

# Murata 3D MEMS technology

Leti Days, July 3rd, 2018





## Our Business

We are worldwide leaders in the design, manufacture and supply of electronic components and solutions.

**We are Innovators in Electronics.**

## Our Strengths

- Advanced materials technology and expertise
- Broad product portfolio
- Extensive global manufacturing and sales network

## Our Figures

- Net sales 1,135,524 million JPY\*
- Employees 59,978\*
- Number of subsidiaries 97\* ( 31 in Japan, 66 overseas)
- Established in 1944

*\*as of March 31, 2017*

*\*Murata Manufacturing Co., Ltd. Is not included in the number of subsidiaries*

# Murata Finland, Operations



We design, develop, manufacture, test and deliver MEMS sensors with the world's best measurement accuracy and measurement repeatability, small size, extreme reliability and high performance.



## Research & Development

Industry leading expertise in developing new technologies and products, including in-house design of MEMS, ASIC and packaging.



## MEMS Manufacturing

Over 60 million silicon-based capacitive sensor elements are manufactured every year using MEMS (Micro Electro Mechanical Systems) processes in state-of-the-art cleanrooms (ISO 4, 5 and 8).



## Assembly and Testing

Assembly of sensor components is carried out in ISO 7 and 8 cleanrooms, and testing in EPA\* area.



\*EPA=Electrostatic Discharge Protected area

# Product lineup

## Accelerometers & Inclinometers



**SCA3300**



**SCA8x0/21x0/3100**



**T-series**



**Inertial  
Measurement Unit  
(IMU)**

High performance analog and digital accelerometers and inclinometers for safety critical automotive and industrial as well as healthcare applications

## Gyroscopes and Combined Sensors



**SCC2000**



**SCC1300**



**SCR1100**

Gyros only or combined with accelerometers with excellent product features for automotive, industrial and healthcare applications

## Acceleration and Pressure Sensing Elements



Ideal for implantable medical devices, thanks to the inherent accuracy, reliability, small size and capacitive principle for low power solution

## Patient Monitoring Devices



**SCA10H**



**SCA11H**

Continuous contactless patient monitoring

# Main markets & applications

We contribute to safer driving, higher quality of life and increased efficiency

## AUTOMOTIVE



#1 in acceleration sensors for automotive active safety systems



Electronic Stability Control (ESP/ESC)



Advanced Driver Assistance Systems (ADAS)



Hill Start Assistance (HSA)



Electronically Controlled Susp. (ECS)



Transmission Control (TCM)



Electric Parking Brake (EPB)

## HEALTHCARE & MEDICAL



#1 in activity monitoring in Cardiac Rhythm Management

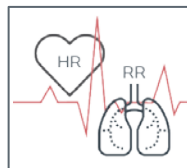


Pacemakers and ICDs



Surgery tables and medical imaging

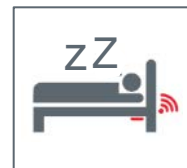
Patient monitoring solutions



Vital signs



Bed occupancy



Sleep quality, stress, relaxation

## INDUSTRIAL



Wide range of sensing solutions across industries



Construction tools and systems



Heavy machines



Structural health monitoring



Weight scales



Airplane instrument systems



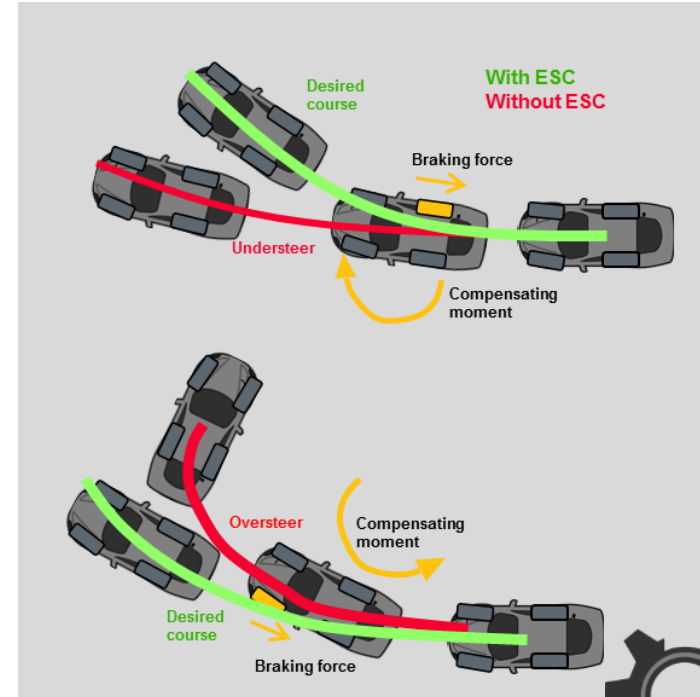
Robotics



# Vehicle Stability Control (ESC, ESP, VSC)

MEMS accelerometers and angular rate sensors utilized in ESC improve vehicle stability and safety on the road.

