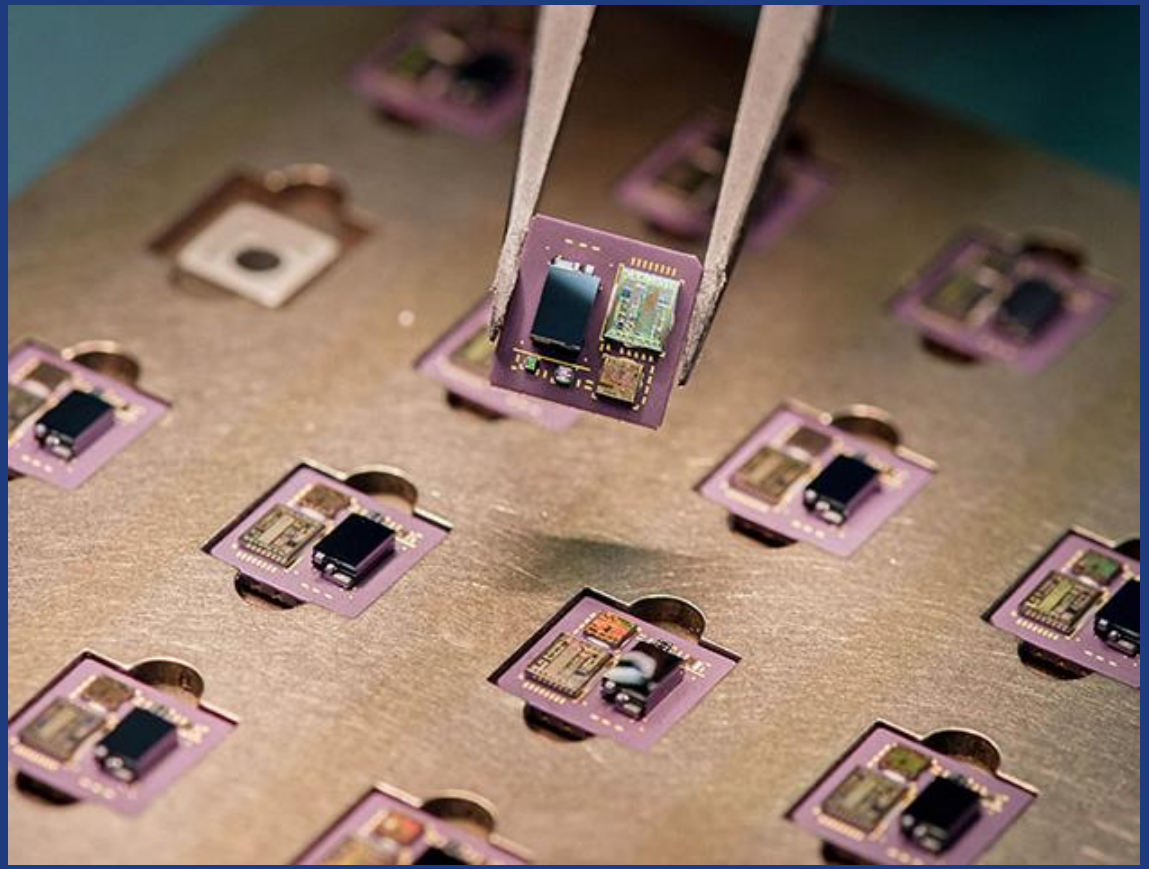
ELECTRONICS & DEFENSE

Industrial Seminars Micro 534
Advanced MEMS

Safran Navigation and Timing: High performances of MEMS inertial sensors

04/03/2025 EPFL



SAFRAN

Nadège Frantz
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Nadege.frantz@sensingch.safrangroup.com

Agenda

01
Safran group

02
Safran Electronics & Defense
Focus on Navigation and Timing

03
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Safran STS
Business model

05
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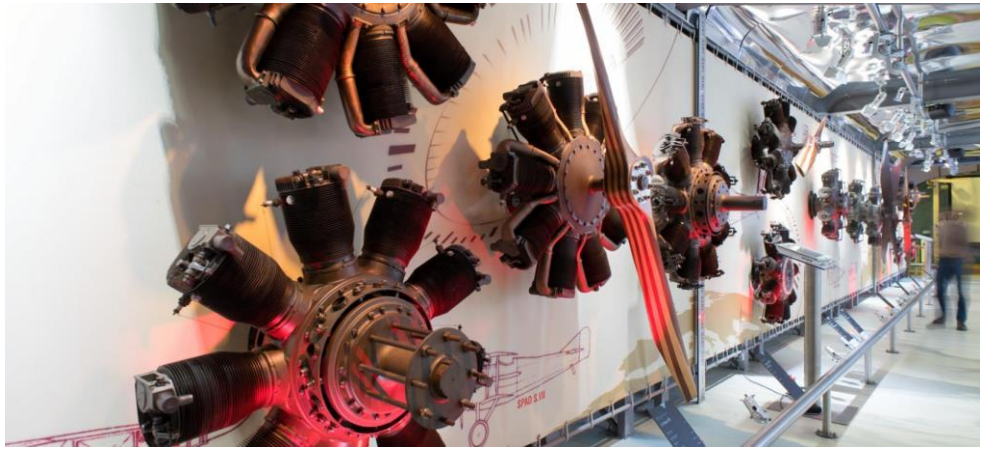
Competitors & Competition

06
Safran STS
Technologies



Safran Group

Chapter 01

SAFRAN

SAFRAN group

INTERNATIONAL **HIGH-TECHNOLOGY** GROUP

More than 100,000 employees in 276 locations across 27 countries

OUR WORLDWIDE PRESENCE

2025

- Australia
- Belgium
- Brazil
- Canada
- China
- Czech Republic
- Finland
- France
- Germany
- India
- Ireland
- Japan
- Malaysia
- Mexico
- Morocco
- Netherlands
- Norway
- Poland
- Republic of Korea
- Singapore
- South Africa
- Spain
- Switzerland
- Taiwan
- Thailand
- Tunisia
- United Arab Emirates
- United Kingdom
- United States
- Viet Nam

61% of employees located in Europe

€ 27 billion in revenues in 2024

3rd Aerospace company worldwide

This global presence reflects the Group's determination to offer its customers responsive, local services and to optimize its competitiveness

3 CORE BUSINESSES

Aviation

Space

Defense

SAFRAN

SAFRAN group

INTERNATIONAL **HIGH-TECHNOLOGY** GROUP
A french story

TECHNOLOGIES & PEOPLE

THIS YEAR WE CELEBRATE OUR 100TH ANNIVERSARY,
THE PASSION LIVES ON, AND OUR FUTURE IS EXCEPTIONALLY PROMISING

WE FOUND OUR WAY
BECAUSE WE ARE DRIVEN BY THE SAME PASSION, A COMMON DESIRE

1925
Creation of the company "Société d'Applications Générales d'Electricité et de Mécanique" (**SAGEM**) by Marcel Môme. Originally focused on mechanical equipment, the company quickly specializes in precision equipment for the French navy.

