# Electronics and Measurements Research Group

**RESEARCHERS:** 2 full professors (Ada Fort and Valerio Vignoli), 2 associate professors (Marco Mugnaini and Tommaso Addabbo), 4 Temporary Assistant Professors A (Enza Panzardi, Elia Landi, Lorenzo Parri and Riccardo Moretti), Technical Staff (Francesco Nicolelli Fulgenzi and Marco Tani), 3 Research Associates (Irene Cappelli and Stefano Parrino, David Baldo), 6 PhD students.

**DIPARTIMENTO:** Department of Information Engineering and Mathematics

**LAB:** Electronics, Electrical Engineering and Measurements Lab (LEEME)

## Research activity

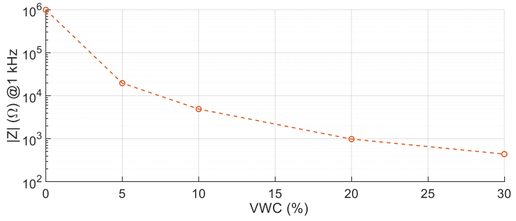
- Development of distributed measurement in the contexts of the Internet of Things and Wireless Sensor Networks.
- Development of innovative solutions for environmental energy harvesting (e.g., autonomous sensor networks for greenhouse horticulture).
- Implementation of embedded solutions on microcontroller platforms and integrated with wireless connectivity.
- Development of data analysis solutions and signal processing based on Embedded Artificial Intelligence and edge processing.
- Development of innovative and prototype sensors.
- Definition and implementation of protocols for characterization and calibration of sensors through dedicated laboratory instrumentation.
- Implementation of open-source data management and visualization systems.
- Laboratory and field measurement campaigns.
- Development of test benches for prototyping and device testing.

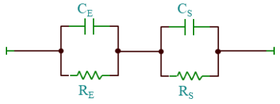
# Research activity

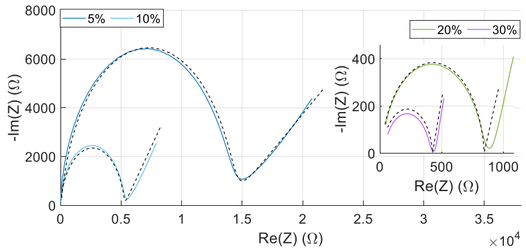
- Design and development of prototype Point of Care (POC) devices for biomedical applications for innovative diagnostic systems such as those based on quartz microbalances and electrical impedance spectroscopy.
- Development of prototype sensing solutions for the measurement of relative humidity and gas concentrations and the realization of related conditioning electronics.
- Development of wearable measurement systems for monitoring biometric and safety parameters in the workplace environment.
- Development of physical and chemical gas sensors for environmental monitoring and for monitoring the operating conditions of combustion plants.
- Development of distributed measurement and monitoring systems for Cultural Heritage.
- Study, realization, and characterization of sensors for vibration measurement in industrial settings and systems for the recognition of failure signatures in ball bearings.
- Development of sensor nodes aimed at monitoring environmental parameters and gas concentrations in the context of Smart Agriculture.
- Development of sensors for soft robots with biomedical applications

