Overview on Micro Electro Mechanical Systems

STMicroelectronics

6th ESA Round Table on Micro
&
Nano Technologies for Space
Applications
October 10, 2007

Salvo Coffa
Antonio Imbruglia
Benedetto Vigna

2007
1987
20 years dedicated to the future

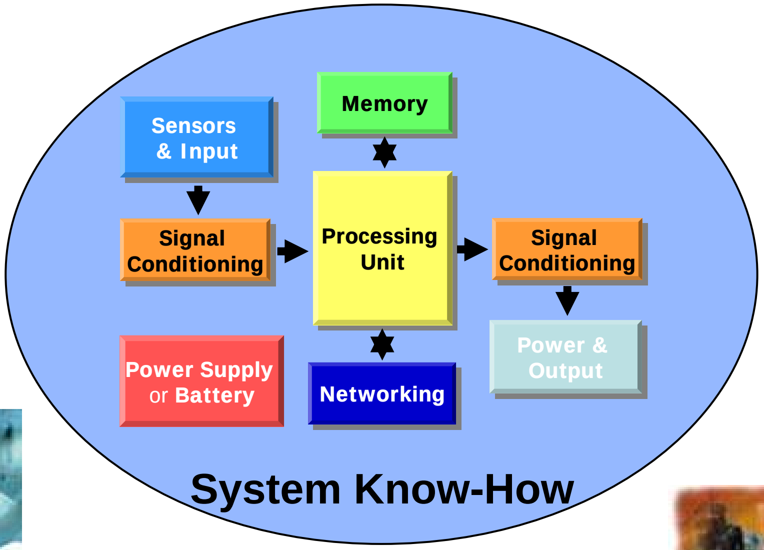
Outline

- R&D activities on microsystems at STMicroelectronics
- Products and roadmaps
- Manufacturing of microsystems

Our approach to manage innovation

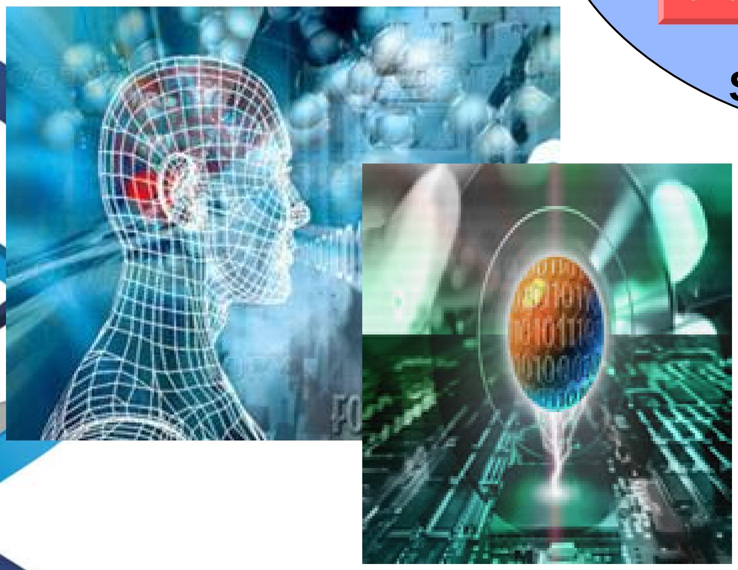
Drivers are market and applications

New Solutions



System Know-How

New Value-added Products



New Technologies

R&D

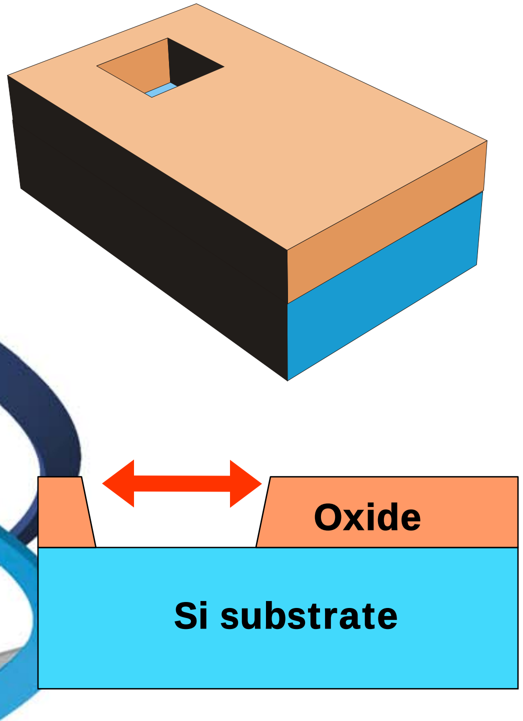
Product Divisions

MEMS motion sensor

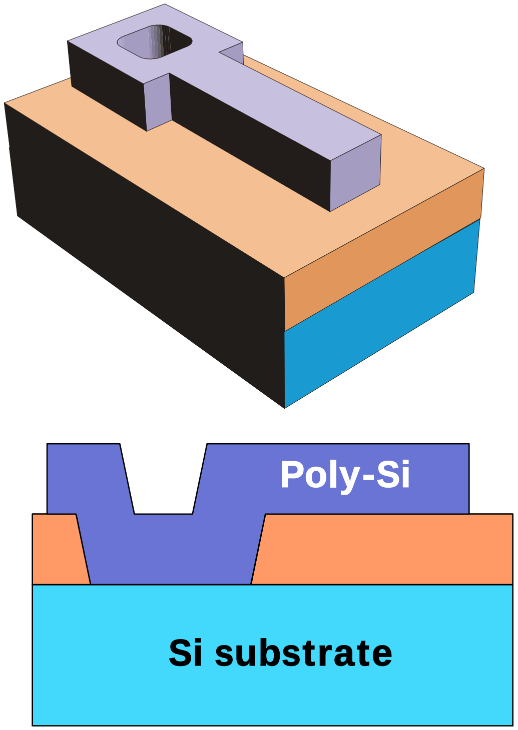
- MEMS Technology
  - Surface micromachining
  - Accelerometer from inside…..
  - Motion sensors
- MEMS applications:
  - Motion sensors
  - Pressure sensors
  - Major challenge in Microsystems
  - Lab on Chip (LOC)
  - Ink Jet Print Heads
  - Probe Storage

Surface **Micromachining**

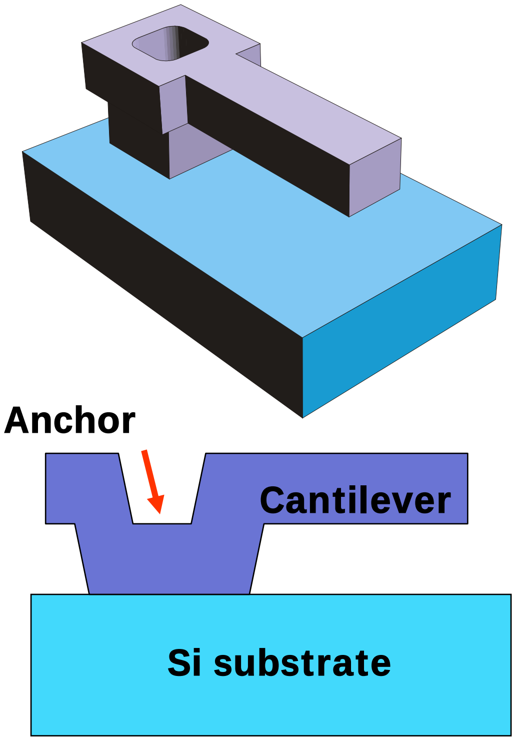
- Micromachining of 3D structures by a sacrificial thin film -



