IMM

Istituto per la
Microelettronica e
Microsistemi

Consiglio Nazionale delle **Ricerche**

www.imm.cnr.it

IMM **Istituto** per la **Microelettronica** e **Microsistemi**

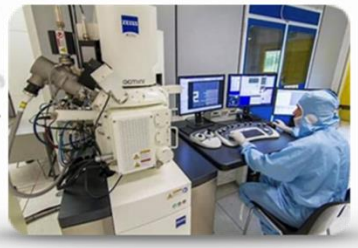
Consiglio Nazionale delle **Ricerche**

6 Units
Main Unit Catania

240 Staff

50 Post-docs, Ph.D. students

Agrate Brianza



Bologna

Roma

Lecce

Catania SEDE

Catania Università

IMM-CNR Unit of Lecce

University Campus

Clean Room Lab @Dhitech (High-Tech District)

- **Micromachining and Microelectronics for Aerospace Applications**
- **Quantum Science and Technology, Photovoltaics**
- **Light Enhanced Phenomena at the Micro-Nanoscale for Advanced Devices**
- **Advanced Multiphysics Modeling and Simulation Techniques**
- **Sensors Integrated Microfluidic Devices for healthcare, organ-on-chip, biosensors**
- **Internet-Of-Things Technologies for healthcare, automotive, smart factory, smart city, smart environment applications**

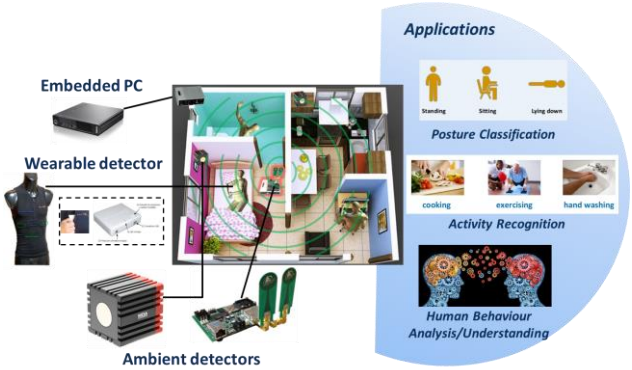
M2DCLab
(Multifunctional Devices Design and Characterization Lab)

AMANDE Lab-Clean Room
(Advanced Micro And Nano DEvices Laboratory)

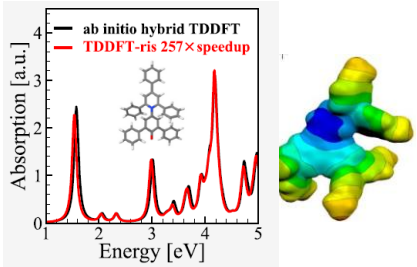
MOVPE – MBE Lab
(III-V semiconductors nanostructures and 2D materials)

M&TA Lab
(Micro & nano phoTonics for Advanced application Lab)

Signal and Image Processing Lab



CEMAS
(CEntre for Materials and Atmospheric Simulations)



Technological areas

Synthesis and Micro/Nano Fabrication

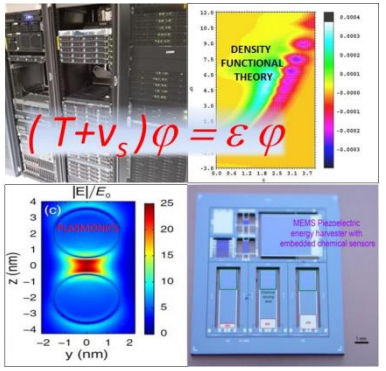
- Optical lithography
- Nanolithography and Nanoprocessing
- Growth, deposition and thermal processes
- Wet and dry etching

Characterization

- Morphological, structural and Chemical characterization
- Electrical, Electro-chemical and Magneto-electrical characterization
- Optical characterization
- Thermal characterization
- Transversal spectroscopic techniques

Modelling

- Development of density-functional theory
- Application of DFT methods to model nanosystems
- Computational (quantum) plasmonics
- Modelling of MEMS devices.