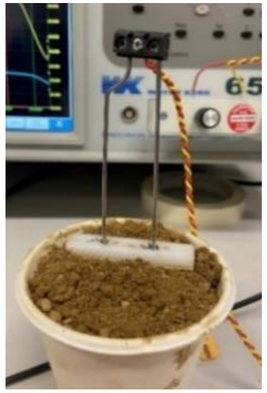
Images

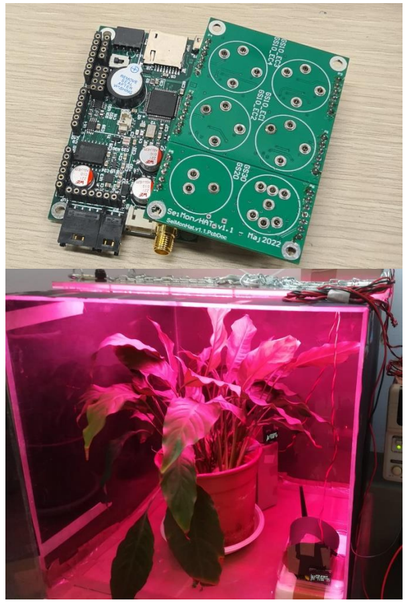
# SMART AGRICOLTURE

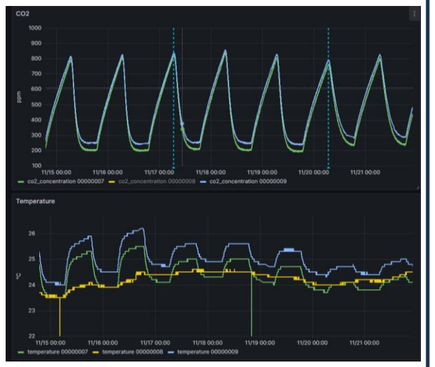



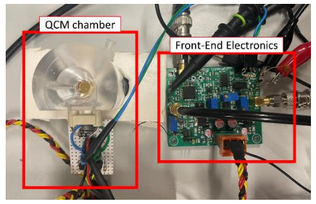



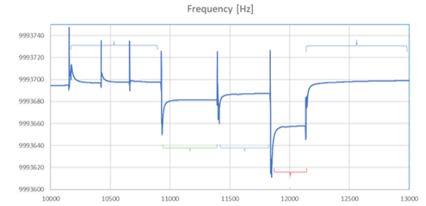


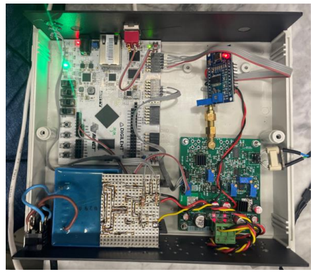


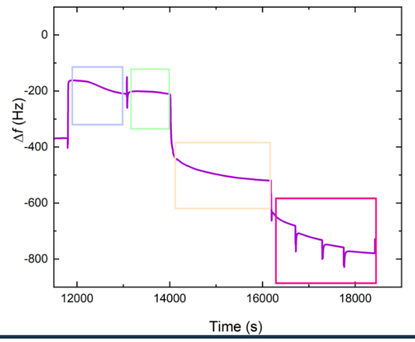
Images

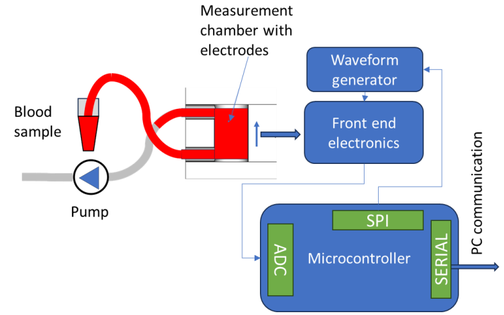