Deposition and patterning of the sacrificial layer

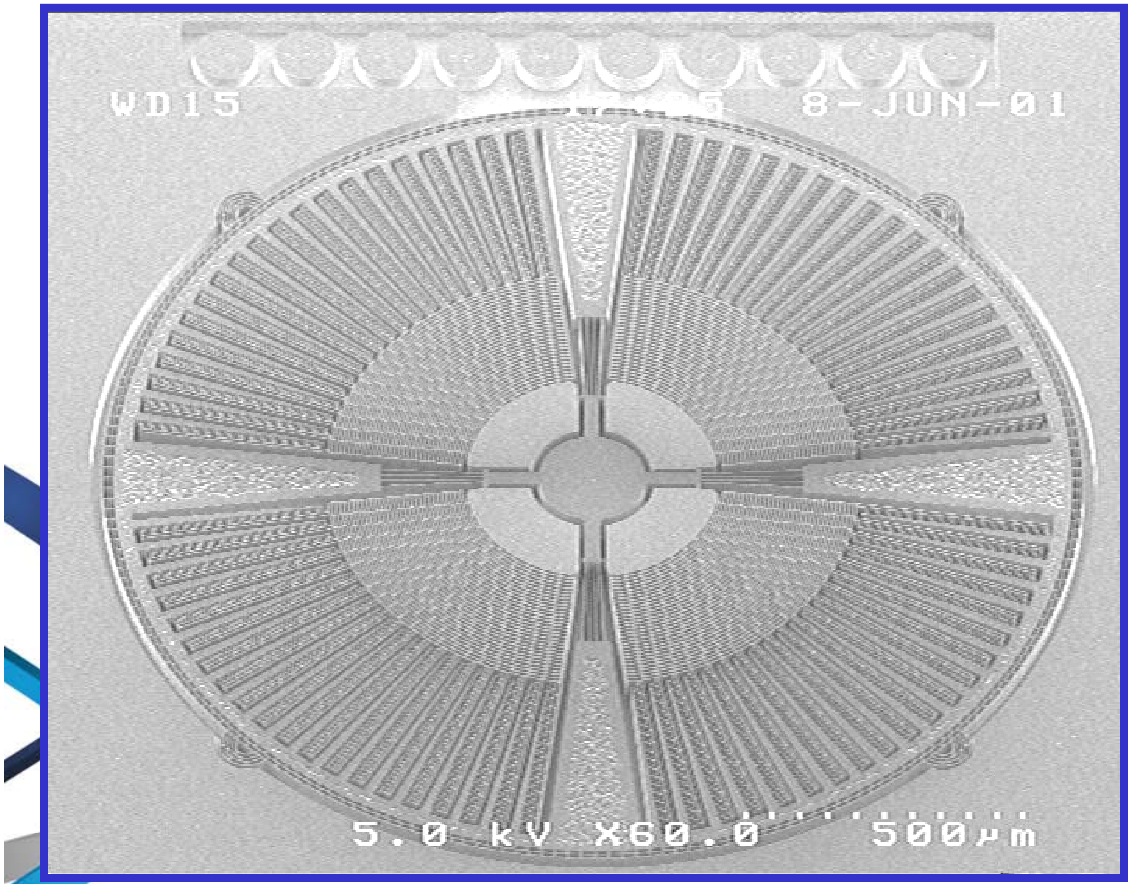


Deposition and patterning of the structural layer

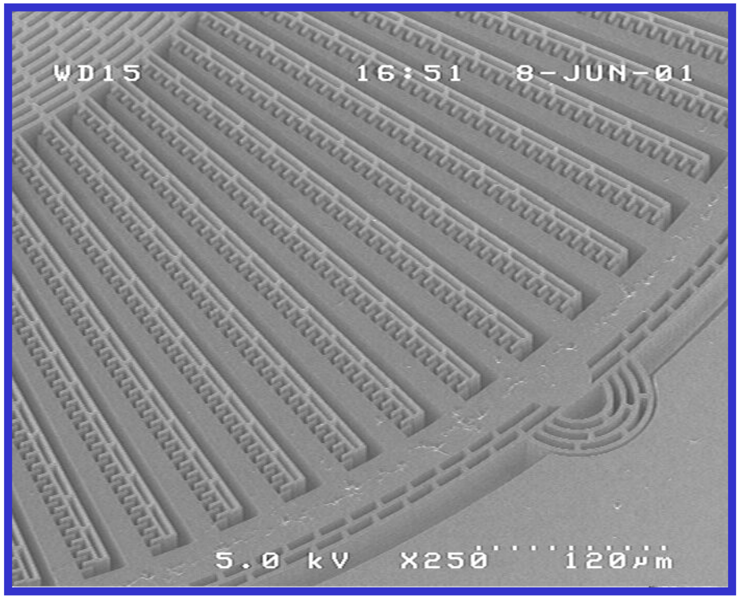


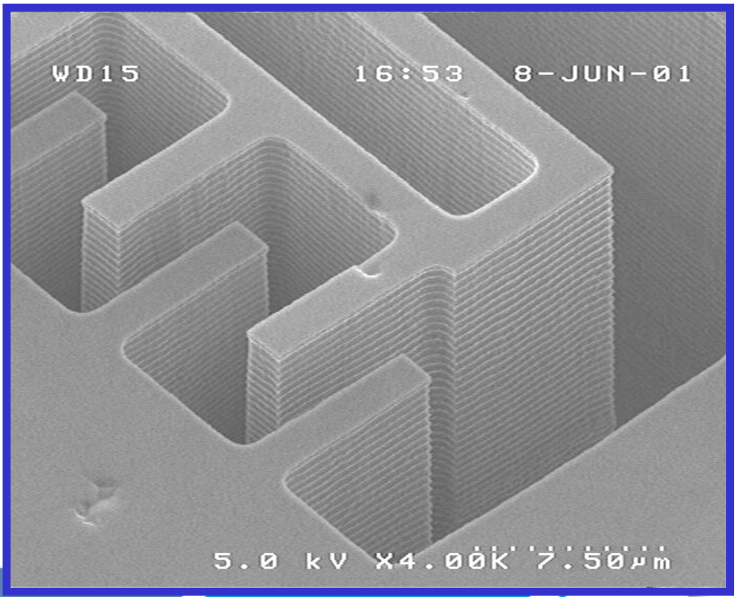
Chemical etching of the sacrificial layer and structure release.

Accelerometer from inside…..

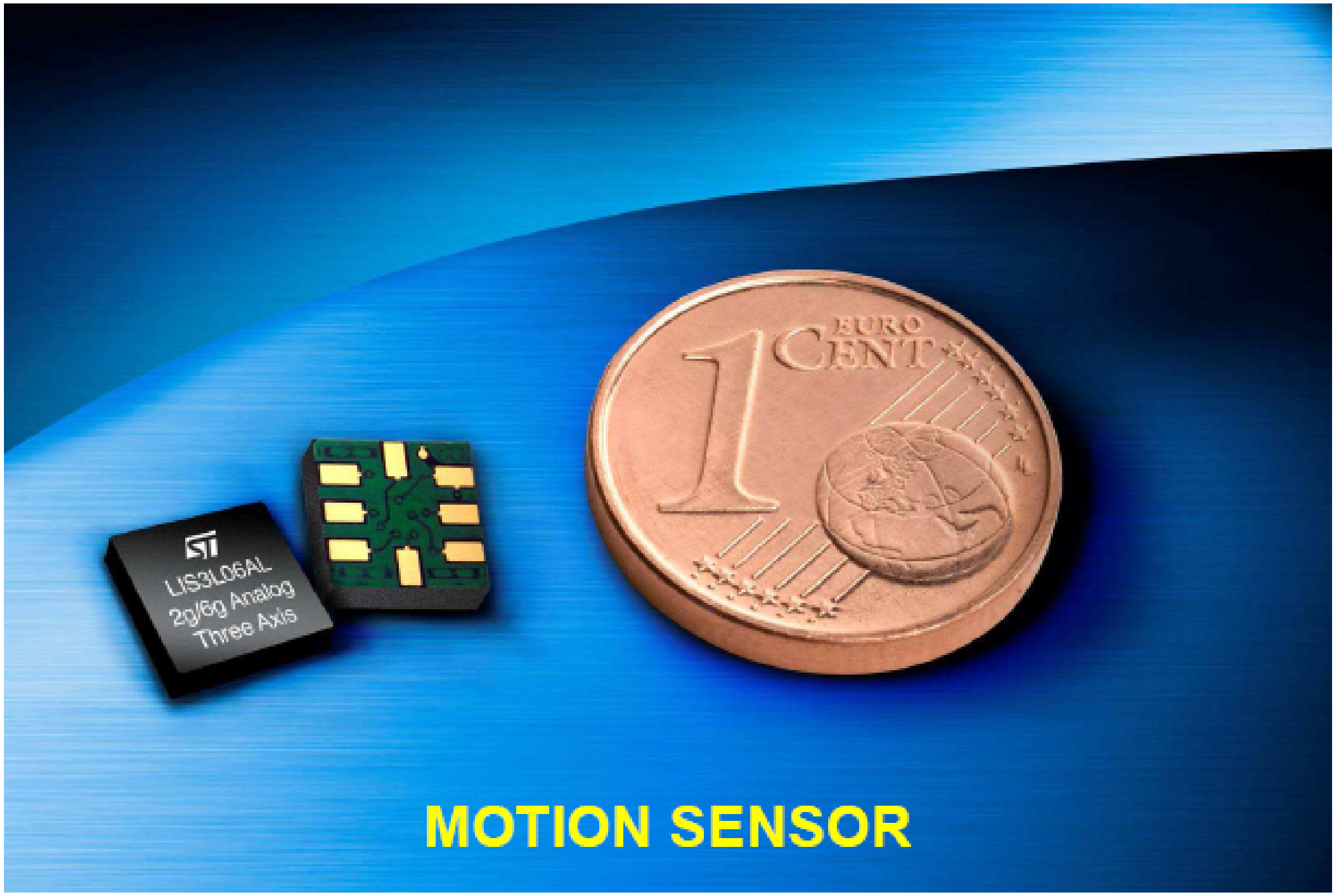


Die dimension 2.5x2.5mm
Rotor diameter 1.8mm
Spring width 4um
Pad dimension 120um