Sensors	Advantages
SCC2xxx Inertial component	<ul style="list-style-type: none"><li>• Vibration robustness</li><li>• High performance</li><li>• Reliability</li></ul>



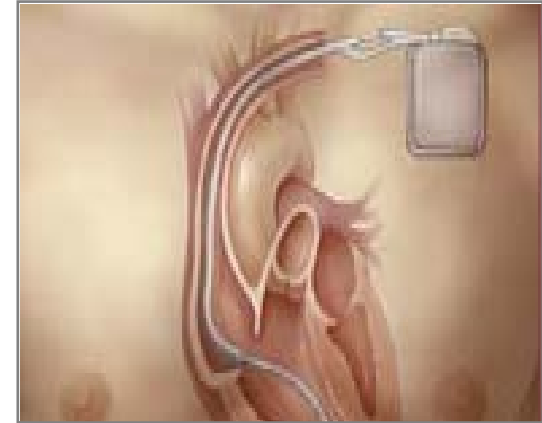
ABS\* is not enough in a curve. ESC corrects for under- and oversteering. Yaw rate ( $\Omega$ ) and centrifugal acceleration ( $a_T$ ) from an angular rate sensor and a lateral acceleration from accelerometer are compared to those calculated from wheel speed and steering wheel angle. \*ABS = Anti-lock Braking Systems



# Medical devices: pacemakers and ICDs

Murata acceleration and pressure sensing elements in pacemakers, ICD's and other implantable devices satisfy the strictest requirements:

- high reliability, stability and quality
- low power consumption, enabling  $< \mu\text{A}$  current consumption for 7-10 years battery life
- smallest possible size



Applications	Sensors
Pacemakers and ICD's	SCG-series accelerometer elements
Other implantable devices	SCB10H series pressure elements



# Heavy machines

MEMS accelerometers and gyroscopes with excellent shock and vibration robustness.

Main applications	Sensors
Excavator scoop position Bull-dozer blade control	SCC2000
Agricultural machine auto steering	SCC2000 SCA3300
Fork lift motion control	SCA3300 SCC2000

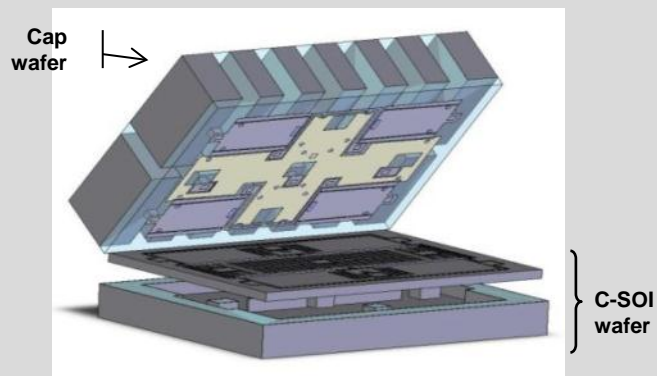




# Best-in-class sensor performance

## Murata 3D MEMS technology

- Stable capacitive sensing
- Single crystal silicon
- Thick, symmetrical 3D structures
- Glass cap wafer for insulation
- Hermetic sealing by wafer bonding
- Designs optimized for application requirements starting from operation principle



## Superior product properties

### High reliability

Best-in-class, proven measurement accuracy over lifetime in harsh environments (temperature, humidity)

### High robustness

Excellent performance in vibrating environments, tolerates extreme mechanical shocks

### Small size

Enabling design of smaller systems with lower costs

### Low power consumption

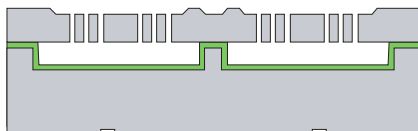
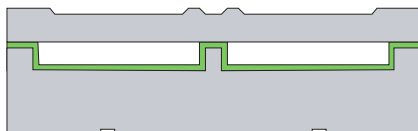
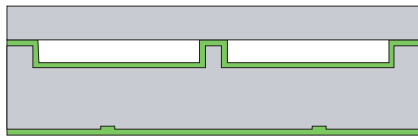
High insulation resistance and large capacitance dynamics enable ultra-low current consumption circuit designs