## POINT-OF-CARE DIAGNOSTIC DEVICES

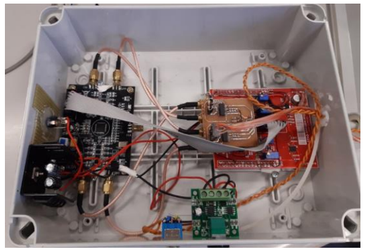


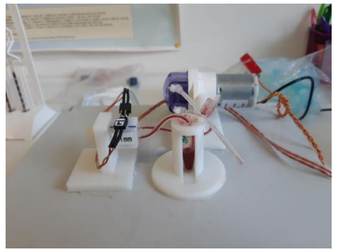



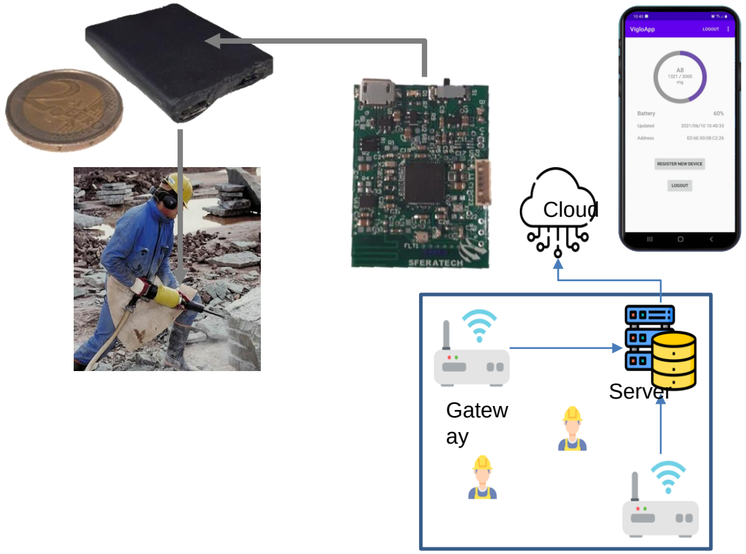


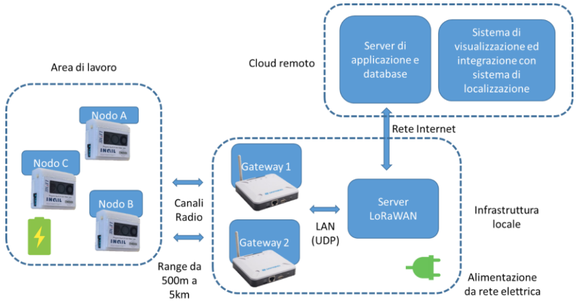





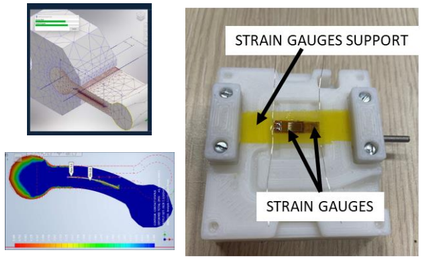
## WEARABLE DEVICES FOR MONITORING BIOMETRIC PARAMETERS AND SAFETY IN WORKING ENVIROMENTAL