1965 – First inertial system

1945
Gnome & Rhône is nationalized and renamed **SNECMA** (Société Nationale d'Etude et de Construction de Moteurs d'Aviation), which also consolidates most French aero-engine manufacturers, some dating back to the turn of the century.

1974 – CFM56 Turbofan

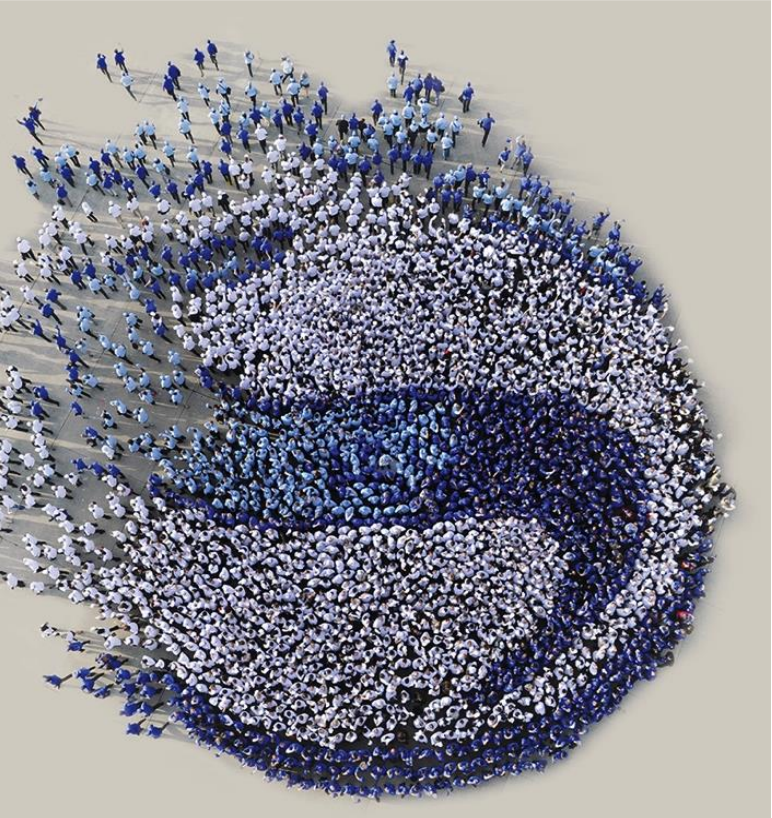
1997 - Space

2005
Safran is created by the merger of **SNECMA** and **SAGEM**. The group specializes in aerospace, defense and security. Eleven years later, in 2016, all group companies gather under one single logo and their historic names change to reflect the Safran brand.

2018
Safran took control of **ZODIAC** Aerospace, significantly expanding its aircraft equipment activities.

3 CORE BUSINESSES

SAFRAN



Safran Electronics & Defense Focus on Navigation and Timing

Chapter 02

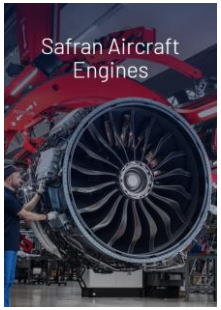
SAFRAN

SAFRAN group
Safran Electronics & Defense

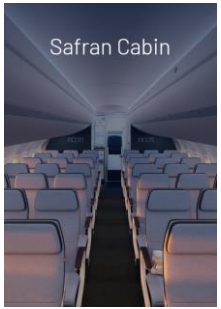
INTERNATIONAL **HIGH-TECHNOLOGY** GROUP
Companies and joint-ventures

Technology partner to aircraft and space manufacturers

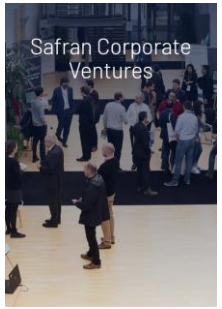
Supplier of systems and equipment for aircraft & helicopters



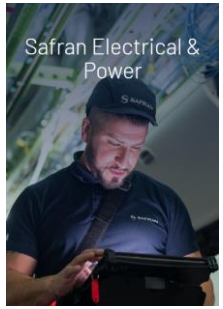
A world-class aircraft engines manufacturer



A world leader in Aircraft Interiors & Systems



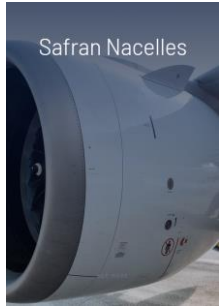
Strategic investor in innovative startups



Smarter electrical solutions for better flight

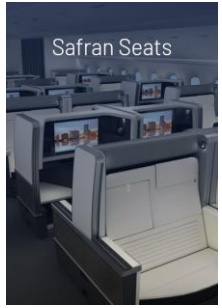
The world's leading manufacturer of helicopter engines

World leader in aircraft landing & braking systems



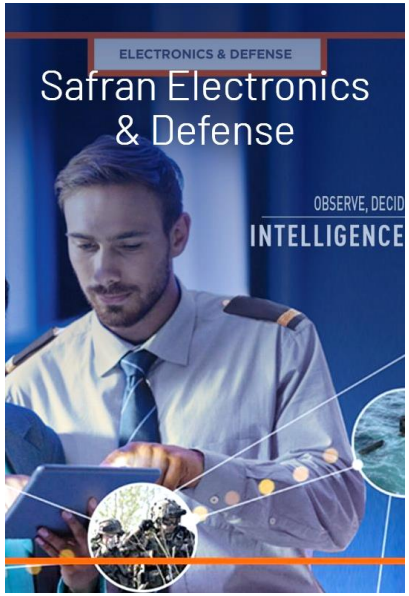
A worldwide leader in aircraft engine nacelles & services

Connected Inflight Experiences for Today & the Future



Passenger & technical aircraft seats

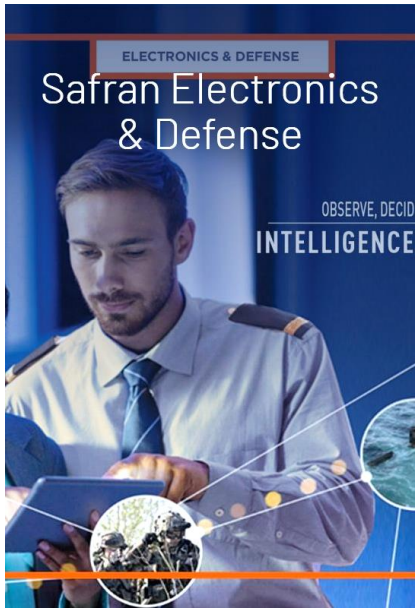
The world leader in mechanical power transmission systems



