…AND…

Benedetto Vigna

Executive Vice President
General Manager, Analog and MEMS Group
STMicroelectronics
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... AND ...  ... JA ...
Diversification
STMicroelectronics Earns MEMS Manufacturer of the Year Award

Shanghai / 01 Aug 2018

STMicroelectronics (NYSE: STM), a global semiconductor leader serving customers across the spectrum of electronics applications, has been named the MEMS Manufacturer of the Year at the MEMS World Summit, a leading MEMS Manufacturing Conference gathering the top executives in the Worldwide MEMS Manufacturing Industry. The event took place in Shanghai on July 25-26, 2018.

The prestigious recognition from the advisory board members° of the MEMS World Summit, which consists of leading research institutes, leading Equipment Manufacturers and MEMS Manufacturers, underlines ST’s position as an industry leader with 11 billion MEMS° sensors shipped to date and the only company with the expertise to cover the full range of micro-machined silicon devices that include both sensors and micro-actuators. In naming ST, the jury highlighted the significant role of ST’s high-efficiency 6-axis MEMS sensor modules in driving the transformation of smartphones into intelligent personal assistants as one of the key winning factors. Other high-score criteria for ST included product development, revenue, and company culture.
“Top 10 Power 2016” Award

World’s smallest full-featured motor drivers for battery-powered devices
The IoT Movement

IoT is a movement where any system is able to leverage the Internet and its eco-system.

Cloud computing
Low cost embedded computers
Explosion of reliable wireless connectivity
Rapid innovation of low cost sensors

Nodes
- Smart Things (With intelligence)
- Simple Things (Send raw data)

Gateways
- Gateway

Cloud
- Network infrastructure (Switch / Router)
- Servers (Big data & cloud)

Sense – Process – Connect – Power - Secure
Process – Connect – Power - Secure
Process – Power - Secure
Smart Devices Come in Many Form Factors
...but Have the Same Challenges and Needs

A smart device has to...

Understand the environment

Manage information

Connect to the world

Protect the data

Be energy-efficient

And therefore needs...

Processing & Security
Sensing & Actuating
Connectivity
Signal Conditioning & Protection
Power & Energy Management
A Broad Range of Needs


Sensing & Actuating: Full range of sensors and actuators

Connectivity: 10 cm to 10 km

Signal Conditioning & Protection: Nano Amps to Kilo Amps

Power & Energy Management: Nano Watt to Mega Watt
MEMS AND Analog

Complementary technologies

Sense → Actuate

- Sensor Interface
- Connectivity
- Signal Conditioning
- Power

MEMS

Analog
Sensing AND Actuating
Complementary Phenomena

MEMS Sensors

Physical change → Signal

MEMS Micro-actuators

Signal → Physical change
**Sensing AND Actuating**

A broad product portfolio

<table>
<thead>
<tr>
<th>Sensors</th>
<th>Actuators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyroscope</td>
<td>Piezo actuators</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>Fluidic MEMS</td>
</tr>
<tr>
<td>Magnetometer</td>
<td>Micro-mirrors</td>
</tr>
<tr>
<td>6-axis &amp; 9-axis inertial module</td>
<td></td>
</tr>
<tr>
<td>Optical image stabilization</td>
<td></td>
</tr>
<tr>
<td>Microphone</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
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<tr>
<td>Humidity</td>
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<tr>
<td>Pressure</td>
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<tr>
<td>UV index</td>
<td></td>
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<tr>
<td>Ranging</td>
<td></td>
</tr>
</tbody>
</table>

**Smart Things**

**Smart Home & City**

**Smart Industry**

**Smart Driving**

*Image credit: STMicroelectronics*
# Sensing AND Actuating

For many applications

<table>
<thead>
<tr>
<th>Sensors</th>
<th>Actuators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearable</td>
<td>Smartphone</td>
</tr>
<tr>
<td>Activity tracker</td>
<td>OIS</td>
</tr>
<tr>
<td>Virtual Reality</td>
<td>Pedestrian Dead Reckoning</td>
</tr>
<tr>
<td>Heart monitor</td>
<td>Noise cancellation</td>
</tr>
<tr>
<td>Drone</td>
<td>Gas detection</td>
</tr>
<tr>
<td>Anti-theft systems</td>
<td>Electronic stability control</td>
</tr>
<tr>
<td>Infotainment</td>
<td>Roll detection</td>
</tr>
<tr>
<td>Engine control</td>
<td>Navigation assistance</td>
</tr>
<tr>
<td>Airbag</td>
<td>Telematics boxes</td>
</tr>
</tbody>
</table>