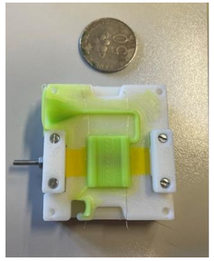


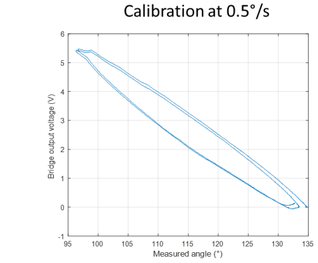



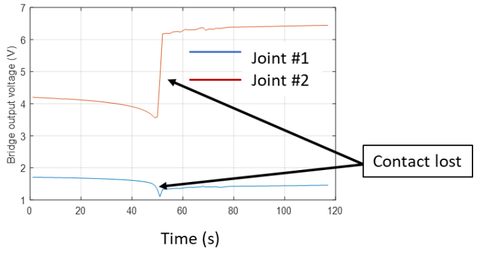
Images

## SENSORS FOR SOFT ROBOTS

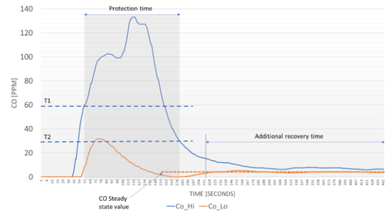


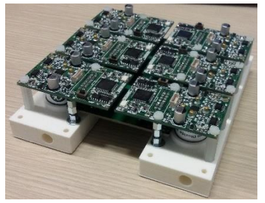





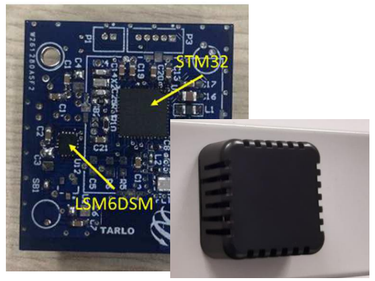




## MEASUREMENT SYSTEMS FOR TOXIC COMPOUNDS IN ENVIRONMENT AND IN FLUE GASES

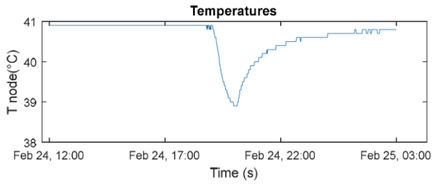


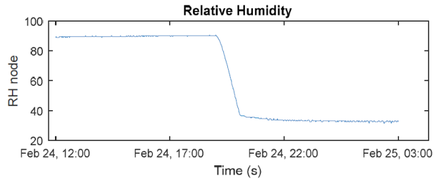



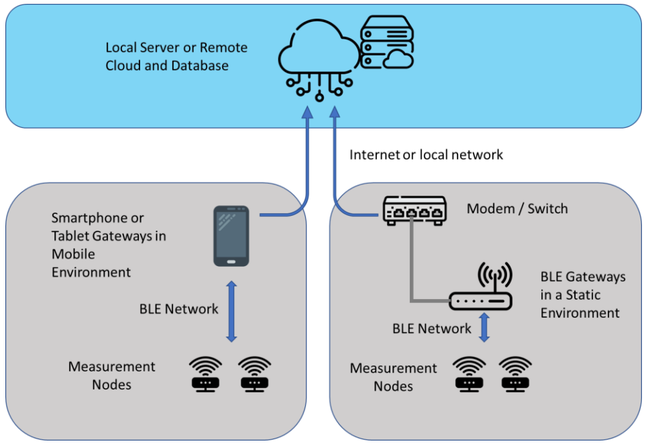
## CULTURAL HERITAGE MONITORING







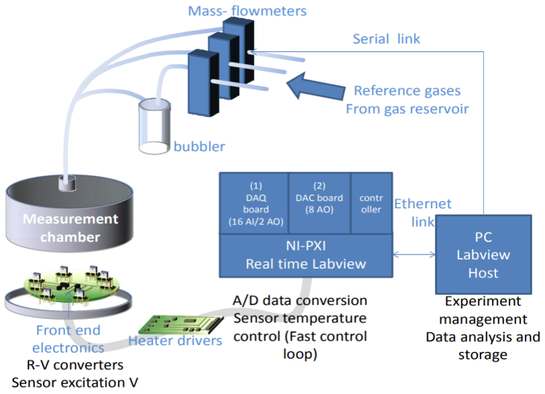



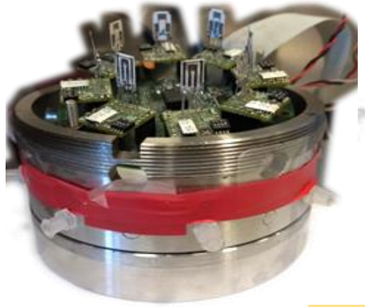



Images

## GAS SENSORS AND GAS MEASUREMENTSYSTEMS BASED ON CHEMICAL SENSORS

### Characterization System for Chemical Gas Sensors



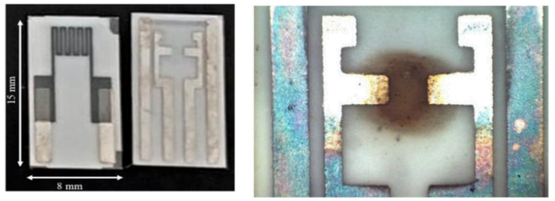



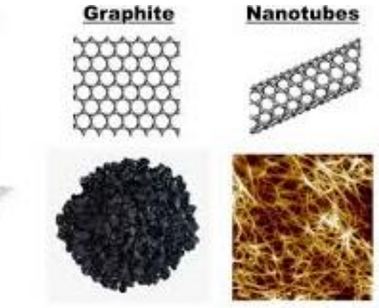
**Automated measurement chain design and data acquisition/processing system**