Application areas

FUNCTIONAL MATERIALS AND DEVICES

- MOEMS and Multifunctional Systems

- Chemical, Physical and Biological Sensors

- Functional Nanomaterials

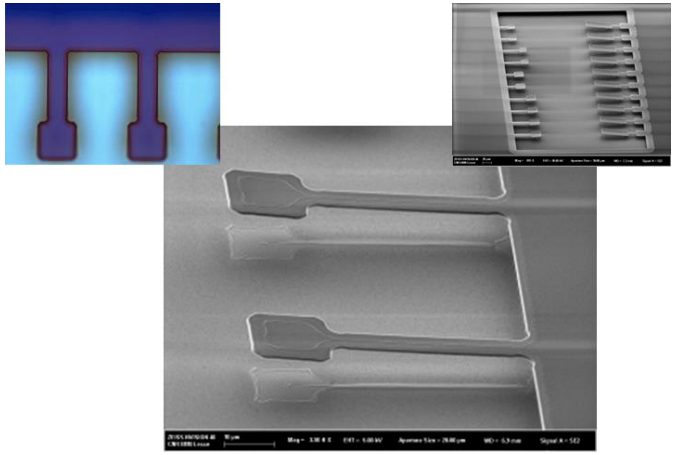
PHOTONICS

- Energy Conversion Devices

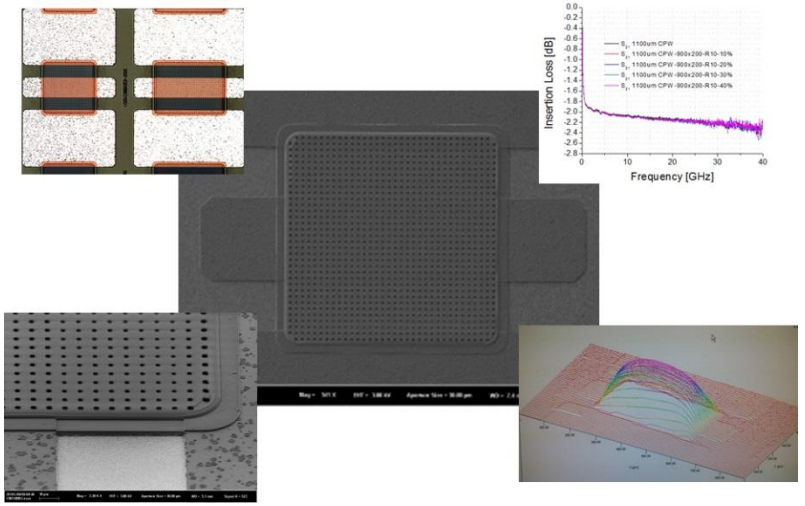
- Optoelectronic, Plasmonic and Photonic Devices

MOEMS and Multifunctional Systems

New materials and enabling technologies for MEMS (Micro-Electro-Mechanical System), and MOEMS (Micro-Opto-Electro-Mechanical System)



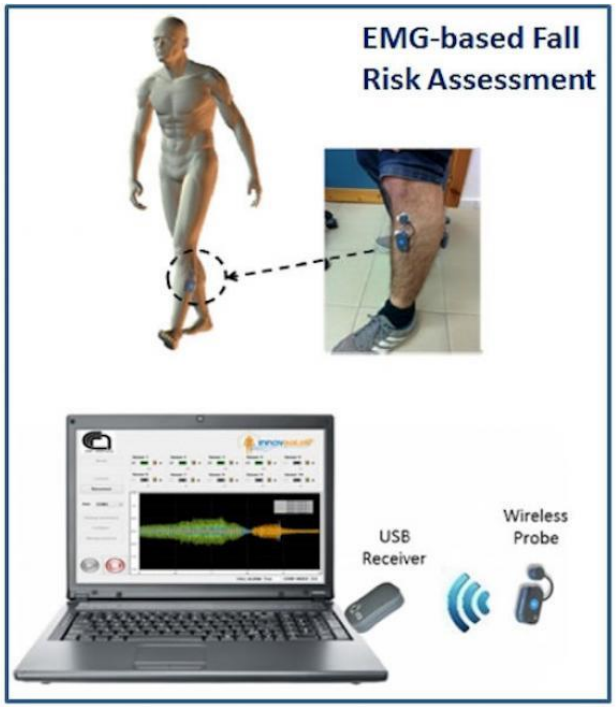
Realization and functional characterization of cantilevers and membranes based on innovative piezo material as aluminium nitride for application in engine component monitoring in the aeronautical and aerospace sectors



Realization and characterization of thin films of new materials, as TaO and TaN, for possible applications in MEMS technology . Power MEMS on flexible substrates for energy microgeneration useful to wearable devices and personal care

MOEMS and Multifunctional Systems

Multifunctional IoT-ready systems for healthcare and quality of life



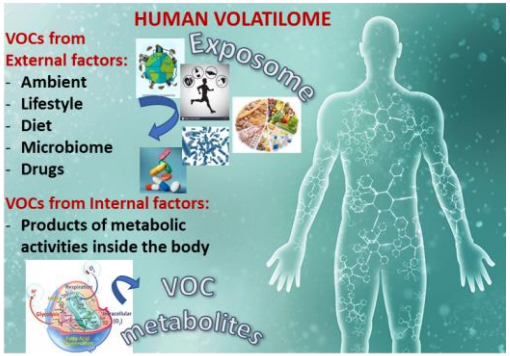
Wearable and portable solutions based on MEMS Inertial Measurement Unit (IMU) and Surface Electromyography Probes for people tracking, posture recognition, critical event detection (fall detection/prevention) in indoor and outdoor context with embedded computing capabilities;

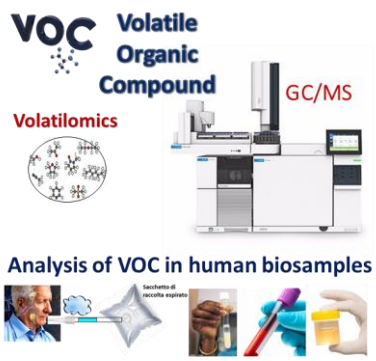
Internet-of-Things compliant multi-sensor systems and objects for context-aware analysis, Human-Machine-Interaction within ubiquitous computing framework in Wireless Sensors Network;