# MEMS process contributing to performance

## C-SOI platform overview

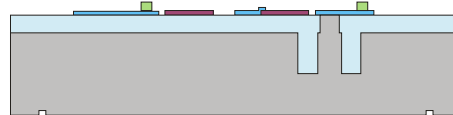
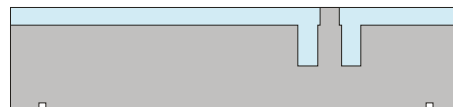
### Structure wafer

1. Cavity-SOI
2. Recess
3. Structure release



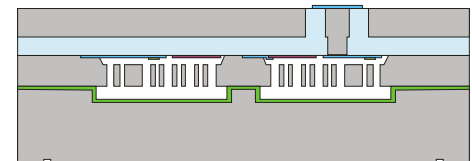
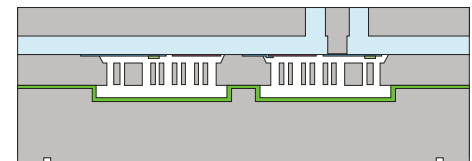
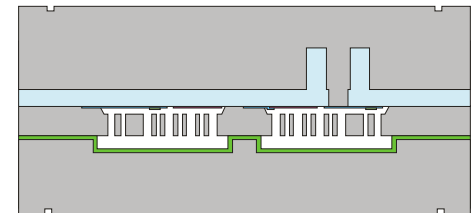
### Cap wafer

1. Feed-through pillars
2. Glass process
3. Thin film process



### Combined wafer

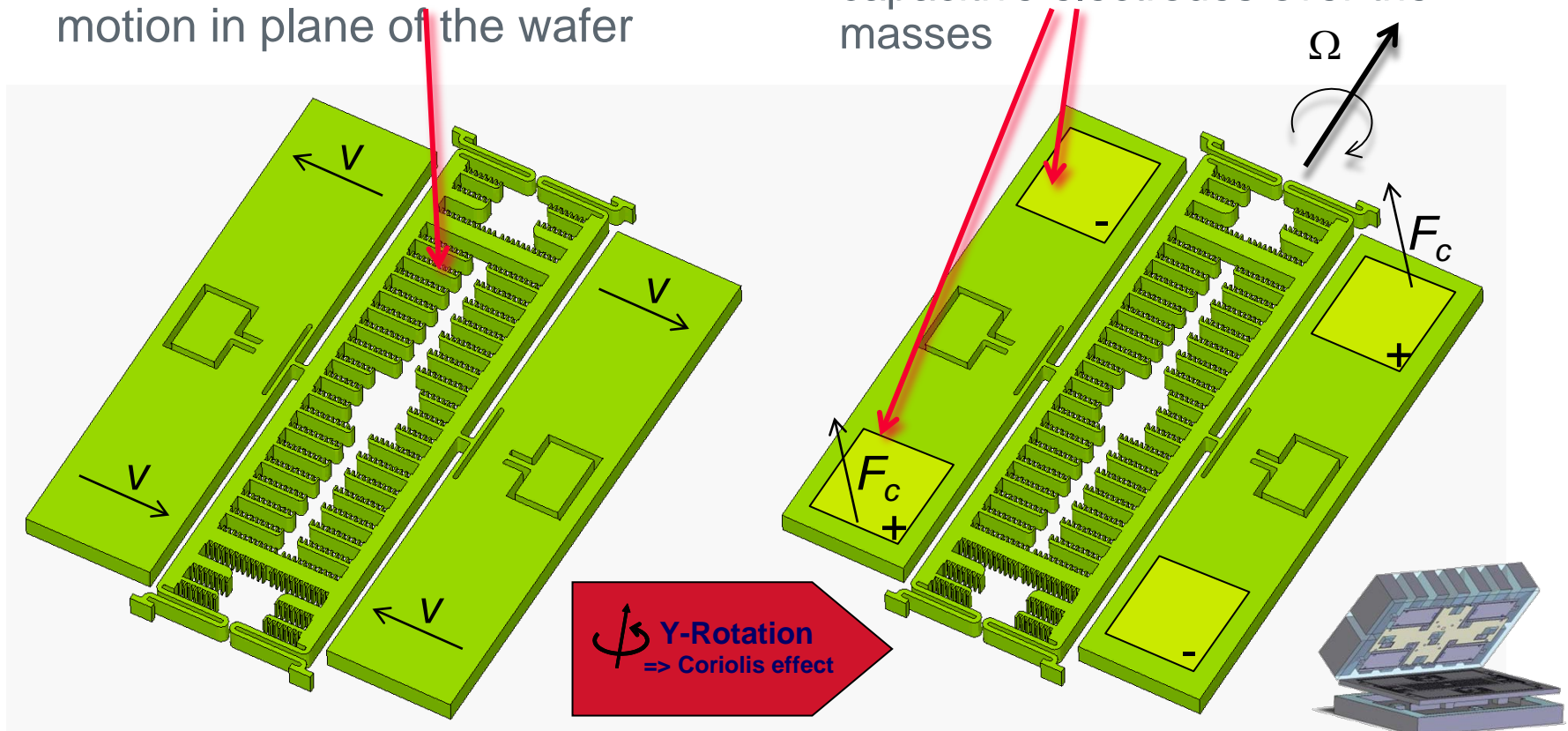
1. Anodic bonding
2. Cap wafer grinding
3. Metallization