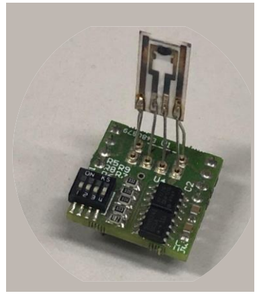
**Target gases:** combustion gases, exhaust gas flow, poisoning and toxic gas for humans

### Development of gas sensors based on innovative materials

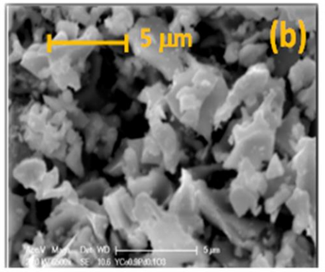
***thin films***



***Carbon nanotubes based material***

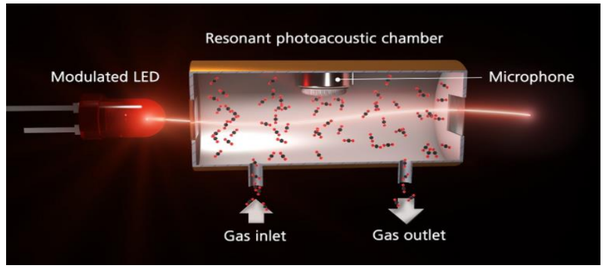


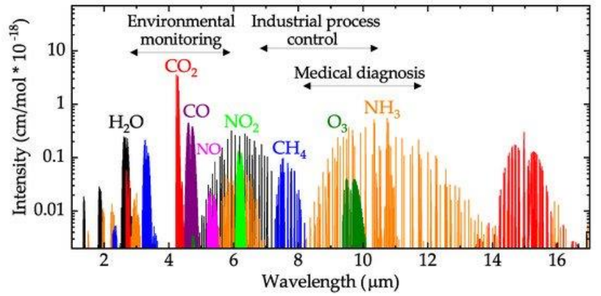

***nanostructured materials***

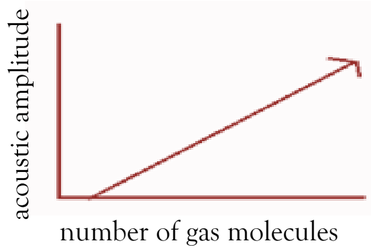
Images

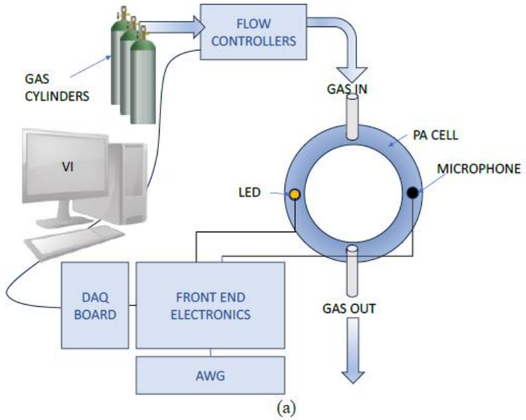
## PHOTOACOUSTIC BASED GAS SENSORS AND MEASUREMENT SYSTEMS

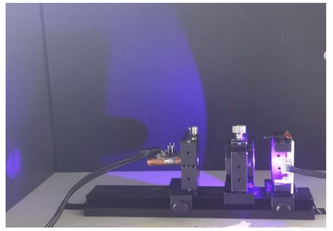
Photoacoustic (PA) based gas sensors measure the pressure changes with the gas exposure inside a measurement cell by means of an acoustic transducer due to an optical stimulus