In-proximity wireless communication solutions for multi-sensor point-of-care;

MOEMS and Multifunctional Systems

Multifunctional chemical systems for food analysis and biomedical applications (breath analysis & metabolomics)

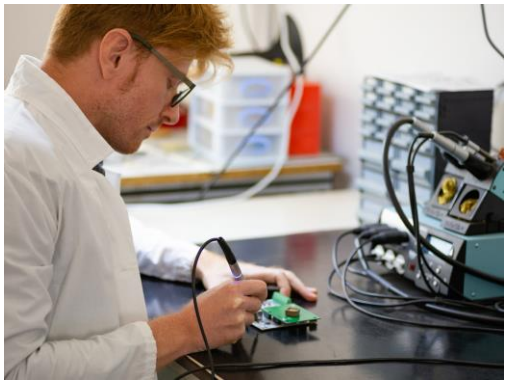


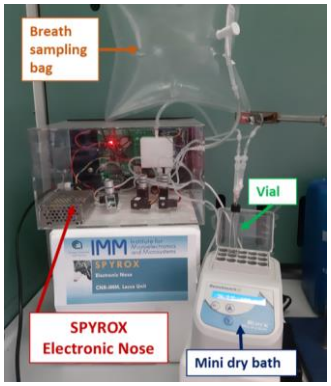


Effettuiamo l'Analisi del Volatiloma umano mediante Gas Cromatografia/Spettrometria di Massa (GC/MS)

We perform Human Volatilome Analysis by Gas Chromatography/Mass Spectrometry for medical diagnostics and human biomonitoring

Ricerchiamo biomarcatori volatili (VOC) di patologia e/o di esposizione ambientale in biocampioni umani (espirato, sangue, urine, liquido seminale, saliva, ecc.) per la diagnostica e l'esposomica.





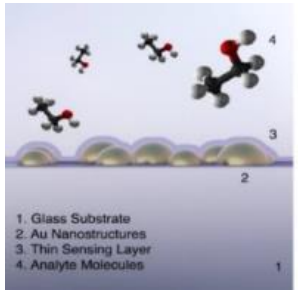
Sviluppiamo dispositivi basati su sensori chimici per la diagnostica medica ed il biomonitoraggio umano

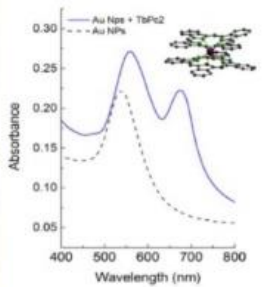
We develop devices based on chemical sensors for medical diagnostics and human biomonitoring

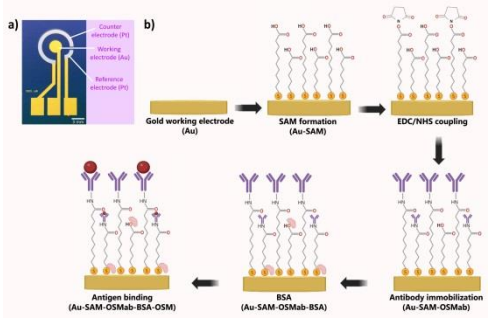
Integriamo sistemi di sensori chimici, interfacce elettroniche avanzate, e analisi dati in Nasi Elettronici addestrati, muniti di connettività IoT e cloud

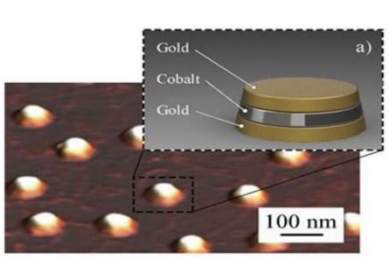
Chemical, Physical and Biological Sensors

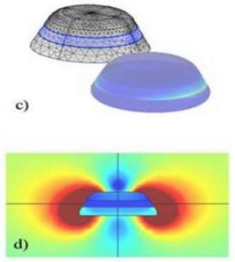
- Sensors for health, environment and food applications (DNA, toxins, proteins) and/or chemical elements (cyanides, heavy metals) in liquids;
- Room Temperature Semiconductor X-Ray planar/segmented detectors for medical, security, astrophysics applications;
- Innovative graphene-, metal-, and metal oxide- based nanostructures for sensing applications;
- Hydrogel-based wearable and portable sensors for chemical and biological parameters
- Optochemical sensors and biosensors;
- Electrochemical sensors and biosensors for Organ-on-Chip devices