Observe, Decide, Guide Intelligence Onboard

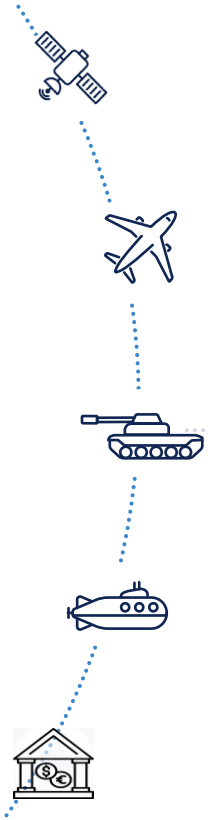
SAFRAN Electronics & Defense

Intelligence Onbord



Observe, Decide, Guide
Intelligence Onboard

14,000 employees worldwide



Observe

No.1
COMPANY IN EUROPE FOR TACTICAL UAV SYSTEMS

- **Discern** the environment
- **Detect** movement
- **Collect data**

Decide

No.1
WORLDWIDE FOR HIGH PERFORMANCE SPACE AND ASTRONOMICAL OPTICS

- **Analyze** the environment
- **Ensure** data integrity
- **Control** critical systems

Guide

European leader IN INERTIAL NAVIGATION SYSTEMS

No.1
COMPANY IN EUROPE FOR INERTIAL NAVIGATION SYSTEMS

- **Control** orientation
- **Navigate** with precision
- **Hit** a target
- **Drive** movement

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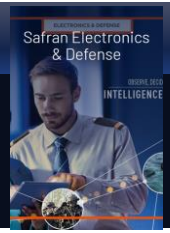
SAFRAN Navigation & Timing

Business Unit of SAFRAN Electronics & Defense

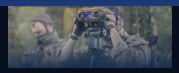
Business Unit of SED



Safran Electronics & Defense

Observe, Decide, Guide Intelligence Onboard


Aviation

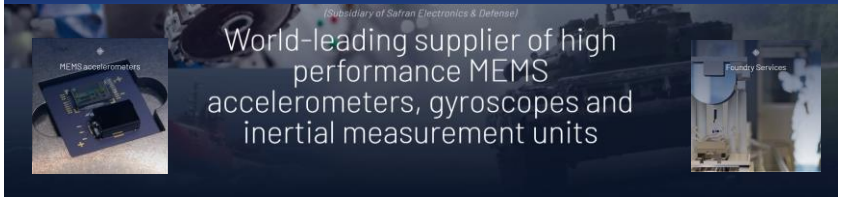

Defense


Space

Safran Navigation & Timing

Inertial sensors

Safran Sensing Technologies



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MEMS Accelerometers

COLIBRYS

Spin off from CSEM

Acquisition in 2013 by Safran

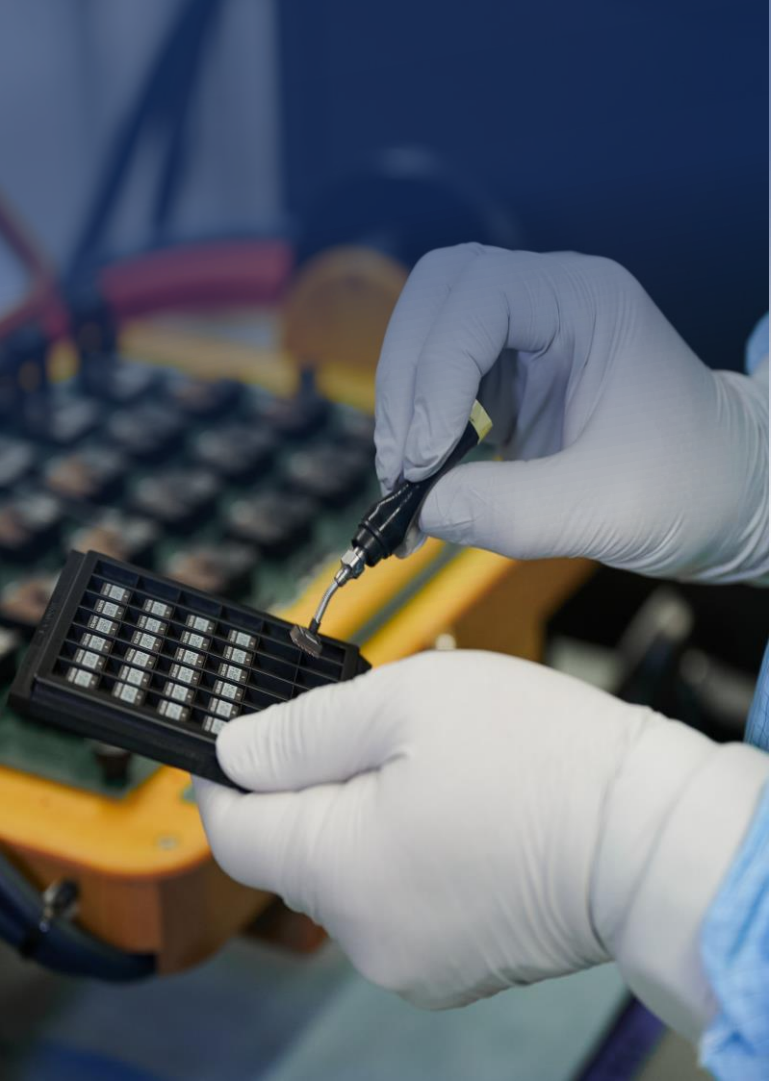
Safran Sensing Technologies Norway

Gyro MEMS

sensonor

Acquisition in 2021 by Safran

SAFRAN



Safran Sensing Technologies Switzerland

Chapter 03

SAFRAN

SAFRAN Sensing Technologies Switzerland

Overview

SAFRAN
Navigation & Timing

SAFRAN

SAFRAN
Navigation & Timing

Safran Sensing Technologies Switzerland at a glance

60 employees
Located in Yverdon, Switzerland

30 years
Experience in MEMS

7 distributors
To support our customers worldwide

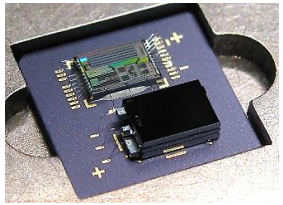
85 patents
To protect our knowledge

MEMS world leader
World leader in high-performance MEMS Accelerometers

+20 millions
MEMS produced

20%
Invested in Research & Development

6 inches
Wafer foundry proprietary



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SAFRAN STS Business Model

Chapter 04

SAFRAN Sensing Technologies Switzerland

Business model

SAFRAN Navigation & Timing

The business model is based on the following elements

1) Development, manufacturing in-house and sale (**Proprietary products)**

2) **High performances** of MEMS inertial sensors designed for **harsh** environment and **safety** critical applications