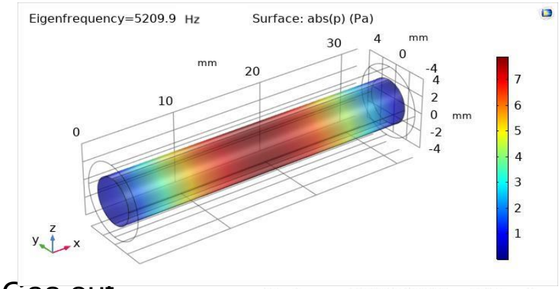


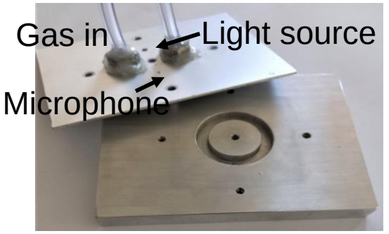



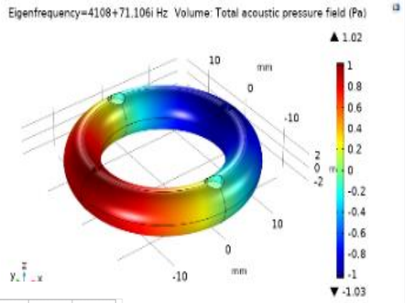



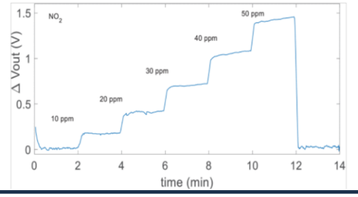









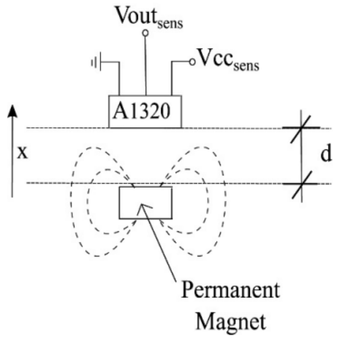

Response to gas

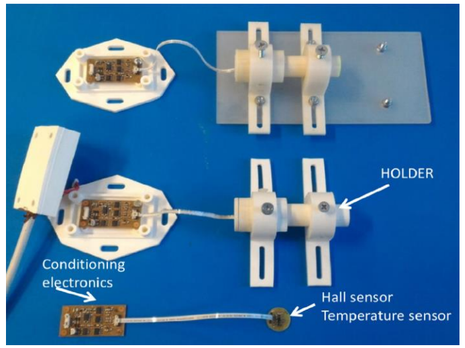
Resonant photoacoustic gas sensors system development and characterization

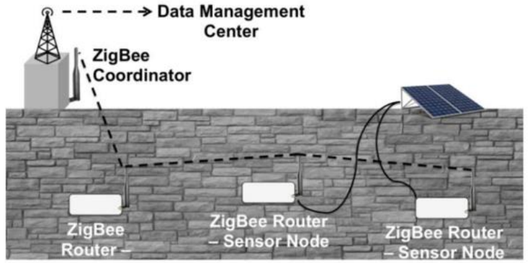
Images

## DISTRIBUTED SYSTEM FOR STRUCTURAL MONITORING

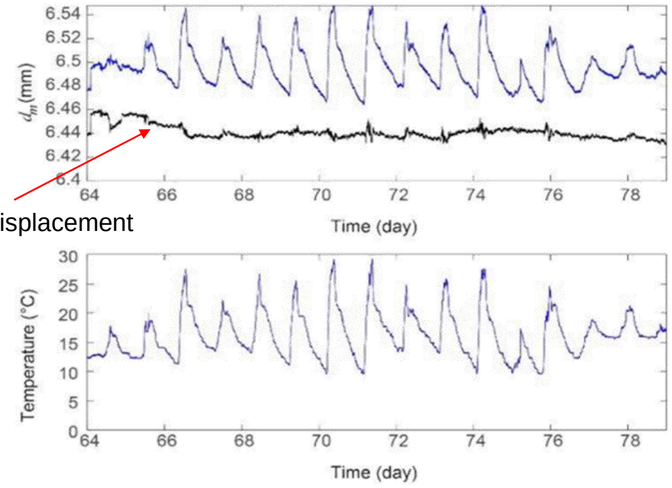
The sensing system is based on Hall sensor technology