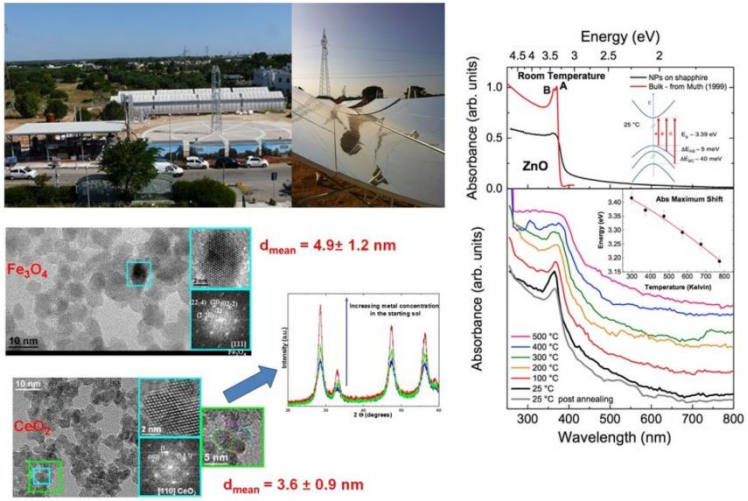




Photonics

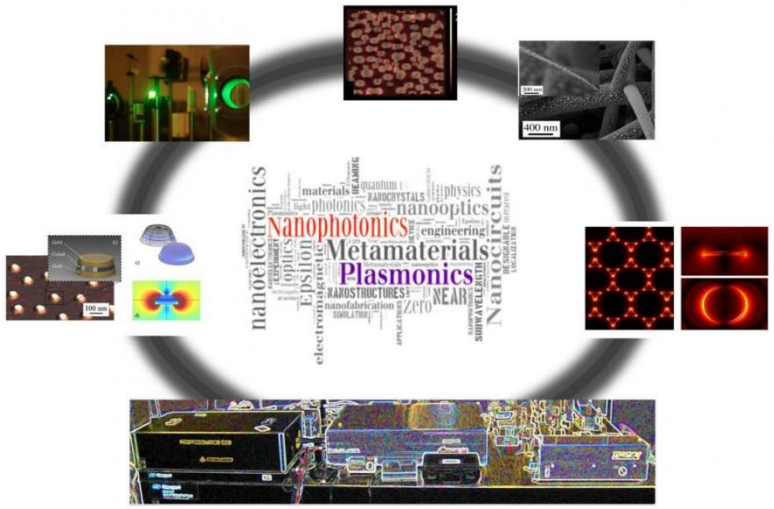
Energy Conversion Devices

Nanofluid based Concentrated Solar Power Plant (SOLAR)
http://www.solar.unisalento.it/index.html



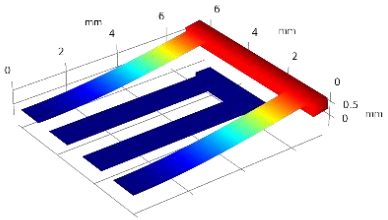
- Nano-fluids for applications in Thermodynamic Solar Power Plants;
- Nano-Rectenna for high Efficiency Direct Conversion of Sunlight to Electricity;
- InAs/GaAs and InAlGaAs/AlGaAs Quantum Dots Intermediate Band Solar Cells (IBSC);
- Third Generation Solar Cells based on core/shell III-V and II-VI semiconductor nanowires.

Optoelectronic, Plasmonic and Photonic Devices



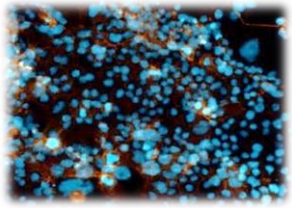
- Optoelectronic components based on reduced dimensionality structures
- Plasmonics and Nanophotonics

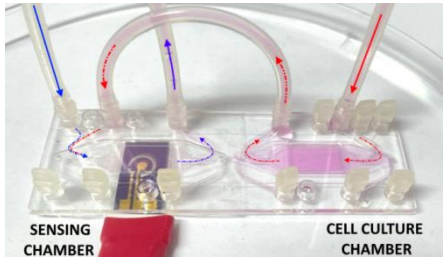
Multifunctional Devices Design and Characterization Laboratory (M2DCLab)



MEMS Devices Design, FEA simulation, Layout

Piezoelectric, impedance/electrochemical spectroscopy, fluorescence





Microphysiological platforms/Organ-On-Chip

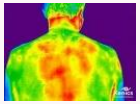
Piezoelectric characterization

- **Piezoelectric force microscopy (PFM):**
  - Nanoscale topography of thin films
  - Mechanical response to the application of electrical voltage
  - Ferroelectric domains structure imaged with micro/nano resolution
- **Piezometer:**
  - Electrical response to the application of mechanical load
  - Direct measurements of d_{33} and d_{31} coefficients down to 0,01 pC/N
- **Electrodynamic shaker:**
  - Figure of merit/power density of resonant MEMS energy harvester

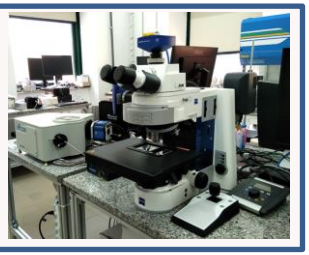
Electrical/impedance characterization

- Biosensors and chemical sensors impedance spectroscopy: 1 mHz - 5 MHz, 1 mΩ-1 TΩ
- I-V and C-V characterization of active devices (MEMS, Sensors, probe station, custom wire bonding to chip/die)
- Transephitelial Electrical Resistance (TEER) and equivalent electrical circuit modeling of biological layers/cells
- Potentiometric/Galvanometric/ZRA electrochemical test and EIS up to 250 KHz (single channel)