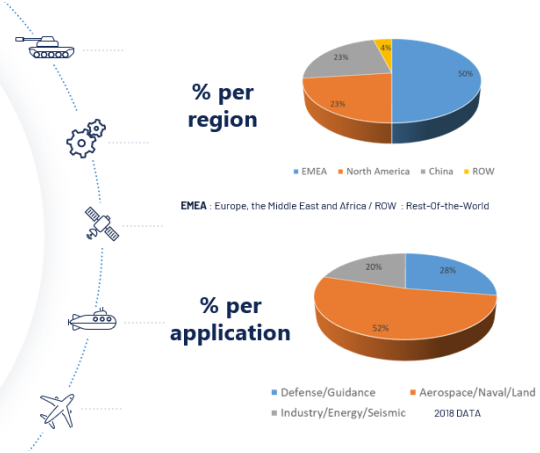
3) MEMS inertial sensors available to respond to many applications (**Versatile sensors**)

High performance sensors using MEMS for harsh environment and safety critical applications

MEMS applications

Same accelerometers or vibration sensors available to respond to many applications

MEMS sales



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MEMS performances

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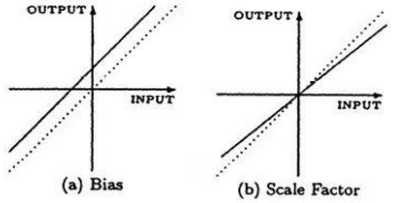
Key factors to measure accelerometers performances



High + +

Grade of Accelerometers

Low --

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Products & Portfolio

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Navigation & Timing

INERTIAL SENSORS 2g - 100g

long term bias repeatability 1.2 mg

Cost-Effective version

Aerospace and Defense

MS1000
Tactical Grade Performances
IMU, AHRS, north finding

MS1000L
IMU

HIGH TEMP SENSORS 2g - 30g

high temp up to 175°C

Oil & Gas

TS1000T
Measurement, logging while drilling (MWD, LWD)

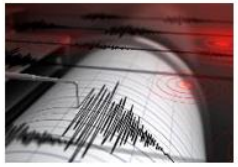
MS1000T
LWD, MWD (Drilling), RSS (Rotary steerable system) high performance

VIBRATION SENSOR 2g - 200g

high bandwidth up to 7 kHz

Industrial

VS1000
Low-noise vibration sensor, Instrumentation, Railway, Machine and Structural health monitoring



SEISMIC SENSOR 3g - 5g

ultra low noise 1µg/√Hz

Industrial

SI1000
Seismic sensor class B, Structural health monitoring

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MEMS accelerometers markets: Average Selling Price

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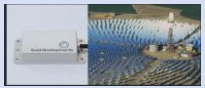
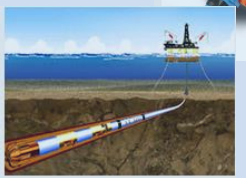
	Consumer	Automotive	Industrial Control , Medical	Tactical High-end (Avionics, Military- Energy,T&M)	Very High end / Niche (Oil Exploration – Nav. system)
Average **sale Price** (1 axis)	<1 $	1-10 $	10-50 $	50-150 $	>150 $
Applications	   	  	            	        	     

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Applications & Market

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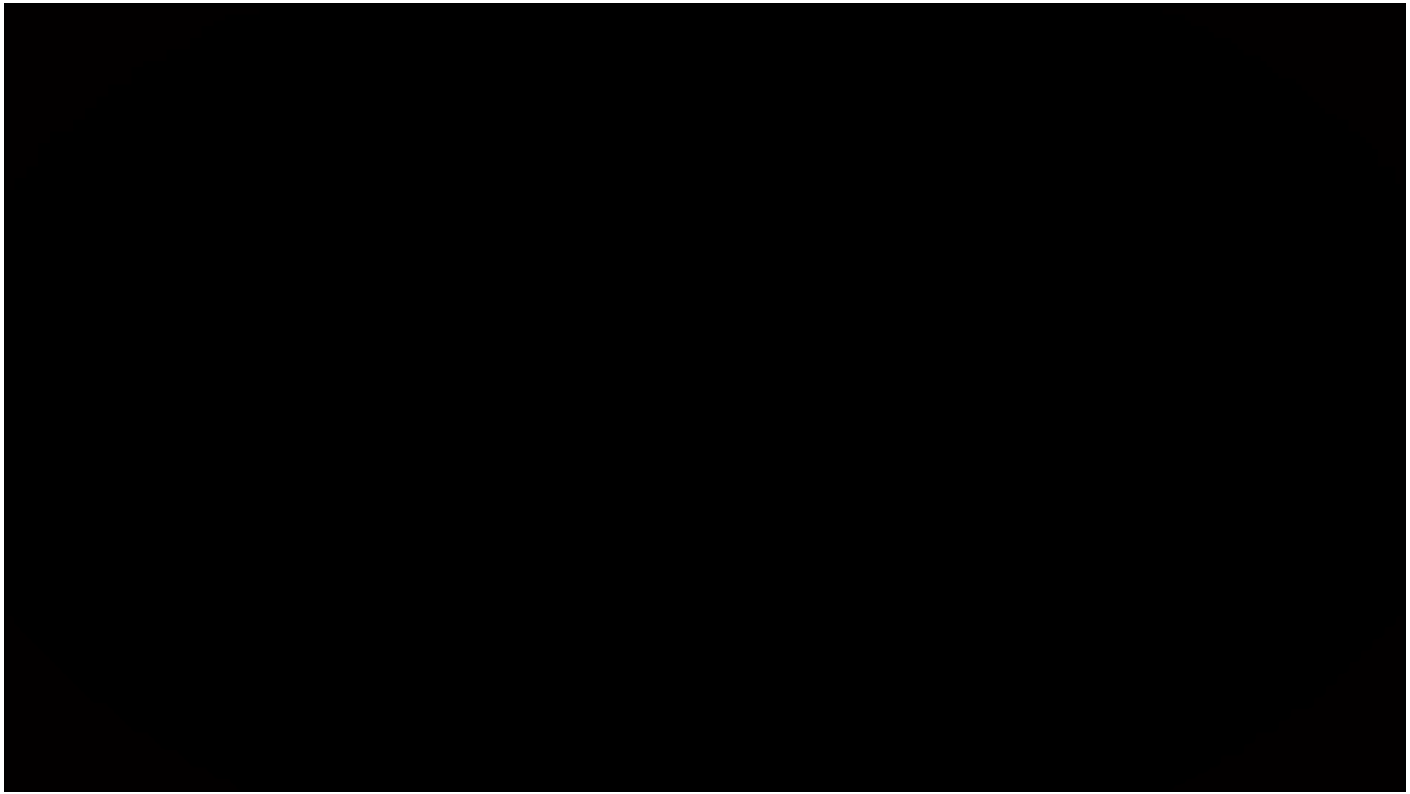