Augmented Reality
3D scanning
Mobile projection
Camera autofocus
Inkjet print head
Vaporizer / Atomizer
Insulin pump
ST - The Only Company to Offer the full range of Sensors AND Micro-actuators

Competitive landscape
Smart Things

Making everyday things connected and more aware of their surroundings

**Sensors**
- Inertial modules and environmental sensors for **Smartphone** and **wearable** devices
- Low power motion MEMS for **Virtual Reality**
- Analog sensors for **heart monitoring**

**Actuators**
- Micro-mirrors for **mobile projection**
- Thin-film Piezo-electric MEMS for **camera autofocus**
- Micro-actuators for **insulin pumps**
Sensors for Smartphone & Wearable

- Activity tracking
- Body temperature
- PDR
- User Interface
- Environmental Monitoring
- Voice control
- Noise cancellation
- OIS / EIS
- Auto-focus
- Sound recording
- Activity tracking
- PDR
- User Interface
Sensors for Virtual & Augmented Reality

- Highly accurate motion detection
- 3D scanning
- Gesture recognition
- Environmental Monitoring
- Ultra-low power MEMS devices
- Highly accurate motion detection
Taiwanese authorities have issued 1,210 tickets for smartphone use in traffic between last Saturday, when the game was released in Taiwan, and
Motion MEMS
Standalone Accelerometer and Gyroscope

Accelerometers
LIS3DH, LIS2DH12, LISDS12, LISDW12

- Ultra thin (0.7mm max) accelerometers families offering:
  - High performance
    (Noise density 90µg/√Hz)
  - Low power
    (Isupply 6 µA [LP])
  - Embedded functions
    (Pedometer, tilt, significant motion)

Gyrosopes
L2G2IS

- Ultra compact two-axis gyroscope for OIS:
  - High performance
    RND: 6mpds/√Hz,
    Phase delay: 5 deg @20Hz
    Sensitivity: (max) ±3%,
    Bandwidth up to 350Hz
  - Low power
    Isupply 3.8 mA

Monthly active users in millions

- LIS2DS12 qualified by WeChat for pedometer application

OIS Off
OIS On
**Motion MEMS**

**A+G Combo Solutions**

**LSM6DSx – 6 axis IMU Product Family for U/I and OIS**

<table>
<thead>
<tr>
<th></th>
<th>LSM6DS3</th>
<th>LSM6DSL</th>
<th>LSM6DSM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>2.5x3x0.86 mm</td>
<td>2.5x3x0.86 mm</td>
<td>2.5x3x0.86 mm</td>
</tr>
<tr>
<td><strong>Applications</strong></td>
<td>UI</td>
<td>UI / EIS</td>
<td>UI / OIS</td>
</tr>
</tbody>
</table>

- **High Performance**
- **Low Power**
- **Dual Core**

**6-axis UI LSM6DS3**

- **Gyro** L2G2IS
- **Application Processor**
- **Optical Image Stabilization module (OIS)**

**Standard Architecture**

**Architectural change**

**6 axis + OIS LSM6DSM**

- **Application Processor**
- **Optical Image Stabilization module (OIS)**

**LSM6DSM enabled Architecture**
FingerTip™ 
Touch-screen Controller

• Expanding customer base
• 3D touch solutions with force sensing
• Winning value proposition
  • Lowest power consumption
  • Very good high-end analog performance
• FingerTip technology well positioned to address wearable, security and active pen applications
ST Sensors and Actuators
winning in Smart Things

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Manufacturer</th>
<th>Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyroscope and Accelerometer</td>
<td>STMicroelectronics</td>
<td>LSM6DS2</td>
</tr>
<tr>
<td>Barometer</td>
<td>STMicroelectronics</td>
<td>LPS25HB</td>
</tr>
<tr>
<td>UV Sensor</td>
<td>STMicroelectronics</td>
<td>No PKG marks</td>
</tr>
</tbody>
</table>

Intel RealSense™

STMicroelectronics Resonant MEMS Micro Mirror Device inside the Structured Light Projector
Smart Home