The proposed solution is suitable for crack monitoring of ancient city walls

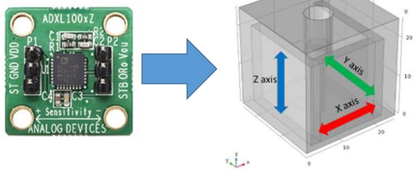



→ displacement resolution in the order of tens of micrometers

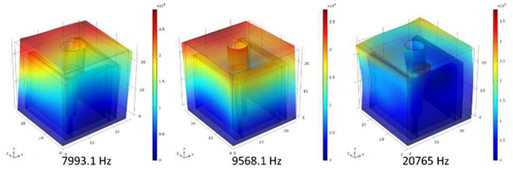
Images

# SENSORS FOR THE VIBRATION MONITORING IN INDUSTRIAL SCENARIOS

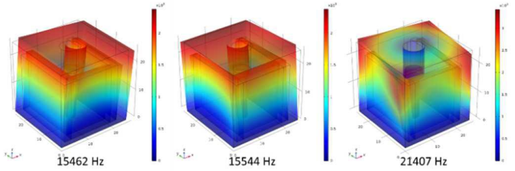
- Case study: embedded triaxial accelerometer stricture exploiting ADXL1005 from Analog Devices
- **Test structure**: cube, 25 mm side