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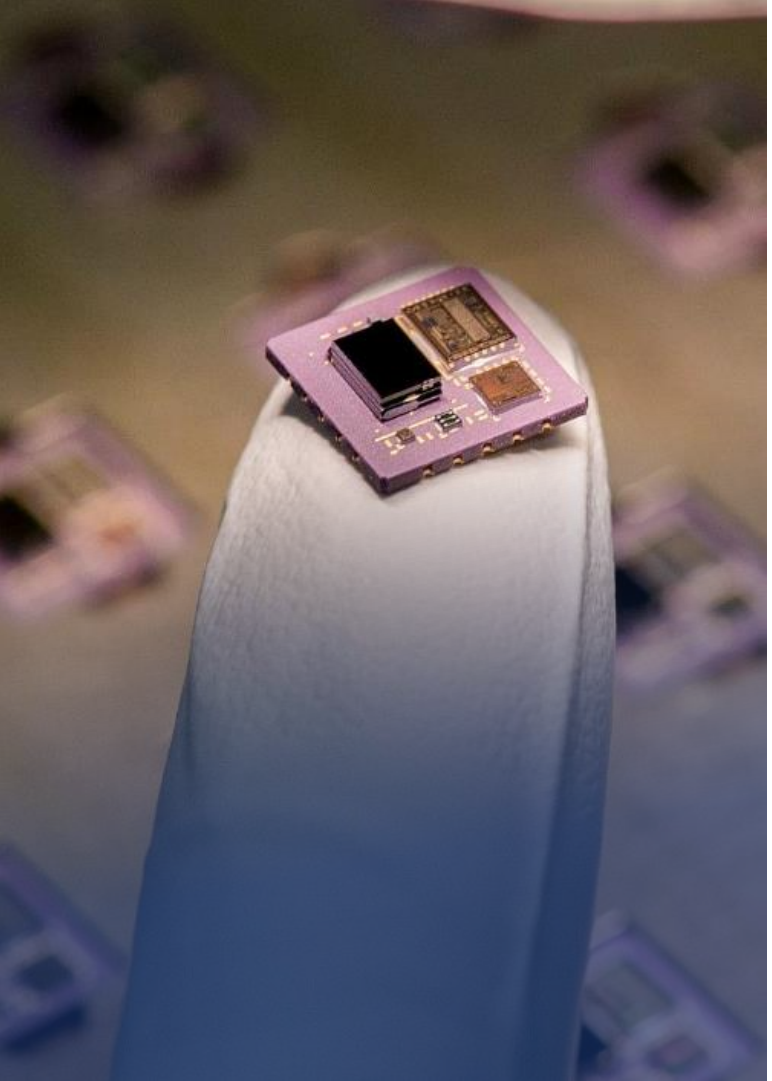

SAFRAN STS
Competitors & Competition

Chapter 05

SAFRAN Sensing Technologies Switzerland

Competitors

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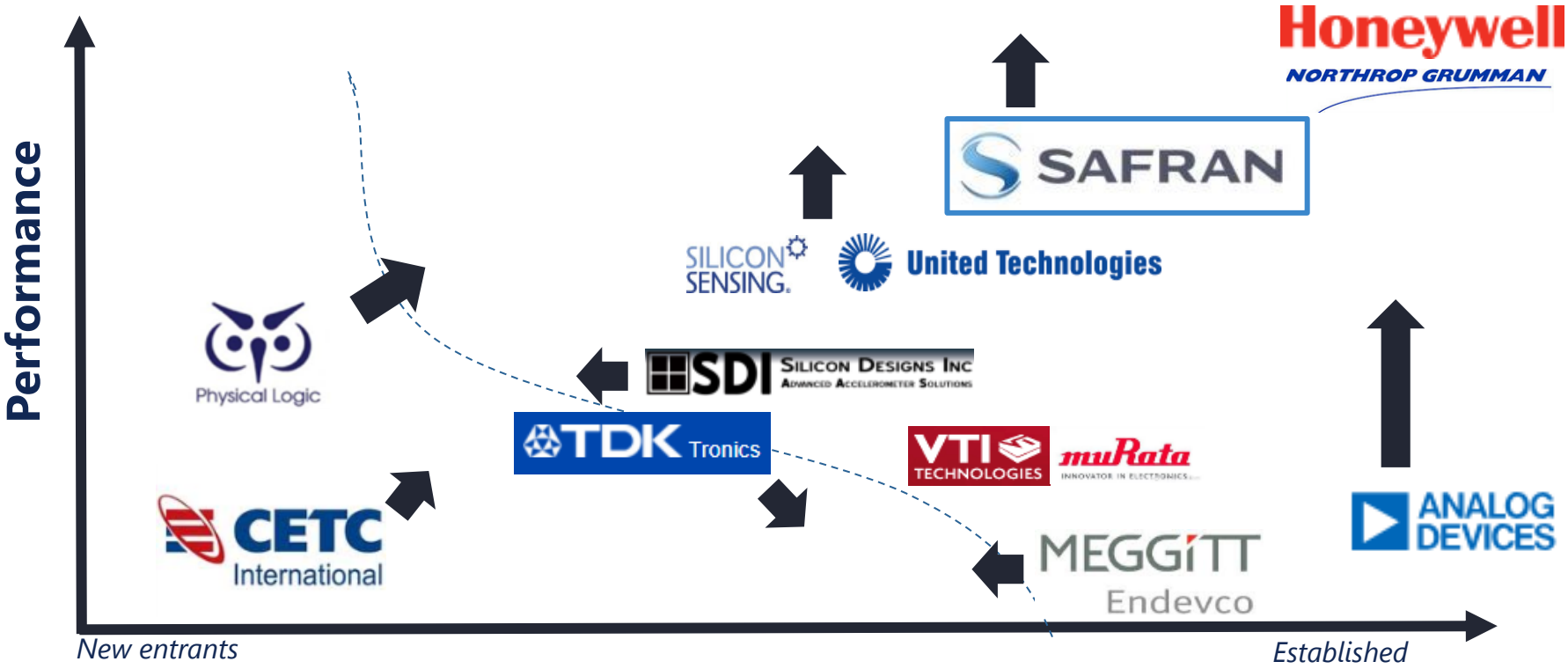

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Our Differentiator: MEMS out of Plane

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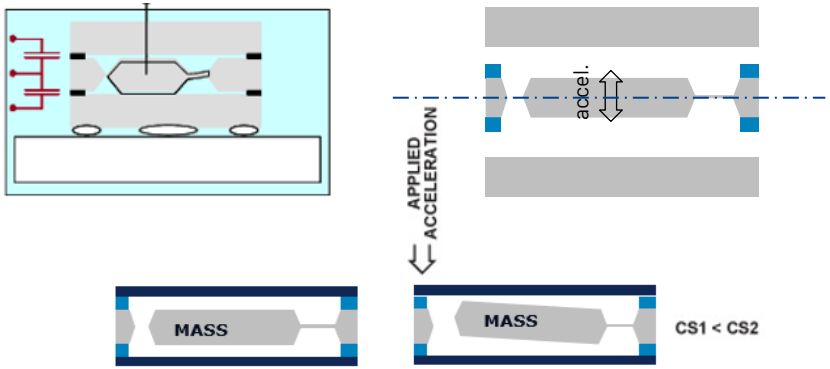
J-M. Stauffer, O.Dietrich, B. Dutoit, RS9000, "a Novel MEMS Accelerometer Family for Mil/Aerospace and Safety Critical Applications", IEEE/ION Position Location and Navigation Symposium (PLANS), May 4-6 2010, Indian Wells, California, USA

Safran Navigation & Timing MEMS accelerometers are all based on Out-of-plane detection. This design offers outstanding performances.