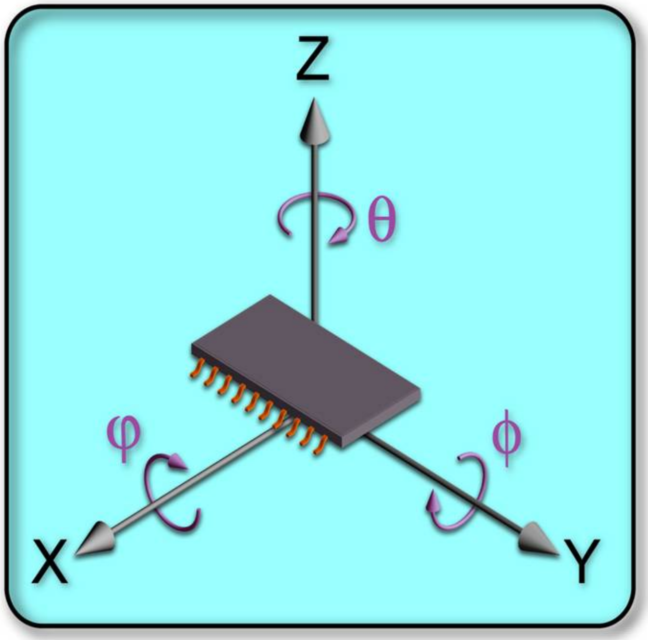


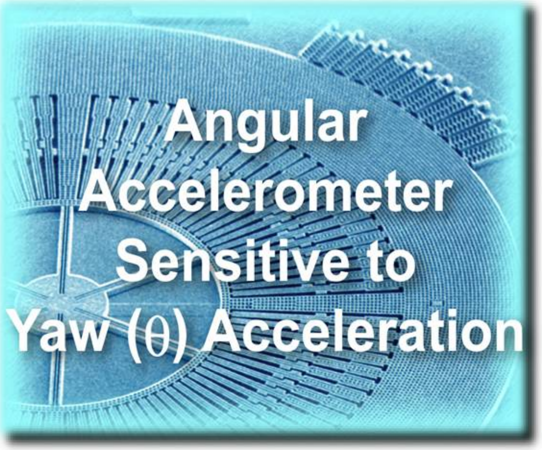


...and from the outside

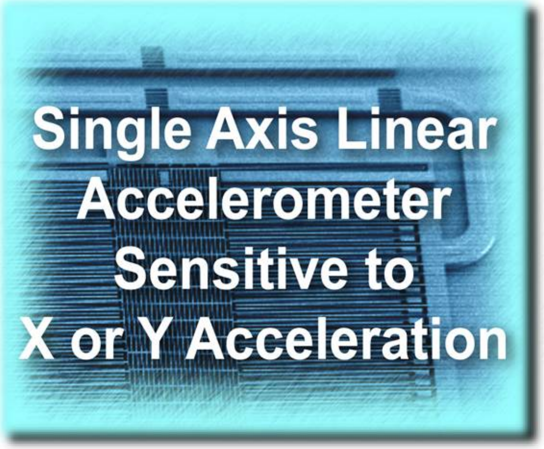


Motion sensors

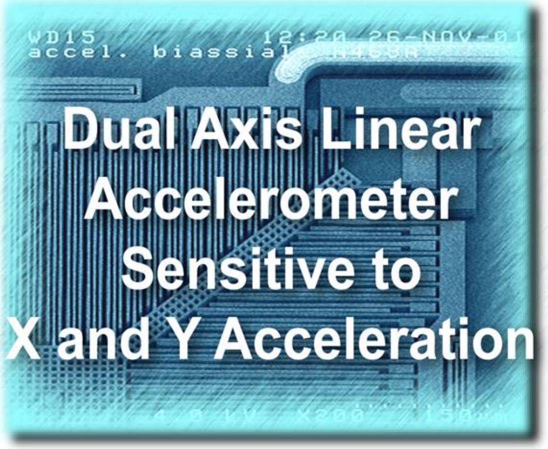




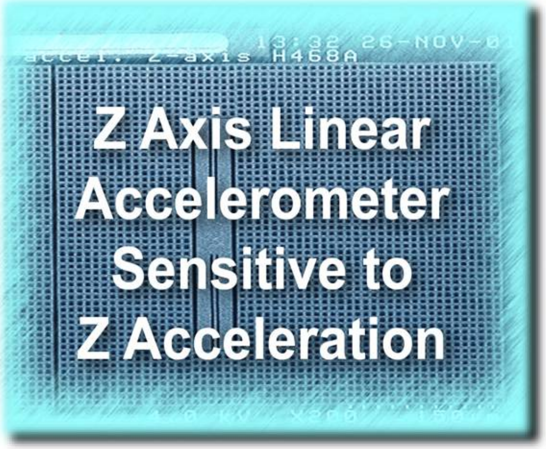
Angular Accelerometer Sensitive to Yaw (θ) Acceleration



Single Axis Linear Accelerometer Sensitive to X or Y Acceleration

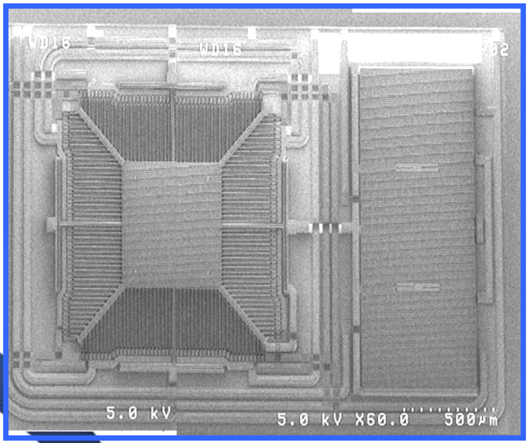


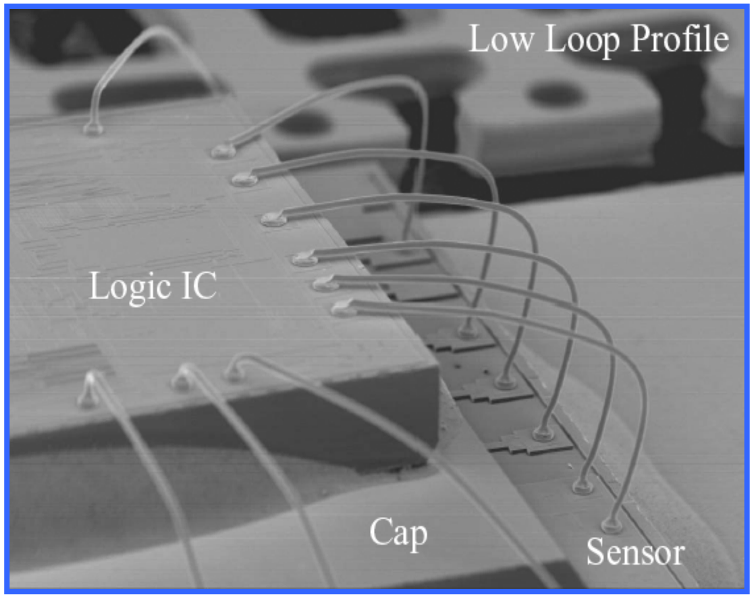
Dual Axis Linear Accelerometer Sensitive to X and Y Acceleration