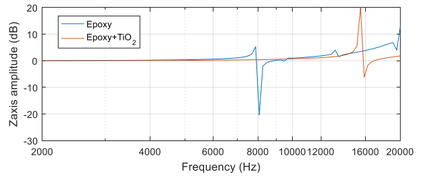


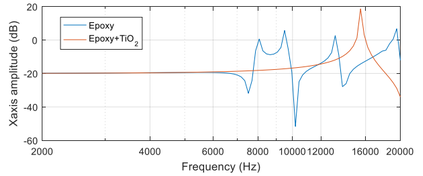

First three modal frequencies: **Epoxy, no filling**

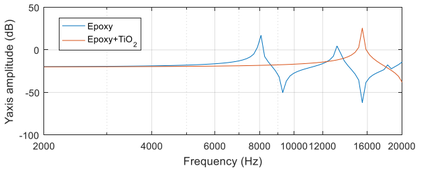



First three modal frequencies: **Epoxy + 5% $TiO_2$**

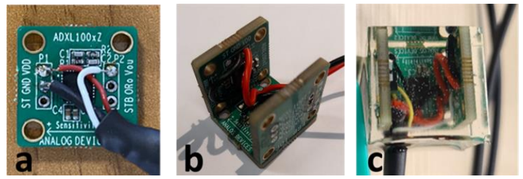


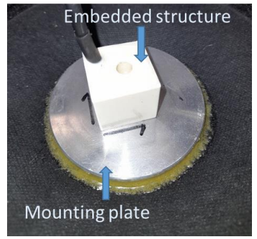



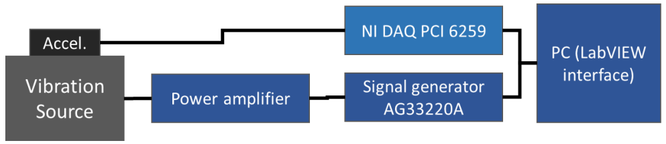




Realization

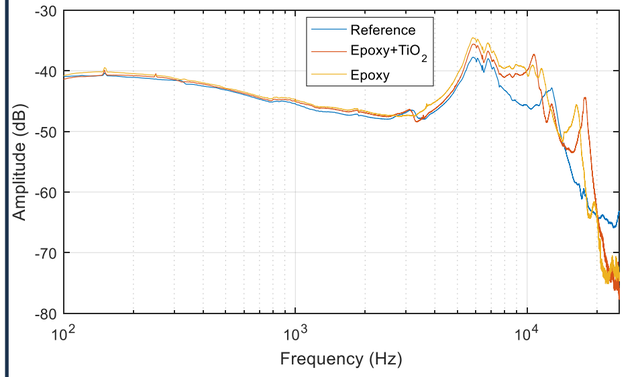


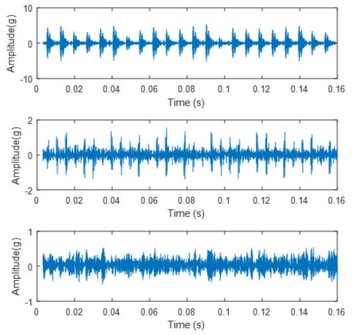

Test bench



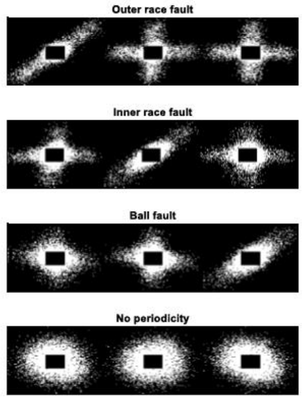

**Accelerometers response along the excitation axis (z-axis)**



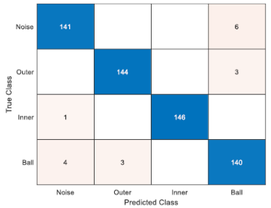

Bearing Failures Signals




Feature Matrix




ML Confusion Matrix



# Technologies and services

Electronic instrumentation (oscilloscopes, signal generators, bench multimeters, picoammeter, vector impedance meter, reworking station, soldering station, optical microscope) and software (Cadence, Altium) for **the creation, the analysis and the prototyping of electronic circuits and systems (including integrated ones)** are available.

Instrumentation (acquisition cards, climatic chamber, bench flow meters) and software (LabVIEW, Matlab) for **the creation of test benches and automatic testing systems, as well as the analysis of the acquired data** are available.

Equipment for the **prototyping of sensors** (screen printer, inkjet printer, industrial oven) starting from micro or nanostructured solutions, inks and powders is present.

The research activity on gas sensors and the know-how acquired in this field led to the design of a **versatile computer-controlled measurement system for the characterization of gas sensing materials** (e.g., chemoresistive sensors and quartz crystal microbalances (QCM)). The system is composed of two sub-elements: the chemical sampling system and the conditioning and acquisition electronics. The chemical sampling system allows to obtain gas flows with controlled concentration and humidity, in a controlled temperature environment. It is inserted in a laboratory chemical fume hood and includes a gas distribution system composed of six gas lines coming from certified cylinders, 9 mass-flow controllers, a bubbler, measurement chambers (developed ad hoc), an incubator and a cryostat bath.

# Applications and collaborations

Contracts for research/development/consulting activities aimed at achieving a specific goal such as, for example, a research activity of interest to the company, the development of an innovative product or service.

Consulting activities for feasibility studies, for the development of innovative products and services. LEEME researchers can collaborate with companies for the study of innovative solutions, processes.

Joint Research Projects financed by external entities and involving, in addition to the Department, one or more companies.

Funding for Research Positions, Fixed-Term Researchers, Research Fellows, and PhD students to carry out research activities of interest to the company Collaboration Agreements.

Establishment of Joint Laboratories between DIISM and Companies for joint research activities, financed by the company, for a period of three years (or more).

For more information

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