Out-of-plane detection

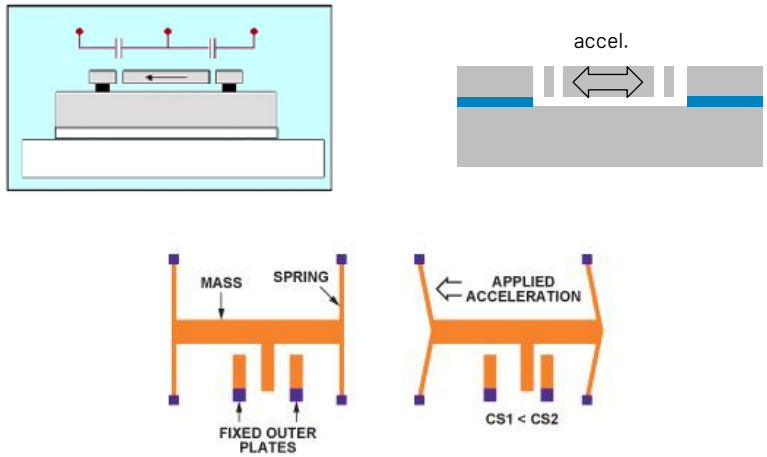
« Bulk »



Vs

In-plane detection

« Surface »



Low noise and High stability

Reliability over shocks & temperature

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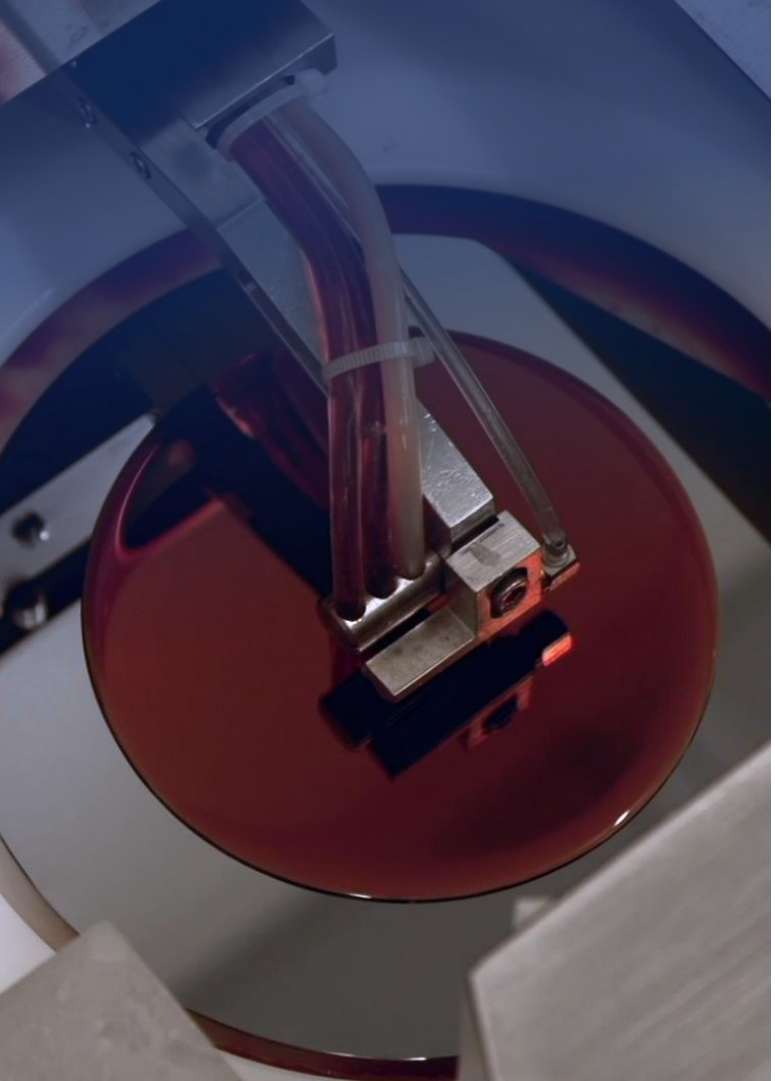

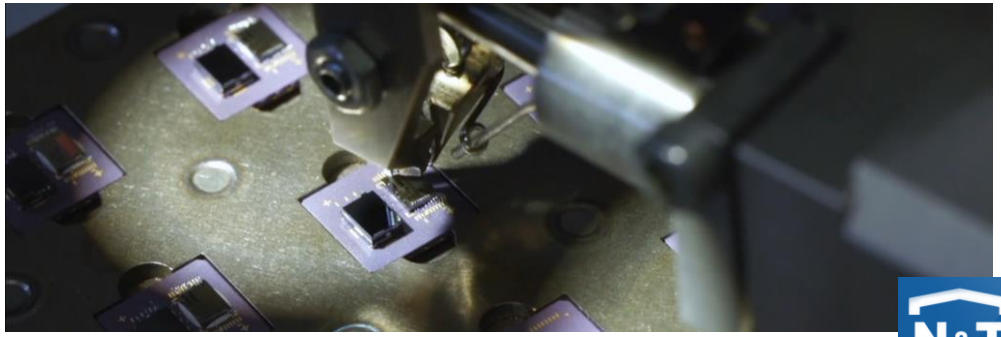

SAFRAN STS Technologies

Chapter 06

SAFRAN Sensing Technologies Switzerland

MEMS from design to manufacturing

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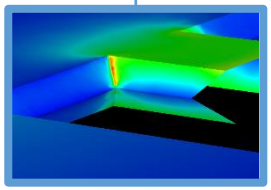
Navigation & Timing

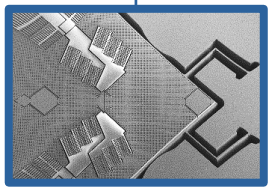
Development, manufacturing in-house and sale of **proprietary products**