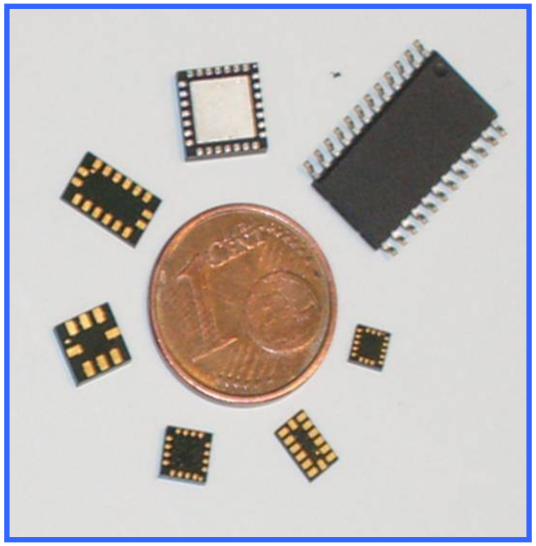


Z Axis Linear Accelerometer Sensitive to Z Acceleration

ThELMA Platform: inertial sensors family







µ-Mechanics

3-Axis High Perf.

3-Axis Small size

2-Axis High Perf.

µ-Electronics

Digital IC

Analog IC

Package

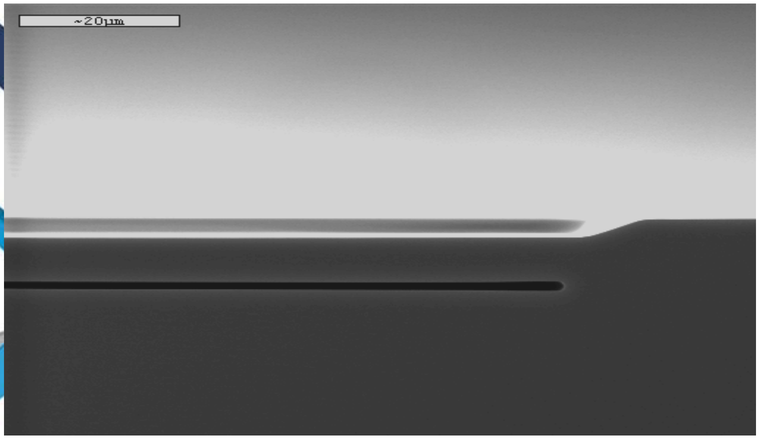
LGA

QFN

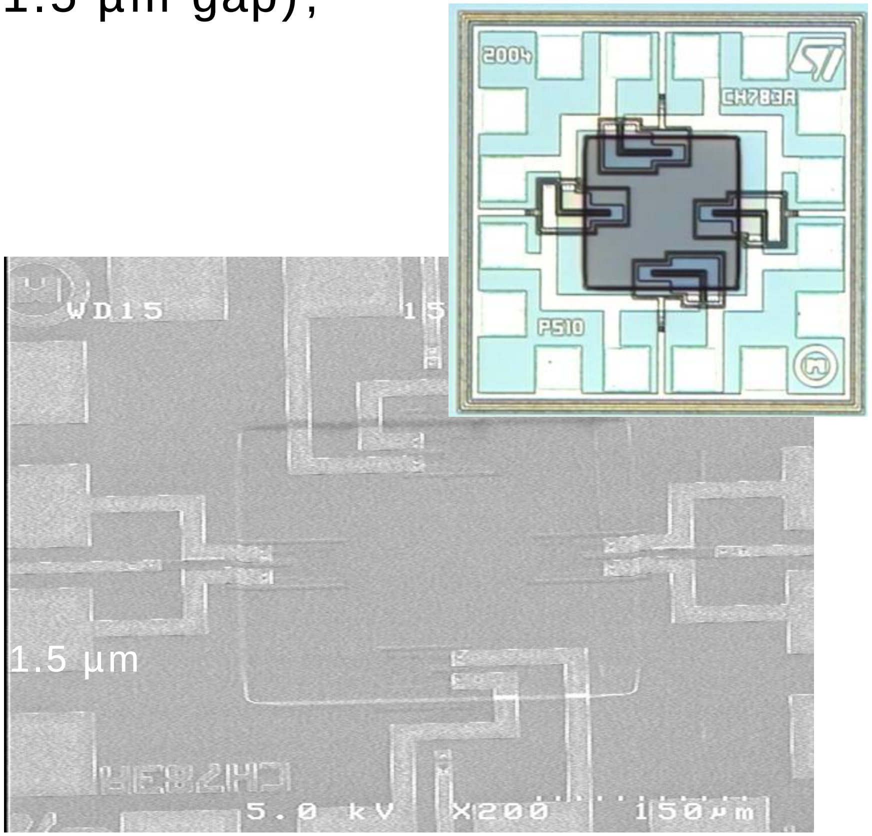
→ ***Consumer Market***

Pressure sensor device

- Wheatstone bridge piezoresistive sensor
- Pressure-cell characteristics:
  - 300 x 300 µm^2 wide, 7µm thick membrane formed in **mono-crystal** *n*-type silicon (on 1.5 µm gap);
  - 4 *p*-type diffused piezo-resistors;



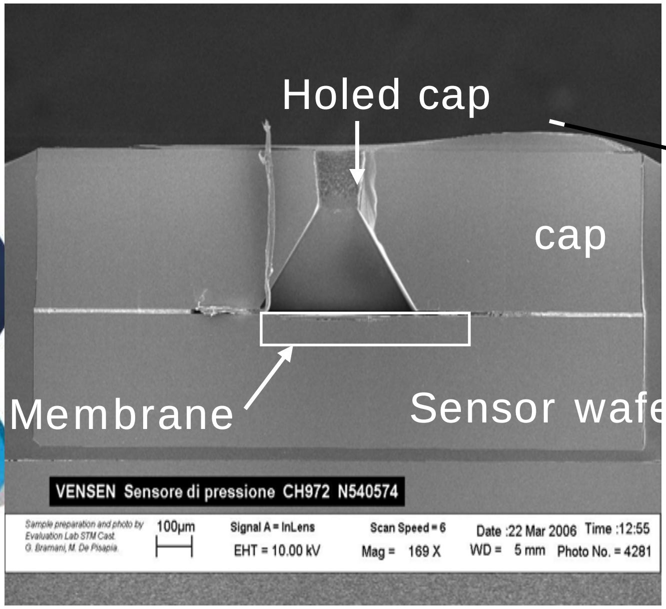
Membrane formation
(ST patent)



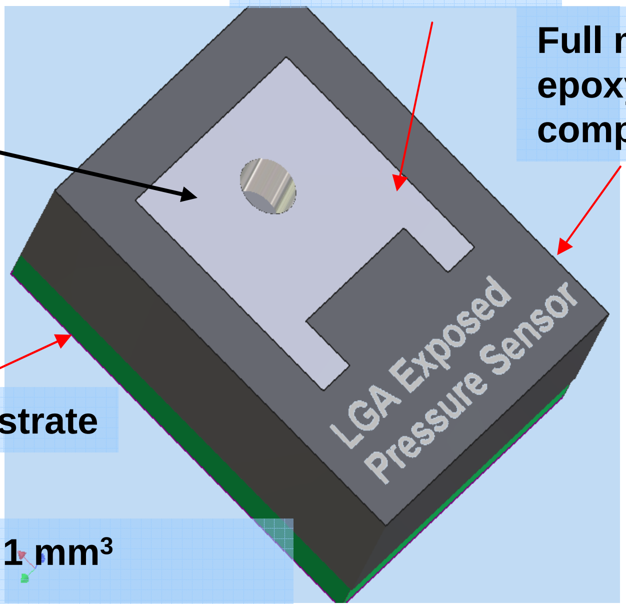
Full device (0.8 x 0.8mm^2)

Pressure sensor device (2)

- Wafer to wafer bonding allows use of LGA full-molded package (currently in production)
- Holed cap wafer
- Glass-frit bonding



Sensor and holed-cap wafer



Exposed Sensor

Full molded epoxy compound

BT substrate

Size 2.5 x 3 x 1 mm^3

8 Lead 0.5 x 0.5 mm pitch 0.8

Major challenges in microsystems

- Integration of devices using new materials/different substrates

  Reliable and cost-effective 3D integration!

