensor HUB
- Specific Algorithms
- Low-Power Mode

Sensor Fusion is Driving Combo Sensors

More Sensors
MEMS Technologies in ITRI
Total Solutions on MEMS

- Advanced Tech
- MEMS Design
- Circuit Design
- Softwares & Applications
- Processes & Materials
- Package & Testing
ITRI’s Smart Sensors

**Fluidic Devices**
- Gas Sensor
- Lab on a Chip

**RF Devices**
- Variable Capacitor
- MEMS Oscillator

**Pressure Sensors**
- High Resolution Barometer
- 0.3-1.3 Barometer
- 0.5-10 Bar Pressure Sensor

**Inertial Sensors**
- Low-g Accelerometer
- Medium-g Accelerometer
- Medium-Rate Gyroscope
- High-Rate Gyroscope
- Inertial Measurement Unit

**MEMS Microphones**
- Analog Microphone
- Digital Microphone

**Optical Devices**
- Electrostatic Mirror
- Magnetic Mirror

**Magnetic Sensors**
- High Res. Compass
- Magnetometer
Newton’s 2\textsuperscript{nd} Law of Motion
\[ \vec{F} = m\vec{a} \]

**Low-noise Accelerometer**
- 3-axis Parts Share Same Mechanical Structure
- Low Off-axis Sensitivity & High Shock Survival
- Low Noise & Programmable Digital Calibration
- Compatible with Inertial MEMS Platform

**Low-power Gyroscope**
- Low Power Consumption (<1mW)
- Robust to Process Variation
- Fully-decoupled Mode Operation
- Multi-axis Angular Velocity Sensing Capability
- Only One Resonator is Required to Drive 3 Coriolis Acc.

**Capacitive E-compass**
- Acc. & M-Sensor Share the Same Structure
- Acc. & M-sensor with Switched Readout
- Compatible with Inertial MEMS Platform
Ultra-compact 6-DOF IMU

- Acc. & Gyro Hermetic Sealed in a Same Cap
- Electrical Isolation of Acc. & Gyro.
- Mechanical Decoupling of Acc. & Gyro.
- Analog / Digital Pulse / Digital Data Output Options

(Source: Internet)
The World’s First Single Chip 9-DOF IMU!

- Small Size, Low Power & Low Cost
- One Chip Integration of 9-DOF Sensor
- Lorentz Force Sensing Mechanism for M-Sensor
- All Capacitive Interfacing for 9-DOF Sensor
- Acc., Gyro. & M-Sensor Hermetic Sealed in a Same Cap
MEMS Microphone

<table>
<thead>
<tr>
<th>Meas. Item</th>
<th>Test Condition</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq. Response</td>
<td>100 ~ 10kHz</td>
<td>100 ~ 10kHz</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>@1kHz (0dB=1V/Pa)</td>
<td>-38+/- 3dB</td>
</tr>
<tr>
<td>SNR [A weight]</td>
<td>@1kHz (0dB=1V/Pa)</td>
<td>&gt; 62dB</td>
</tr>
<tr>
<td>(Typical)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>THD</td>
<td>At 94dB SPL</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td></td>
<td>At 100dB SPL</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

MEMS Capacitive Barometer

- High Shock Survivability
- Input Saturation Immunity
- Active Temperature Stabilization
- Analog / Digital Pulse / Digital Data Output Options
- Capable Integration of Accelerometer on Single Chip (TPMS)
Smart Sensors for the Future

- Gas Sensors

- Highly Sensitive IR Array

- PPG Sensor (Healthcare)

- MEMS Tactile Array
Roadmap toward Smart Living

- Inertial Combo (Motion)
- MEMS Microphone (Acoustic)
- Barometer (Positioning)
- Gas Sensors (Environment)
- PPG Module (Healthcare)
- IR Image Sensor (Safety)
- Tactile Array (Service Robot)

(Source: Internet)
Driven by the sensing needs of smart living, a new wave of MEMS is coming.

Motion and environmental sensors look to play as the key roles for smart living applications.

The three devices Inertial combo, MEMS microphone and pressure sensor are with very huge market opportunities currently.

ITRI is committed to be the total-solution provider for smart living, leading Taiwan’s MEMS industry to win in this booming era.
Thank you for your attention!

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