Biolayers optical characterization

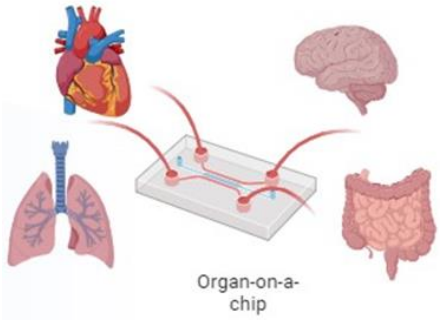


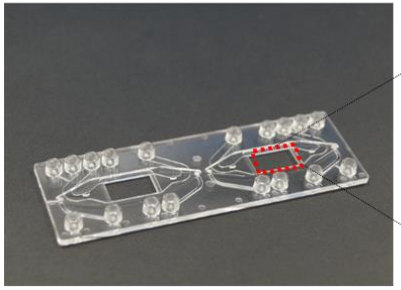
- Fluo/BF Microscope + 632.8 nm µRaman Spectrometry with cell incubator
- High throughput (384 wells) UV-VIS fluo/absorbance, real-time BF imaging of multiple cells cultures
- Long working distance optics for optical investigation in microchannels and sealed chips

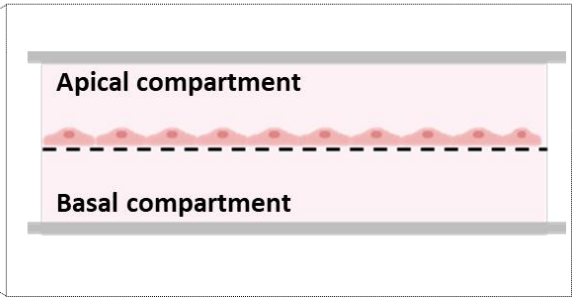


Microphysiological platforms/Organ-On-Chip

Development of a simple model of Intestinal Barrier on Chip (IBoC)