- Enabling equipments for smart nodes

  Tools for precision alignment of chip/wafers
  Wafer level package

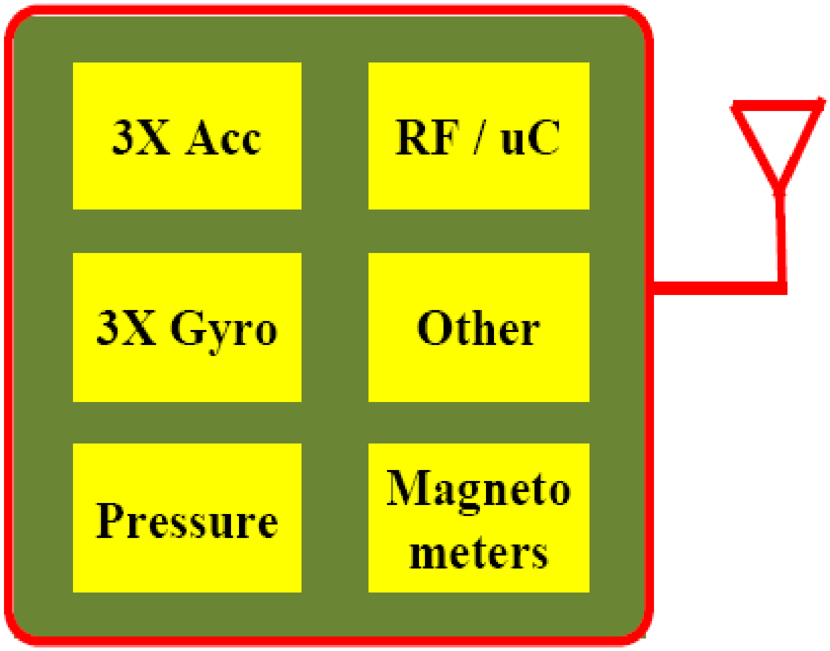
- Smart systems for bio- and chemical analysis

  Support the merging of electronics, photonics and biology

↓

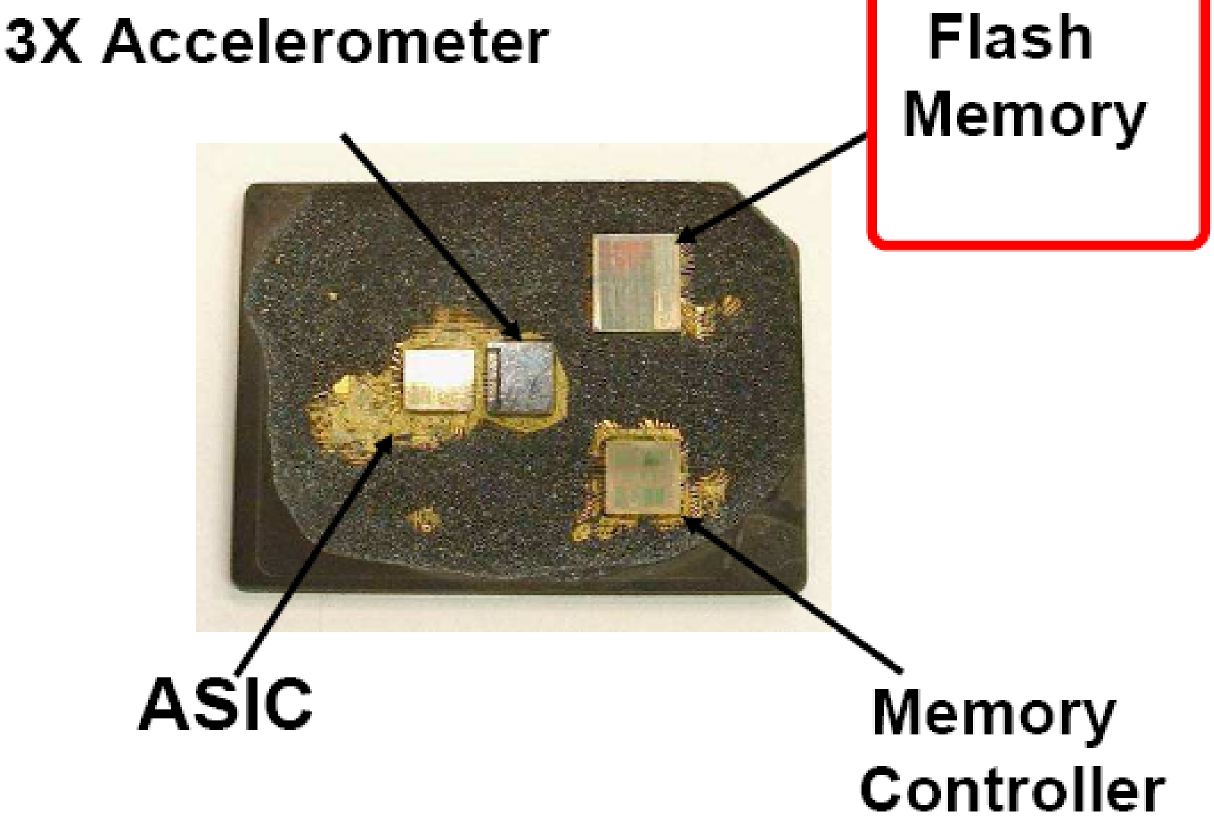
Enable consumer market applications

Combination of Different Sensors, Technologies and Functions in one single Module



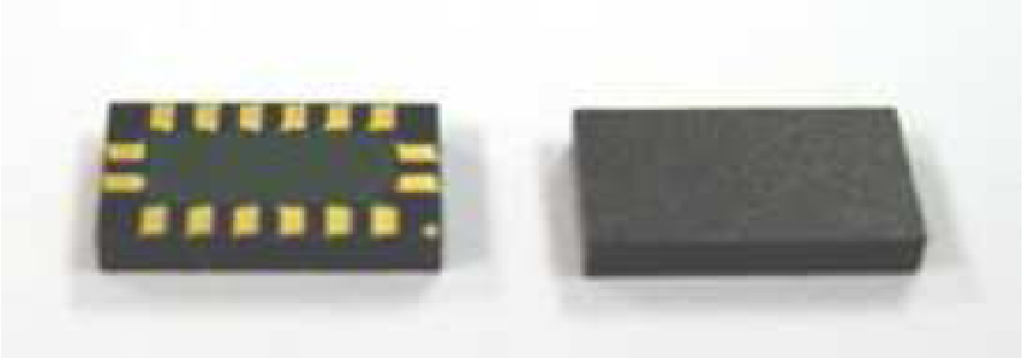
STMicroelectronics has a competitive advantage

ST started already



3X Accelerometer and 3X Magnetometer

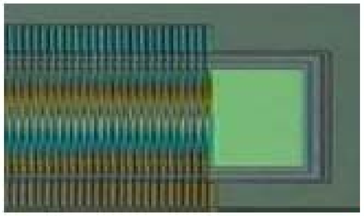
- 3MAG channels & 3ACC channels
- 2.6V to 3.3V supply voltage
- Max. 10mA current consumption
- ±3 gauss MAG full scale
- 3° resolution of E-compass
- No user calibration of E-compass
- ±2g / ±8g ACC full scale
- 2° resolution of ACC
- I2C serial interface
- Power down mode
- 4.4 x 7.5 x 1.1 (mm)
- LGA 16 pin

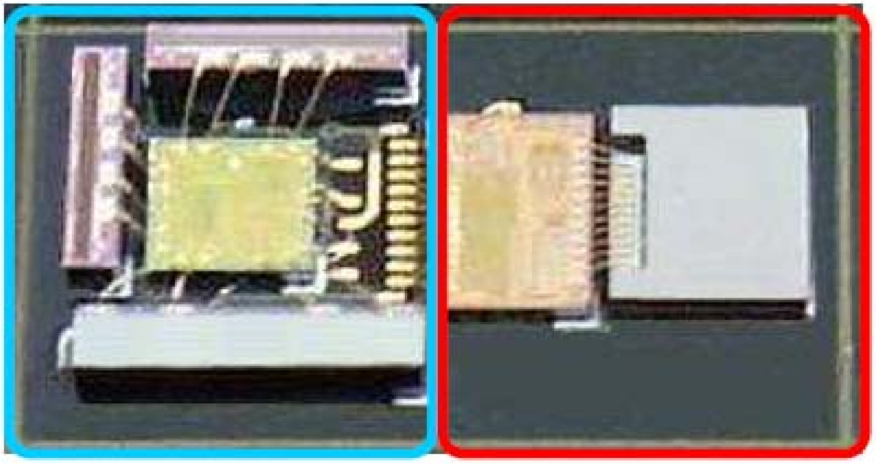


4.4 x 7.5 x 1.1 mm^3

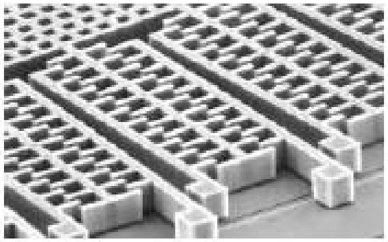
What's inside?