# MEMS Design contribution to performance

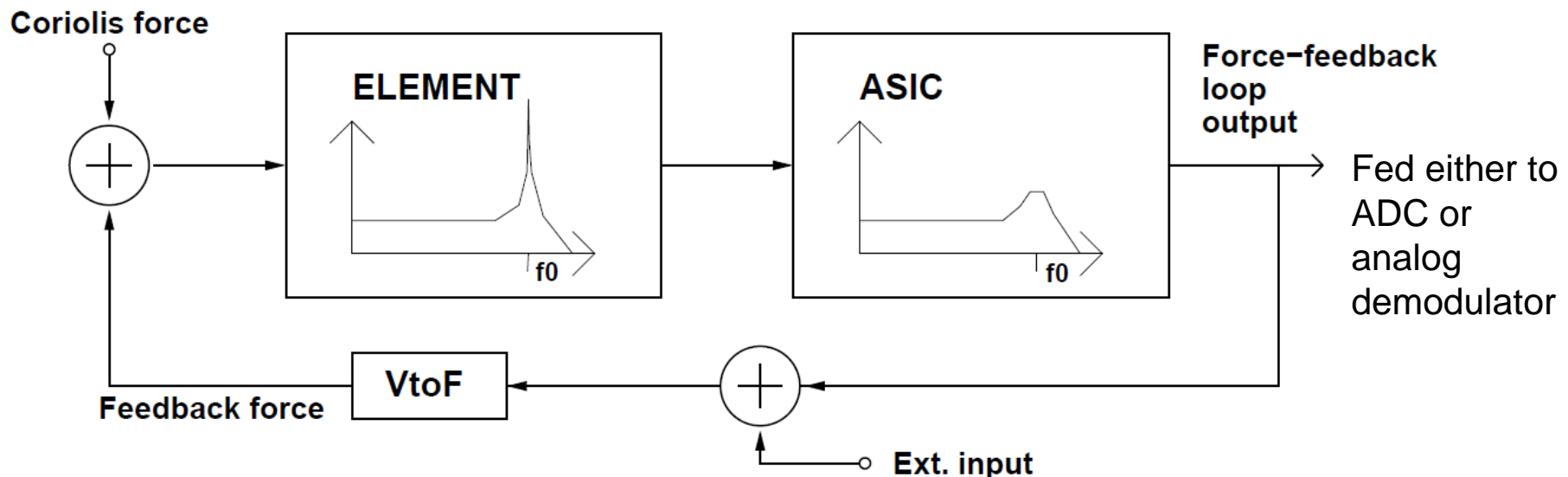
## Example of X-gyro operating principle

- Capacitive linear comb structure between the masses excite and detect the anti-phase drive motion in plane of the wafer
- Out of plane displacement induced by rotation is double differentially detected by capacitive electrodes over the masses