For better living, higher security, and less waste

Sensors
Environmental sensors to **monitor home** air quality
Ranging sensor and MEMS microphone for **security** and **surveillance**
Ambient light sensor for **illumination level**

Actuators
Micro-mirrors for **3D scanning**
Thin-film Piezo-electric MEMS for **high-speed inkjet print head**
Home Monitoring

- Temperature Measurement
- Carbon dioxide monitoring
- Atmospheric pressure measurement
- Humidity monitoring
- Ambient sound monitoring
- Temperature Measurement
Audio MEMS
MEMS Microphones

Analog and Digital Solutions for All the Needs

**Narrow Roll-Off Spread**
(<1dB roll of )

*Enabling phase matched applications*
(Noise suppression, sound source localization, steerable beam forming, stereo recording)

Full In House Supply Chain

- MEMS
- ASIC
- EWS
- ASSY
- Test

Manufacturing Excellence

**Standard Freq. Response**

**Narrow Roll Off Response**

**Dimension**
- MP23AB02DH: 2.5x3.35x0.98 mm
- MP34DT04/5: 3.0x4.0x0.95 mm
- MP23DB01DM: 3.0x4.0x0.95 mm

**Features**
- Narrow Roll-Off Spread
- Enhanced ESD Immunity
- Low distortion & current cons.

**Applications**
- Noise suppression
- Sound source localization
- Steerable beam forming
- Stereo recording

**Graphs**

- Sensitivity vs. Frequency
- Response vs. Frequency

**Brands**
- MP23AB02DH
- MP34DT04/5
- MP23DB01DM
Acoustic Processing – MEMS Microphones

Open.Audio acoustic libraries

Sound Source Localization
osxAcousticSL

Using a MEMS microphone array, it estimates the angle of arrival of audio signal

Beamforming
osxAcousticBF

Small and compact directional virtual microphone based on ST MEMS microphone array

Acoustic Echo Cancellation
osxAcousticEC

Based on the Speex.org Open Source libraries

Support for μ4 (micro-4)
The smallest microphone array architecture ever!
Environmental Sensors
Humidity and Pressure Sensors

Humidity Sensors

**HTS221**

Humidity and temperature sensor:
- **Extended operating range**
  Temp: -40°C / +125°C
  Humidity: 0% RH / 100% RH
- **High accuracy**
  Temp: ±0.5°C
  Humidity: ±3.5% RH
- **Low power**
  Isupply 2 µA @ 1Hz ODR
- **Planar capacitor structure**

Pressure Sensors

**LPS25HB, LPS22HB, LP225HB, LPS35HW**

Ultra-compact, piezo-resistive pressure sensors:
- **High performance**
  Pnoise: 0.0075 hPa RMS
  Relative accuracy: ±0.1hPa
  Abs accuracy:
    - ±1hPa (T ~ 0°C / 80°C)
    - ±4.6hPa (-20°C)
  ODR 1Hz - 75Hz
  Operating range: 260hPa – 1260hpa
- **Low power**
  Isupply 3µA @ 1Hz ODR
- **Robustness**
  Dust free and water resistant solutions
Enabling cities to make more of available resources

Sensors & Actuators
Environmental sensors to detect dangerous gases
Ranging sensor and MEMS microphone for security and surveillance
Complete sensor node for maintenance, air quality, security and traffic monitoring on smart street lighting
Micromirrors for touchless interfaces on any surface

Analog
Solutions for the Smart Grid
Digital power management for LED lighting
Signal conditioning and protection devices for sensors
Short and long range Wireless connectivity to connect smart objects around the city
Smart Metering

Smart Sensing & Actuating
- Motion MEMS
- Environmental sensors (Temperature, humidity, UV)
- Acoustic MEMS
- Ranging sensors
- Micro-actuators

Connectivity
- STarGRID™ PLC
- NFC
- Wi-Fi Modules
- SubGHz
- STCOMET Smart-Meter on-chip
- 32-bit MCU & Secure MCU

Processing

Energy management
- Smart Metering ICs
- Digital power drivers
- Energy harvesting ICs
- Power MOSFET
- Power management ICs