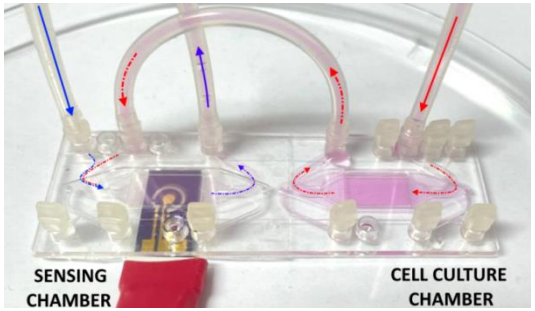




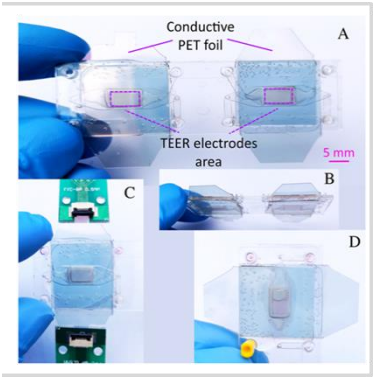


Development and integration of sensors into OoC platforms

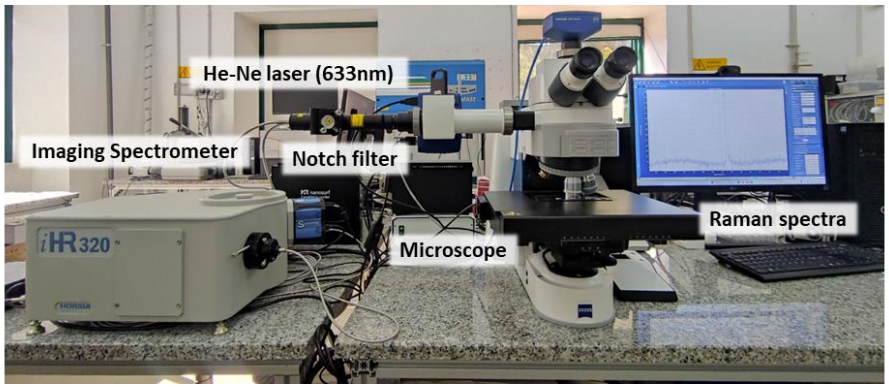
ION SENSING



TEER MEASUREMENTS

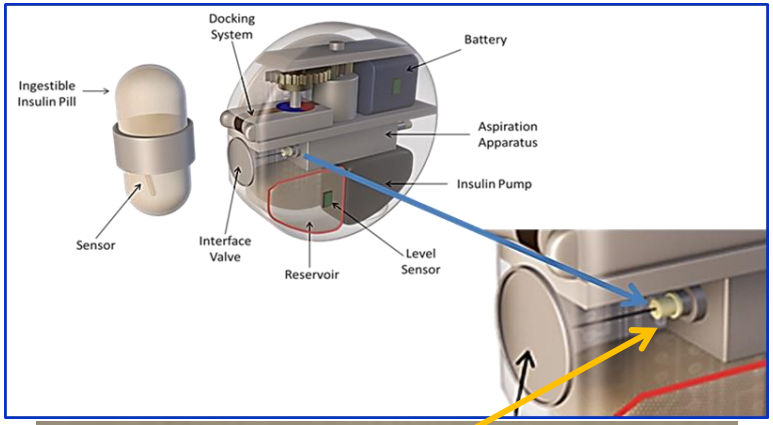


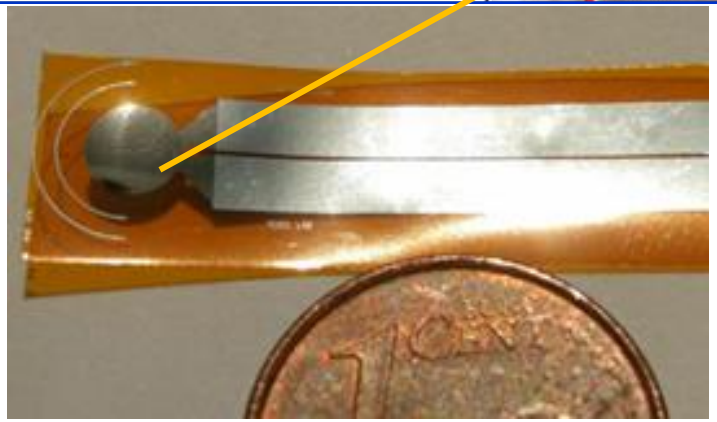
MICRO RAMAN SPECTROSCOPY



Microfabrication of the flexible piezoelectric pressure sensor (proprietary AlN piezo thin film, SSSA collaboration)

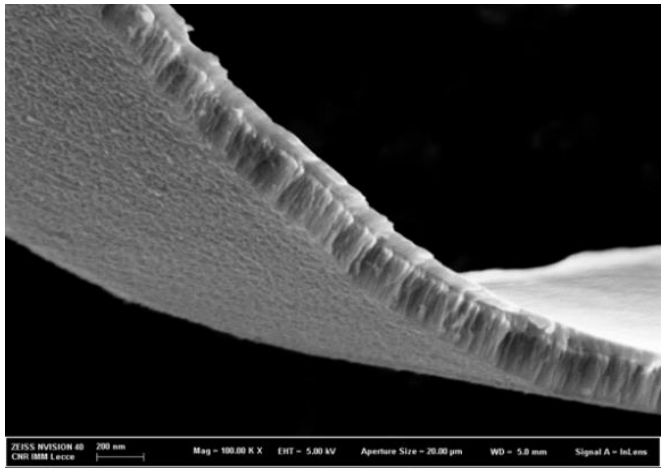
Flexible piezoelectric devices based on AlN thin films for wearable and implantable devices





Fabricated piezoelectric pressure sensor

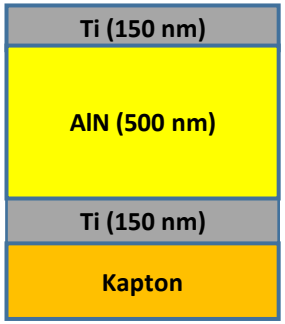
SEM of AlN/Ti on kapton substrate



AlN deposition on kapton substrate by RF magnetron sputtering in reactive atmosphere at room temperature

- **Top and bottom electrode:** 150 nm of sputtered Ti thin film
- **Active layer:** 500 nm of AlN
- **Bottom electrode diameter:** 4 mm
- **Top electrode diameter:** 3.8 mm
- Standard **lithographic processes** optimized for Kapton substrate

Device cross section



Signore, M.A et al.. Fabrication and characterization of AlN-based flexible piezoelectric pressure sensor integrated into an implantable artificial pancreas (2019) Scientific Reports, 9 (1)

IMM Consiglio Nazionale delle Ricerche
Institute for Microelectronics and Microsystems

Resp. Maria Assunta Signore

Water-propellant vaporizing liquid microthruster for small satellites (University of Salento cooperation)

The context

System miniaturization thanks to strong advancements in Micro-Electro-Mechanical Systems (MEMS) fabrication technology

- Application to the development of **cubesats**: micro and nano-satellites made of multiples of 10x10x10 cm^3 cubic units with total mass less than 20 kg

These satellites usually need for attitude control capabilities, which usually require:

- small thrust forces
- high specific impulse
- satisfaction of severe mass, volume and power constraints

VAPORIZING LIQUID MICROTHRUSTERS

Liquid-propellant micro-resistojets

Pros

- High density/no pressurization -> lighter/smaller storage tanks
- Reduced system complexity

Cons

- vaporization -> higher power consumption
- **flow instabilities due to two-phase flows to be controlled**