Thin Film
Fluxgate Sensor





MEMS
Capacitive type



3X Magnetic Sensor
by <u>Microgate</u>^{TM} <u>(SK)</u>

3X Accelerometer
by ST

Manufacturing process for Sensors in STMicroelectronics

S. Coffa

2007
1987
20 years dedicated to the future

New MEMS Market

- *Few years ago "MEMS Consumerization Era" started with Accelerometers and Microphone adoption by major consumer OEMs:*
  - *Wii of Nintendo is the most famous example, though also Sony PS3 uses motion sensors.*
  - *Laptop and Mobile Phone manufacturers are using on big scale accelerometers and microphones*
- *Gyroscopes and pressure sensors start to enter now the consumer market.*
- *Some players started from scratch to develop sensors for consumer market, while others tried to adapt automotive sensors to this new market*

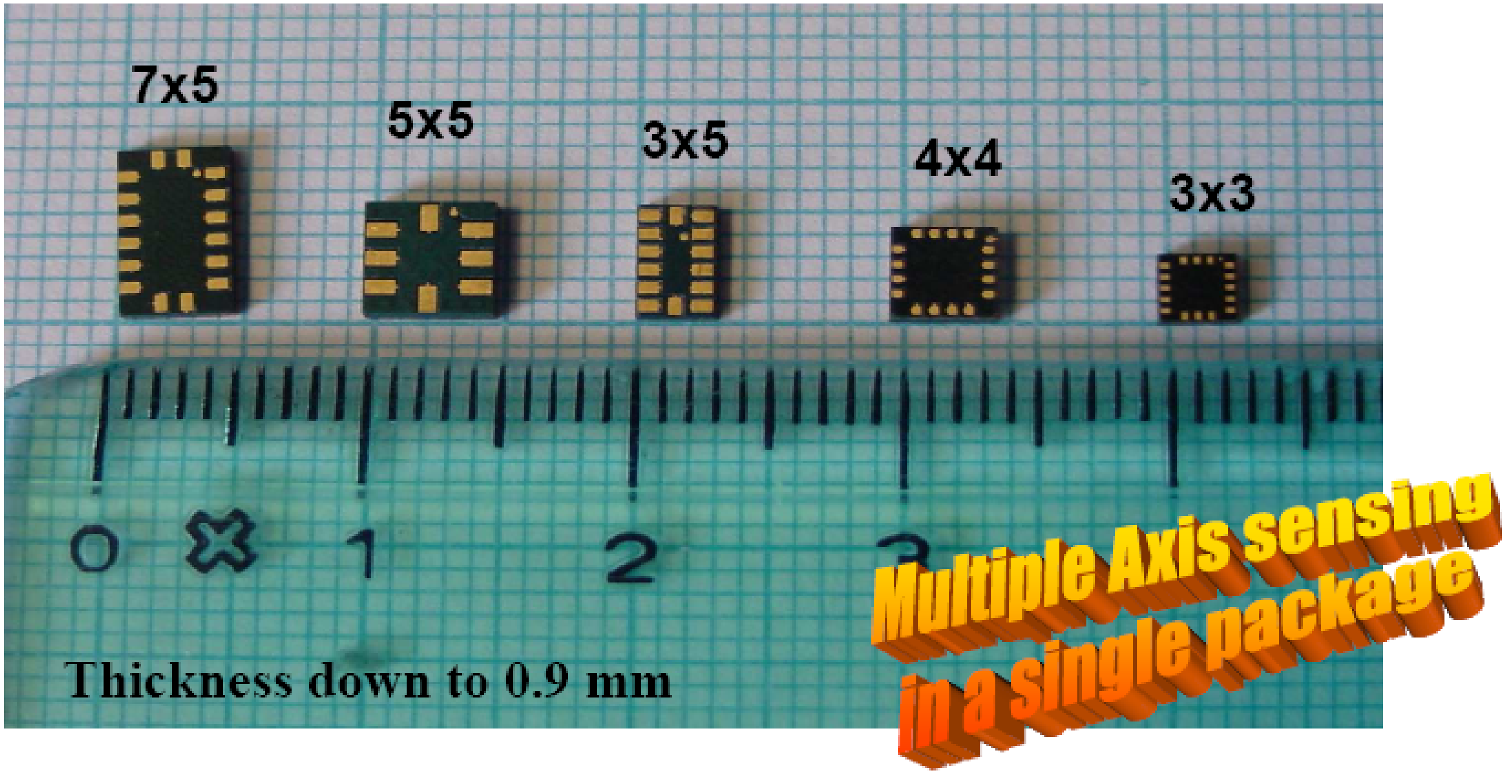
Emerging Markets Applications

- **Mobile Phones, Portable A/V Players and Personal Navigation Devices:**
  - User Interface
    - Image rotation
    - Menu Navigation
    - Game interaction
  - Fitness / Pedometer
  - Free Fall Protection
  - Compass
  - Enhanced Voice Interface
- **Laptop:**
  - Free Fall Protection
  - VoIP/Windows Vista Features
- **Game Consoles**
  - User interface
- **HDD**
  - Free Fall Protection
- **Digital Camera and Camcorder**
  - User Interface
  - Image Stabilization
  - Free Fall Protection
- **Other**
  - Miscellaneous

STMicroelectronics 8″ Fab

- Several companies re-used old fabs to run MEMS production, BUT STMicroelectronics built a state-of-the-art 8″ fab for production and for new MEMS development

ST Accelerometers for the Consumer Market



Thickness down to 0.9 mm

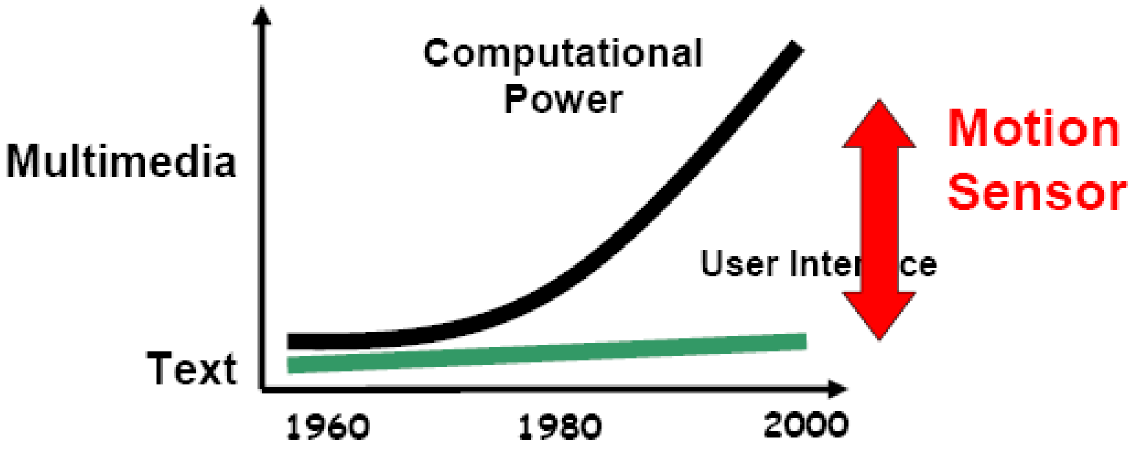
Multiple Axis sensing in a single package