# System architecture contributing to performance

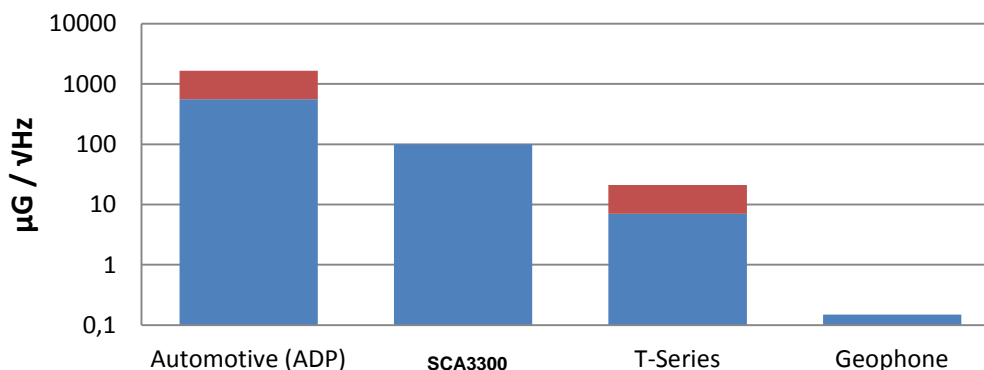
- Figure: Block diagram of closed-loop sense resonator
  - Element: Secondary resonator ( $Q=50-500$ ) with feedback electrode
    - Both primary resonance and secondary resonance designed at  $f_0$ 
      - No active resonance matching is needed
  - ASIC: Continuous-time CtoV-converter and high-Q (3-10) LPF with resonance frequency ( $f_0$ ) same as that of the element
  - Positive DC feedback



# Some performance metrics for reference

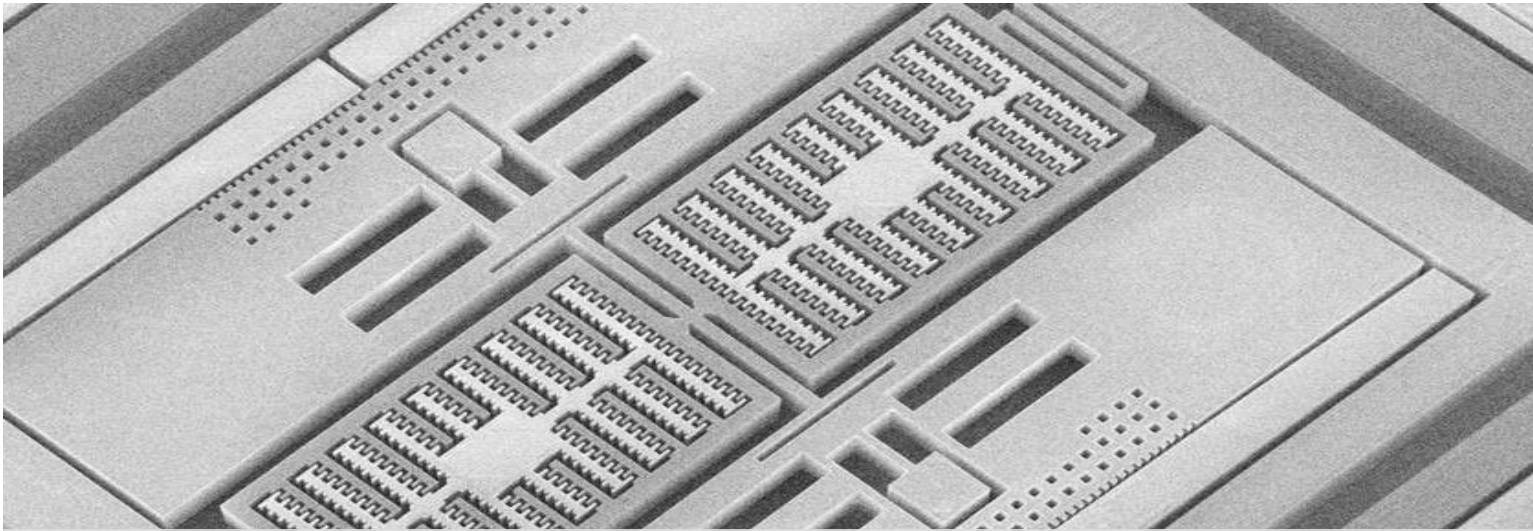
Parameter	Product SCC2XXX	Comment
Rate noise density	0.008°/s /√Hz	Short term positioning
Rate bias instability	2 °/h	Long term integration
Rate offset error	±1.0°/s	Can be compensated partly
Rate sensitivity error	2%	Dynamic angle estimation
Accel offset error	± 50 mg	Angular accuracy < ± 5 mg (SCA103T)
Accel sensitivity error	± 20 mg	Contributes in multi-axis and larger angles (max. value, @ 1g)

Accelerometer noise performance (Max values)



## Other values:

- Robustness (vibration)
- Environmental conditions
- Error tolerance
- Safety (ISO26262)



## Murata 3D MEMS technology

- Capacitive sensing principle, Cavity-SOI technology, DRIE etching
  - Wafer level capping and packaging for chip scale system in package
  - Innovative accelerometer and gyro designs and detection architectures
- Resulting in robust, small sized MEMS and low power products*