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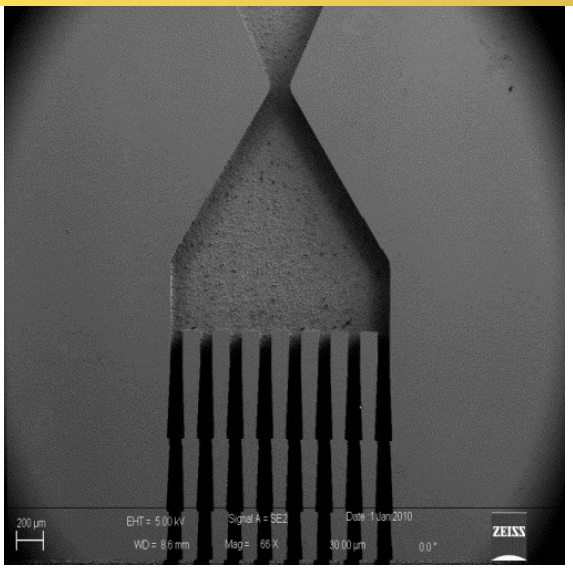
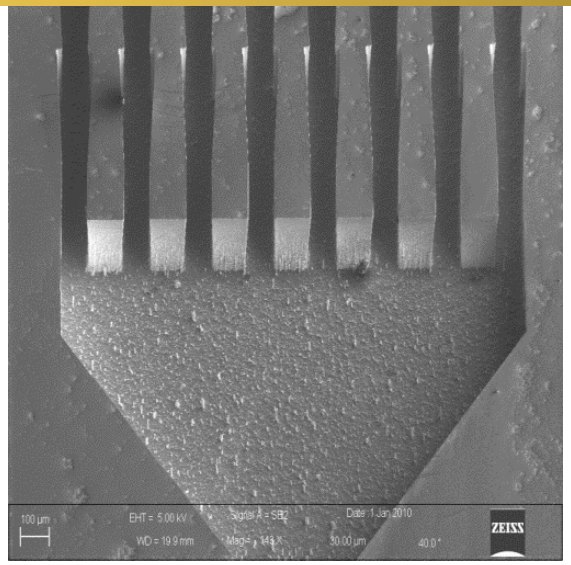
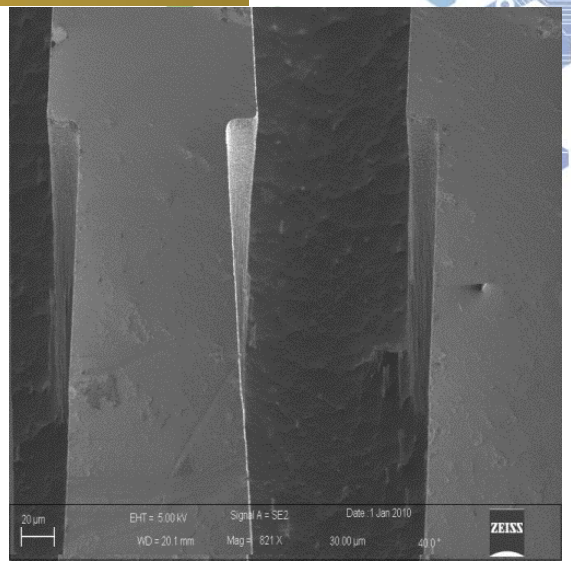
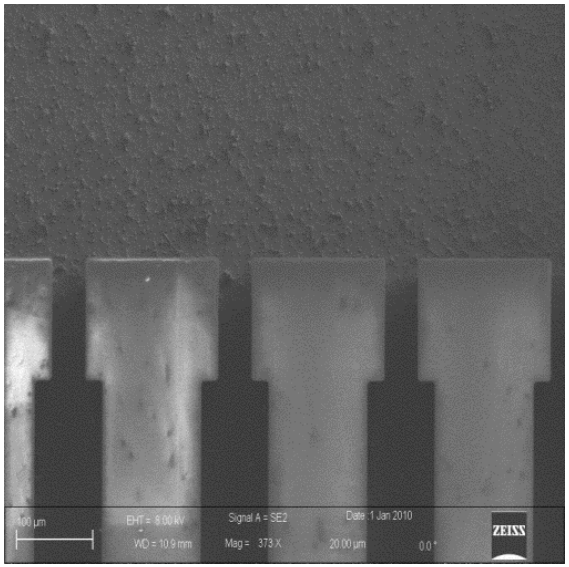
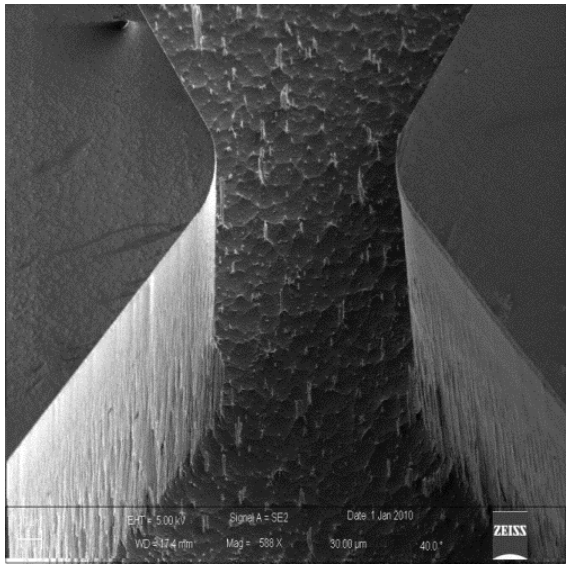
Water-propellant vaporizing liquid microthruster for small satellites