Capacitive Micromachined Sensors

MEMS in Nintendo Wii™

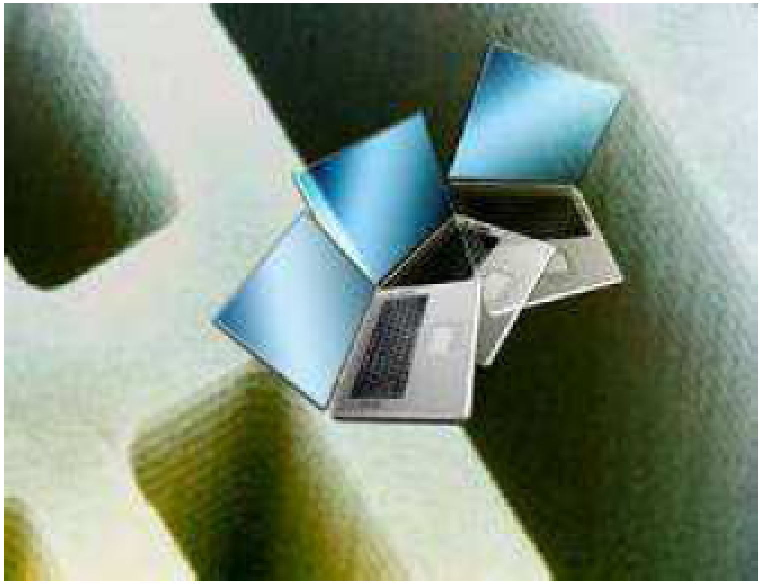
Throw away the Button. Just Move it

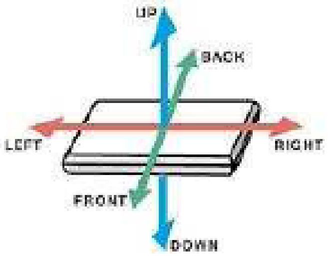
Just as graphical icons and a <u>mouse</u> have transformed the way people use desktop computers, today motion sensors are revolutionizing the way people use handheld devices

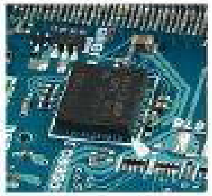


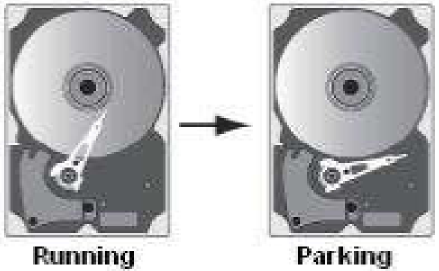
Motion Sensors = Mouse for handsets

Hard Disk Drives in Portable Equipments need an Airbag






3D Accelerometer



Take a better Picture

Piezoelectric Solution are power hungry and bulky

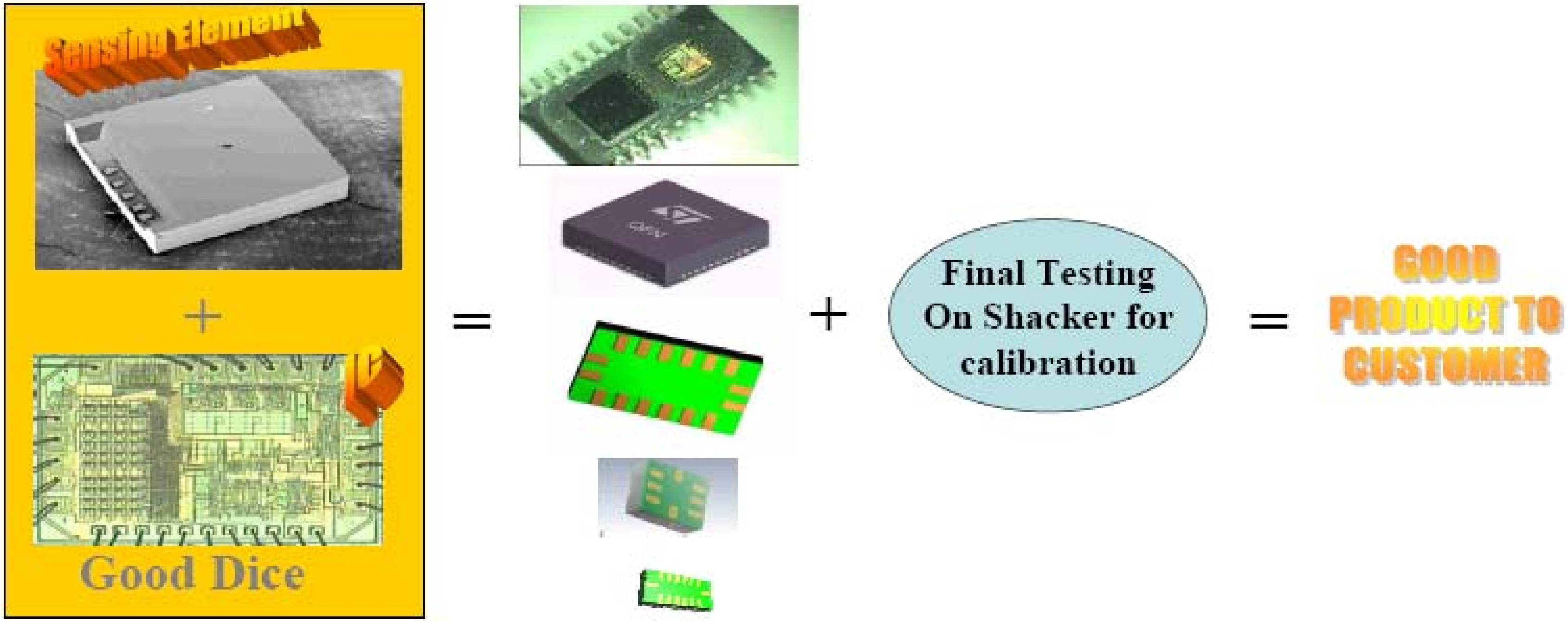
Stabilized

MEMS: SOFTWARE + hardware

Customers need Hardware and Software for turn-key solution.

ST may offer both

Manufacturing of ST Sensors

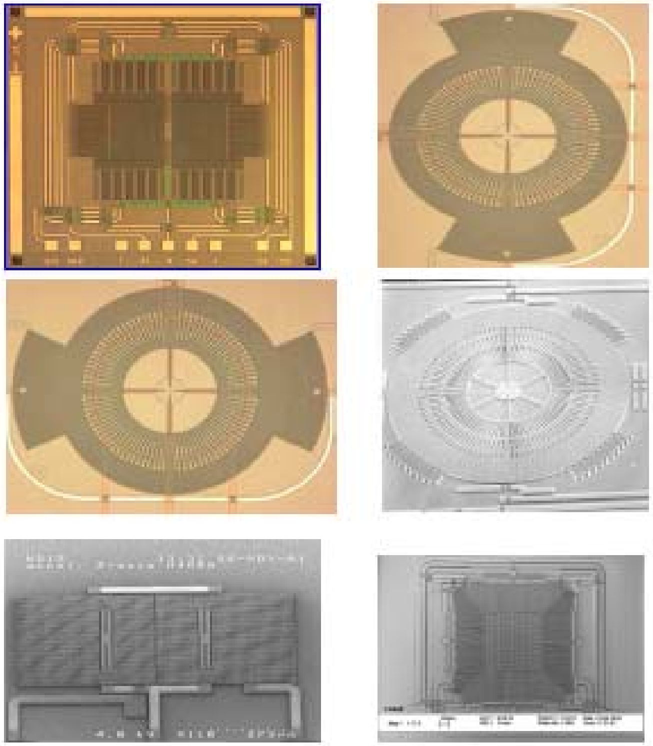


Final Testing On Shacker for calibration

GOOD PRODUCT TO CUSTOMER

<u>No ideal approach exists</u>, though System in Package reduces development time and cost

Multi-Axis Motion Sensors



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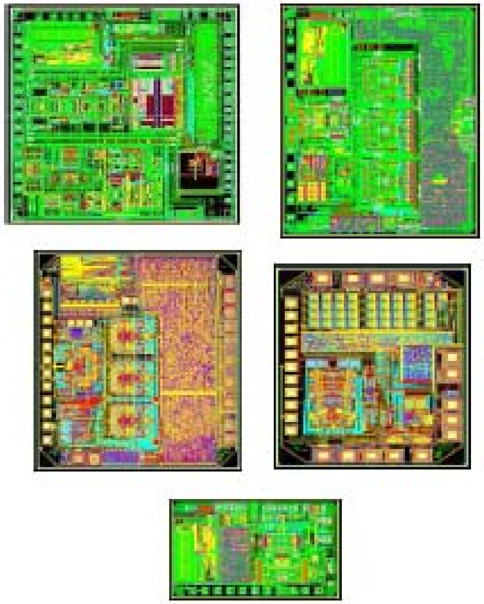
Analog and Digital