Processing & Metrology
- STarGRID PLC

Processing
- Gas Flow Meter
- SubGHz connectivity
- Smart Metering IC

Smart Metering
- Gas Flow Meter
- SubGHz connectivity

STarGRID™ PLC

NFC
Smart Industry

Smarter, safer and more efficient factories and workplaces

**Sensors & Actuators**
- Industrial sensors to **monitor process variables** (proximity, level, flow, pressure, temperature)
- Motion and ranging sensors for **robotics**
- Micro-mirrors for projection to help assembly workers
- Piezo-electric MEMS for industrial and 3D printing
- Piezo-electric MEMS for micro dosing

**Analog**
- Motor drivers for **all size motors**
- Wired and wireless connectivity to **connect all parts** of the factory
- Digital lighting controllers for **factory lighting systems**
- Signal conditioning and protection devices
Reliable and precise monitoring of electrical power systems

The SENTRON PAC3200 is a powerful compact power monitoring device that is suitable for use in industrial, government and commercial applications where basic metering and energy monitoring is required. The meter may be used as a stand-alone device monitoring single-phase parameters or as part of an industrial control, building automation or a global power monitoring system.

Metering and monitoring applications range from simple analog volt and amp meter replacements to stand-alone sub-metering or cost allocation installations with multiple tariffs. The SENTRON PAC3200 can also be used to support LEED certification and provide the needed energy monitoring data for federal, local government energy reduction programs.

The SENTRON PAC3200 provides open communications using Modbus RTU/TCP and PROFIBUS-DP protocols for easy integration into any local or remote monitoring system. Simple configuration of the meter can be done from the front display or by using a PC with SENTRON meter setup software, supplied with the meter.

Factory Automation
Motion Control
Smart Industrial Meter
Industrial Power Supply

Microcontrollers
EEPROM
NFC EEPROM

Wide Band Powerline Modem

Voltage / Switching regulator
Op Amp
Power MOSFETs
Power Diodes
Protection

Communications Controller
ASIC

Programmable Logic Controller

- Fast
- Robust
- Easy

Realtime I/O
Smart Driving

Making driving safer, greener and more connected

**Sensors**
- Inertial measurement units for **safety** applications
- Sensors for **engine control**
- Motion MEMS for **dead reckoning**

**Actuators**
- Micro-mirrors projection for **heads-up display** on the windscreen
- Micro-mirrors for **adaptive headlights**

*life.augmented*
Smart Cars

- Engine control
- Electronic Stability control
- Heads-up display
- Navigation assistance
  - Dead reckoning
- Air quality monitoring
- Airbags
- Roll detection
- Adaptive headlights
- Anti-theft systems
- Engine control
- Electronic Stability control
Automotive Motion MEMS
Safety Applications

Dedicated MEMS Design for Improved Performance

**Hi-g Accelerometers for Airbag Applications**

1-ax Accel
Satellite Airbag TPMS

2-ax Accel
ECU Airbag

2-ax Accel
Satellite Airbag TPMS

- 2009
- 2011
- 2014

**Gyrosopes for Vehicle Dynamics Applications**

1-ax Gyro
ESC - Combo

1-ax Gyro
ESC - Combo

3-ax Accel
ESC - Combo

- 2014
- 2015
- 2015
ST SensorTile

Making form-factor prototyping even easier

**Sensing, Tracking and Monitoring**
Remote Processing Unit

Motion MEMS
Environmental sensors
MEMS microphone
Low-power brain
Sensor fusion
Bluetooth Smart

Motion
Algorithms
Gaming
Audio
Augmented living
Motion & Gesture Processing
Open.MEMS motion libraries

Activity Recognition
osxMotionAR
- Detects
  - Walking, Fast Walking, Running, Biking, Driving, Stationary

Carry Position Determination
osxMotionCP
- Detects
  - In Hand, Near Head, Shirt Pocket, Trouser Pocket, On Desk, Arm Swing

Gesture Recognition
osxMotionFX
- Detects
  - gestures such as Glance, Pick-up, Wake-up

Optimized for low power and always on experience
Uses Machine Learning based models to achieve higher accuracy
Takeaways

- Internet of Things presents a wealth of opportunities
- ST has all the building blocks adapted to the different needs of diverse applications
- Sensors are key component for the smart applications
- There are many different types of sensors and infinite possibilities to use them.
- ST has a comprehensive offer of sensors and micro-actuators and provide a complete development ecosystem to make developers’ lives easier
Thank you!

ST stands for life.augmented