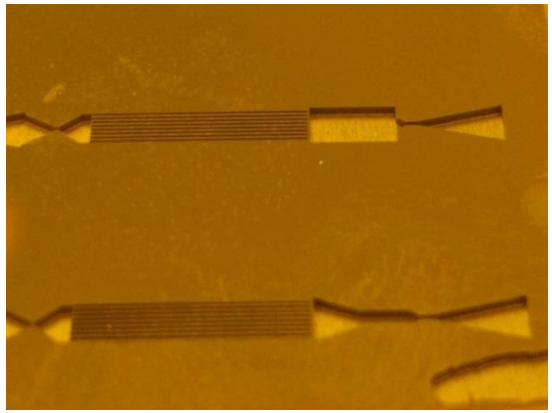


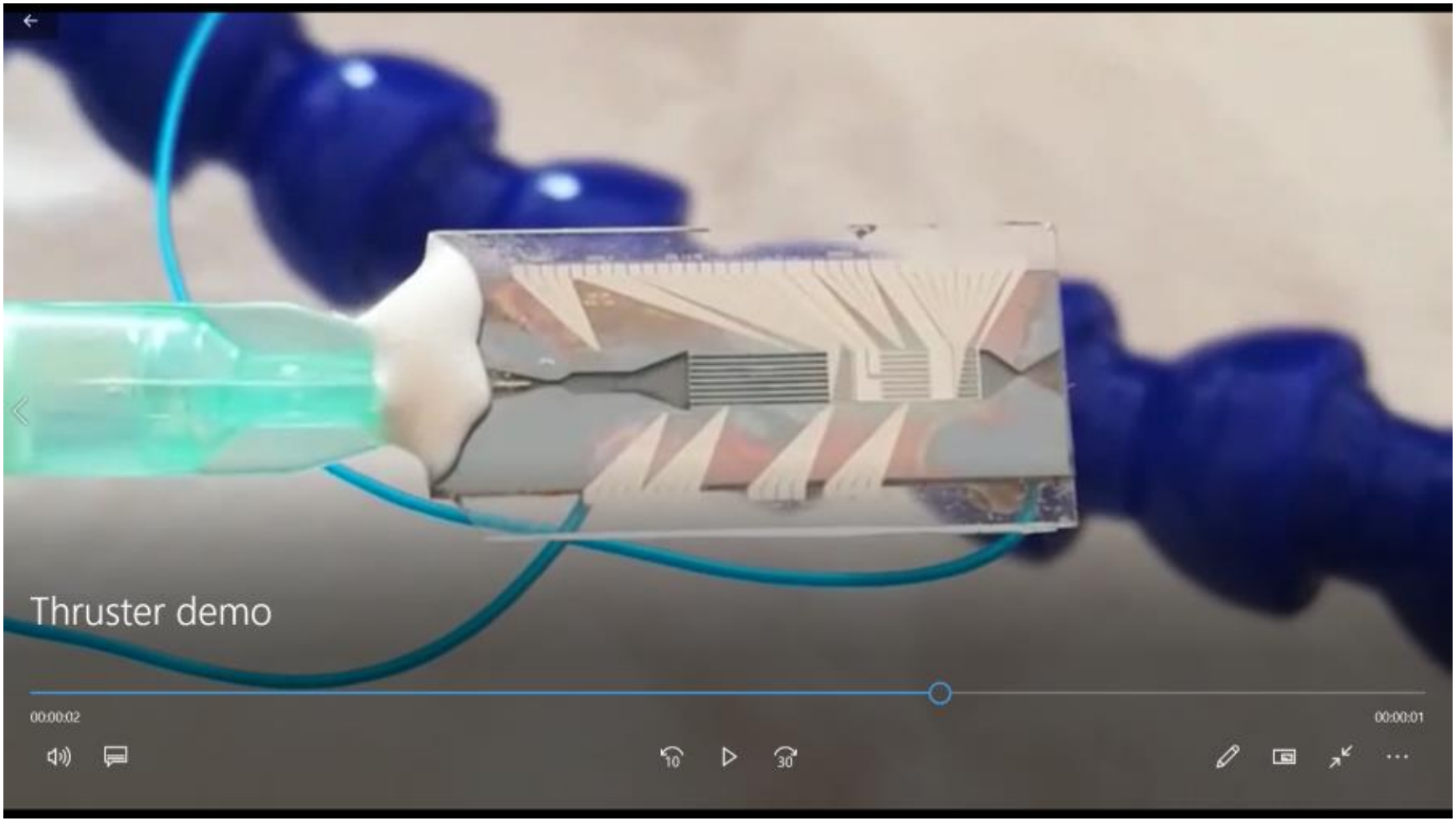











Thruster demo
00:00:02
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Thank you
for your attention!

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