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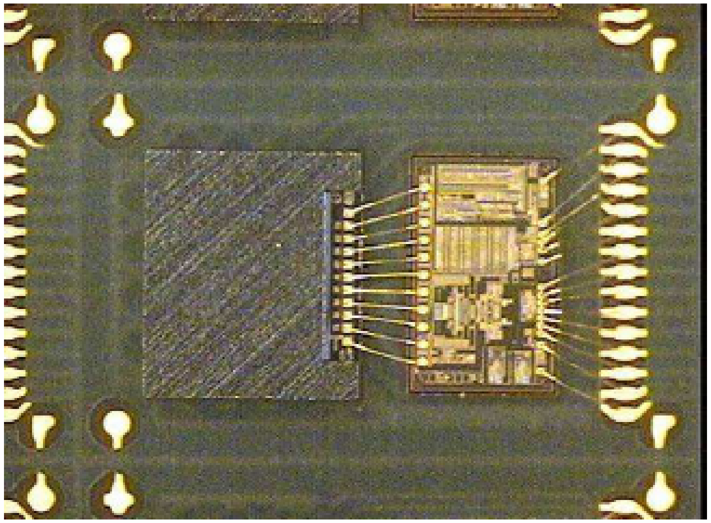
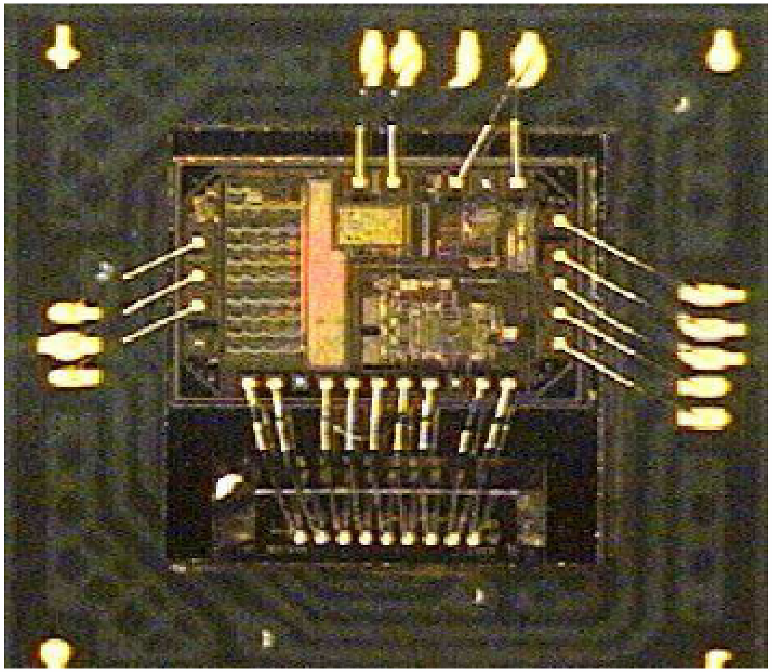
LEGO Approach

Packaging Solutions for SiP: Plastic Land Grid Array

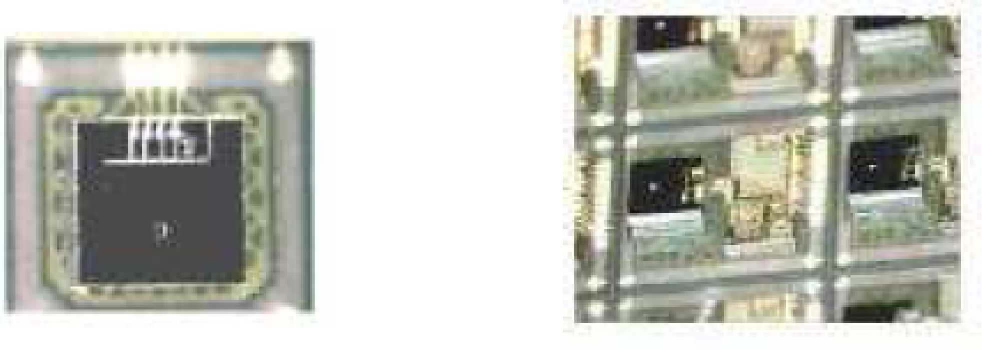


Side by Side

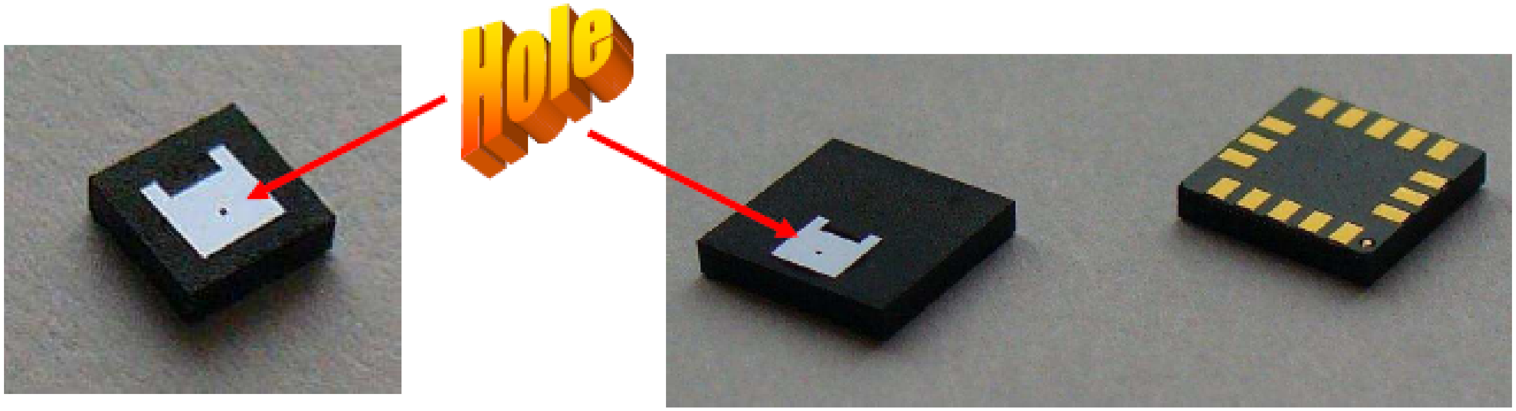


Stacked Chip

HLGA for Pressure Sensors



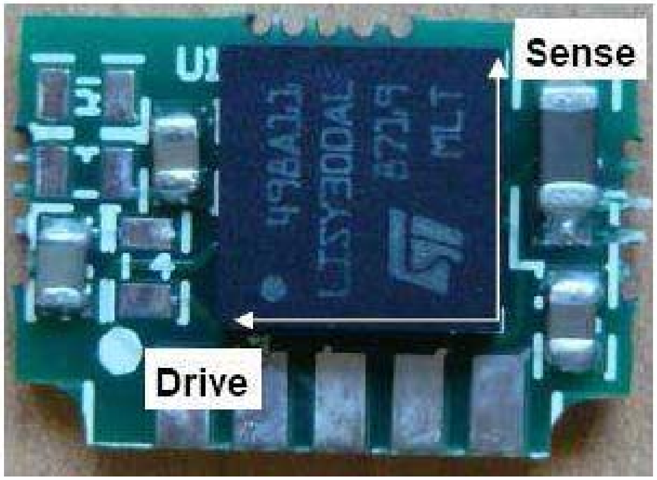
Before Moulding



Final Package

ST Gyroscope for Consumer Market

7x7x1.5mm3



Coriolis' Gyroscope with Capacitive drive and sense and Getter from Saes Getters

MEMS contact people

All information on MEMS products are available on official web-site

www.st.com.mems

Looking at *Products*

Sensors

Motion Sensors (MEMS)

In case of New Products or Design IN right person to contact is:

Benedetto Vigna
STMicroelectronics
MEMS Product Division
STMicroelectronics, S.p.A.
Via Tolomeo, 1
Casella Postale 176
20100 Cornaredo Milano (Castelletto)
ITALY