MEMS sensor and system design



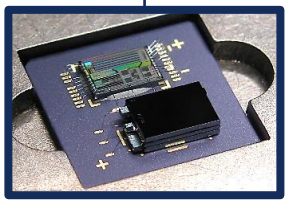
- High performance mechanical design of MEMS chip: robust, low noise and high stability

Silicon wafer processing



- Multi-stack all-silicon processes for capacitive motion sensors
- Bulk micromachining: Precision alignment and DRIE etching processes

Assembly and Testing



- Low stress MEMS die-attach
- Assembly for high-shock environments
- Miniaturized hermetically sealed multi-chip packaging

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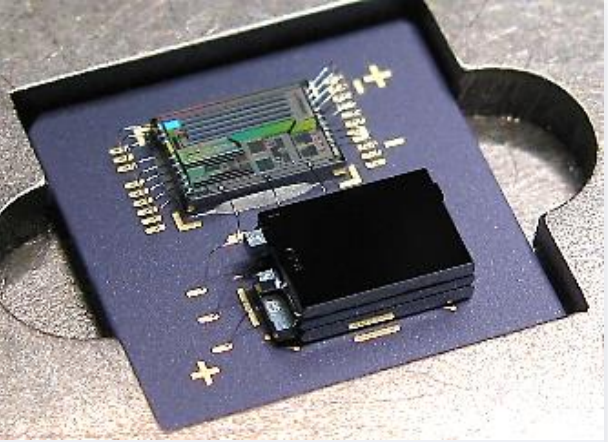
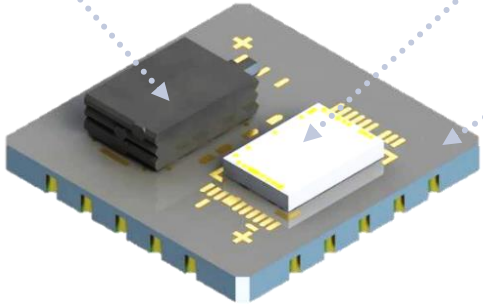


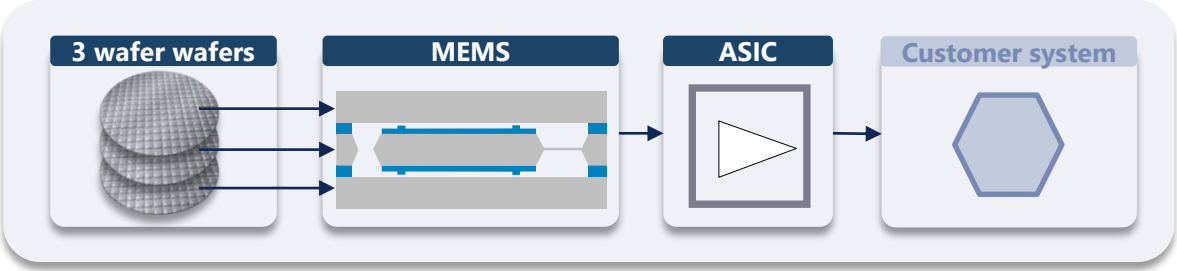
- Silicon micro-machined sensor chip
- High-end dual side alignment and photolithography
- 3 wafers assembly by silicon fusion bonding (SFB)

MEMS | **ASIC** | **Package**



MEMS capacitive accelerometer

Our technology



SAFRAN Sensing Technologies Switzerland

Front-end process (Wafer Fab)

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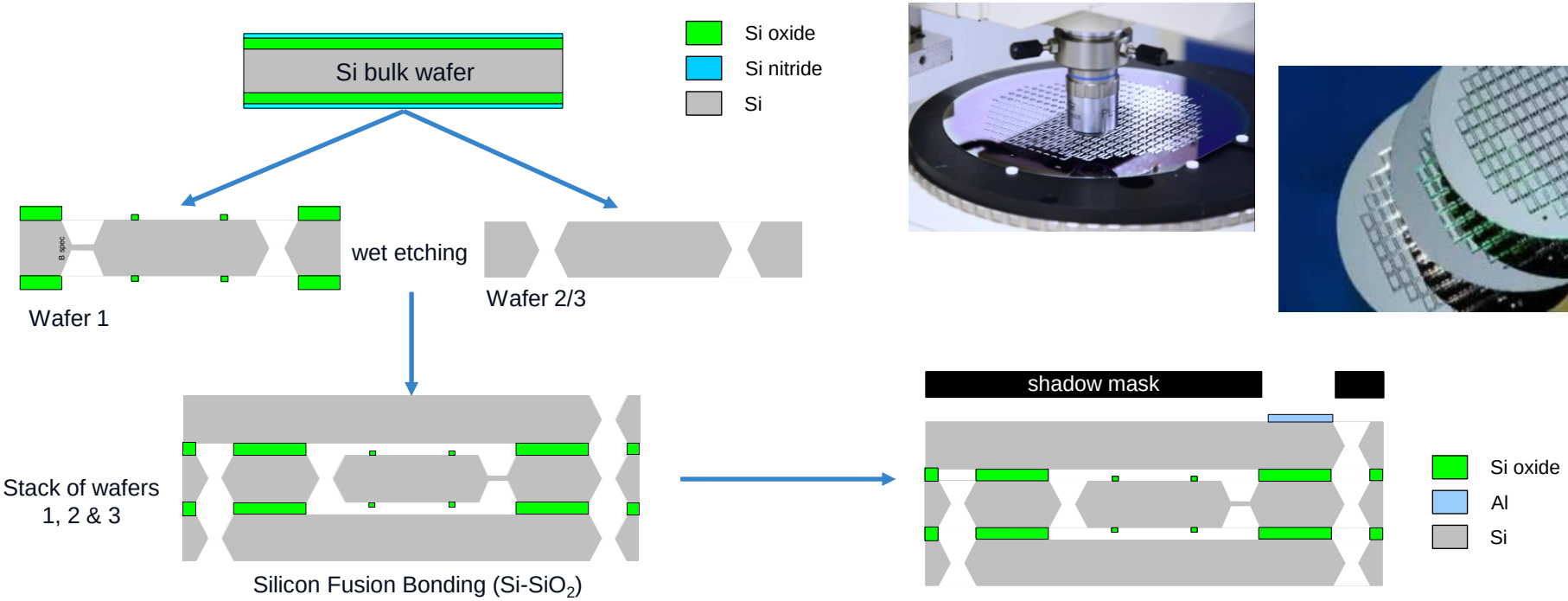
Machining is performed using **microtechnologies** and silicon fusion bonding



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Front-end process (DIE singulation)

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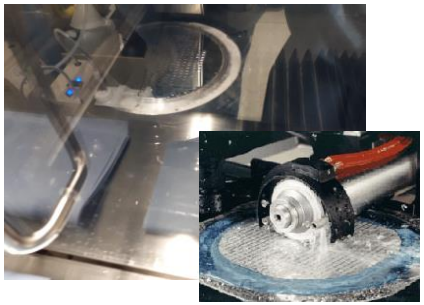
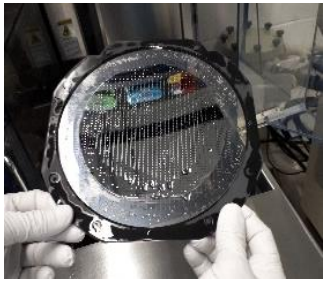
Navigation & Timing

1) Dicing of 3 wafers stack

Performed on UV tape



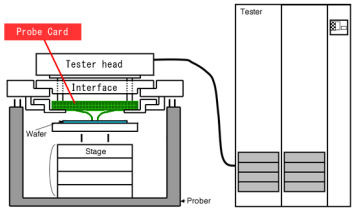


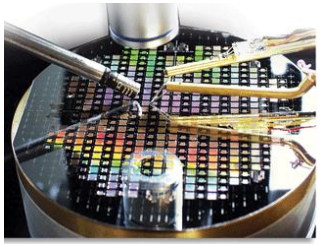
2) Electrical tests on each MEMS

Directy perfomed on tape on all MEMS

Parameter measurements related to accelerometer functionality

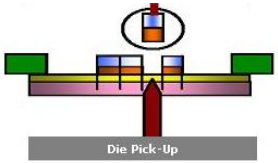
Capacitance, resistance, sensitivities, stifness

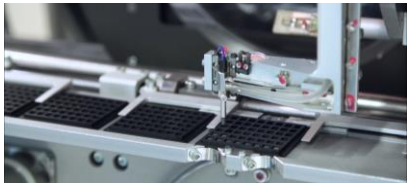




3) Die pick-up

Die separation from tape, pick-up and storage into boxes





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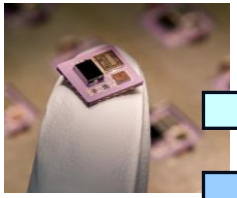
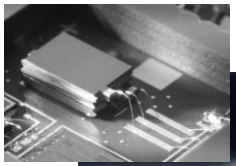
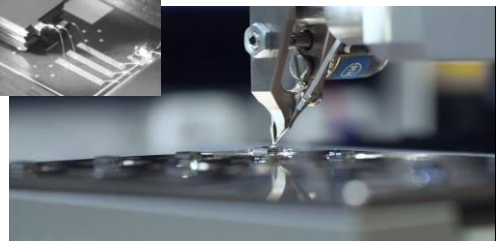
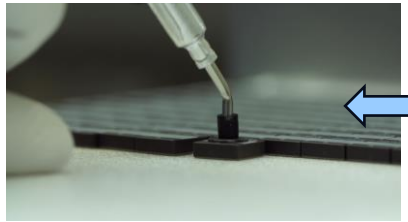
Back-end process

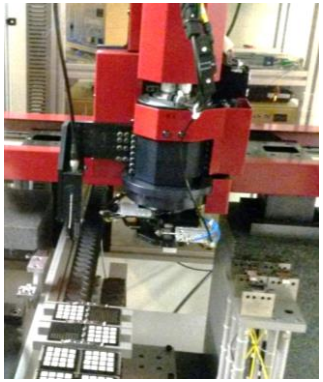








- Assembly
- Optical control
- Wire bonding
- Optical control
- Lid sealing
- Leak checks
- Dynamic test
- Static test
- Final inspection
- Delivery / C o C



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Last words about Our Values

SAFRAN
Navigation & Timing

HSE

NOUS FORMONS DES PROS. ENTREPRISE FORMATRICE
FORMATIONPROFESSIONNELLEPLUS.CH

CO_2 &kWh reduced
WE ARE ON BOARD 2016
ENERGY AGENCY
SWISS PRIVATE SECTOR

swiss safety center
ISO 9001
ISO 14001
ISO 45001
certified system

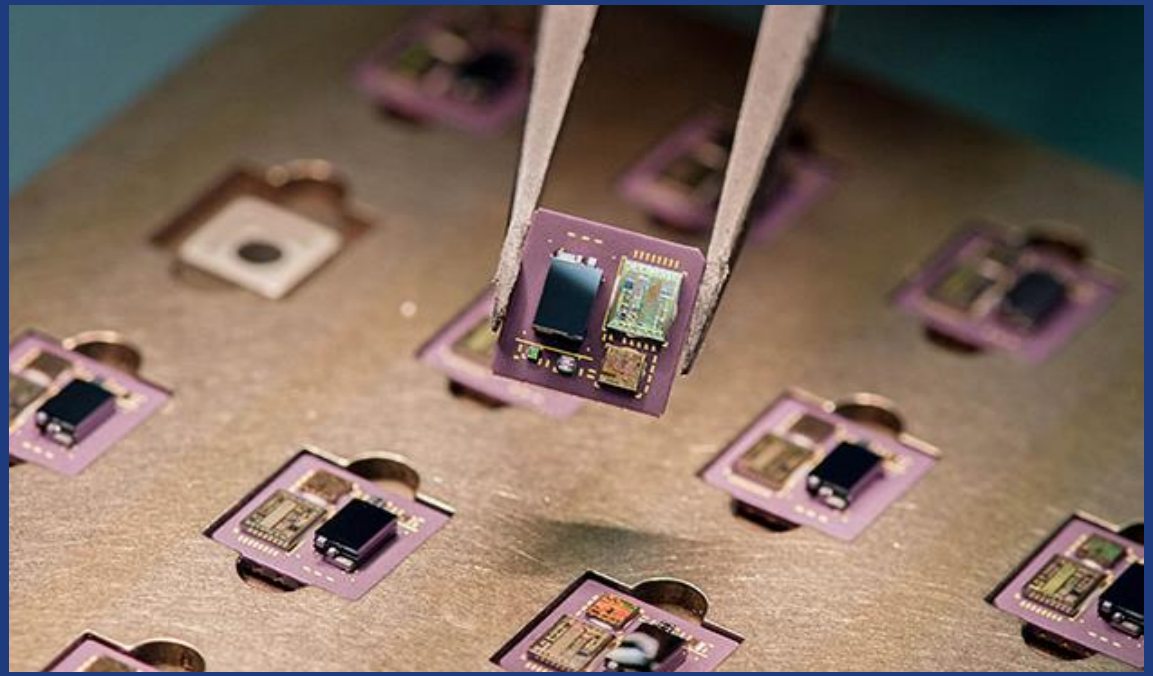
COMPLIANT · COMPLIANT
REACH

COMPLIANT · COMPLIANT
ROHS

SAFRAN

ELECTRONICS & DEFENSE

Thank you for your attention



Safran Navigation and Timing: High performances of MEMS inertial sensors

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