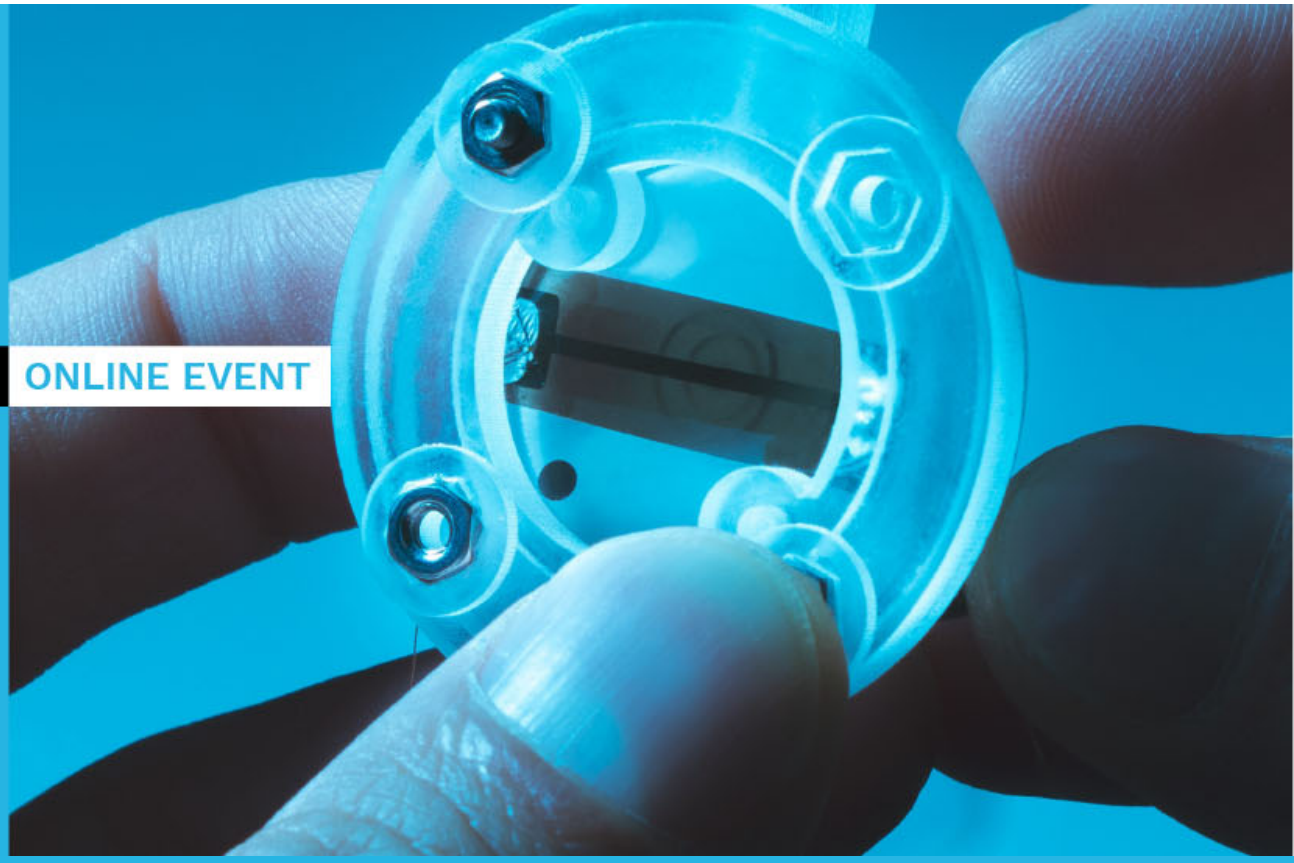
# ASSIST

## Smart valves based on active soft materials

**Project results and exploitation perspectives**

**15 October 2021** 14:30 (CET)

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# "Supersonic Cluster Beam Fabrication of Active Soft Nanocomposites"

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# SOFT ELECTRONICS AND SENSORS

**CONDUCTIVE SPECIES**

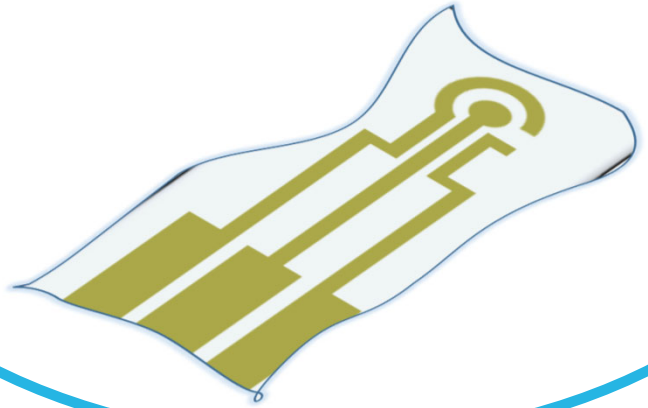
Electron conduction
Hardness

Metallic atoms
Metallic Nanoparticles
Carbon Nanotubes
Graphene
Conductive polymers

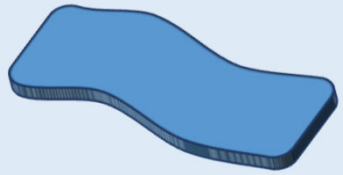
**COMMON FABRICATION TECHNIQUES**

Physical techniques (e.g. vapour deposition)
Printing of conductive inks

**SOFT ELECTRONICS and DEVICES**



**SOFT POLYMERIC MATERIALS**



Softness
Deformability
Compliancy

Rubbers
Elastomers
Thermoplastics
Gels
Biological tissues
Cellulose-derivatives

# SOFT ELECTRONICS AND SENSORS

## CONDUCTIVE SPECIES

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Graphene derivatives
Conductive polymers

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Physical techniques (e.g. vapour deposition)
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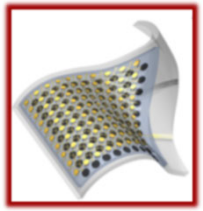
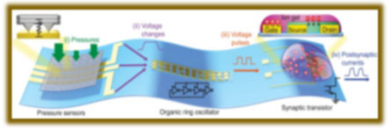
## SOFT ELECTRONICS DEVICES and APPLICATIONS

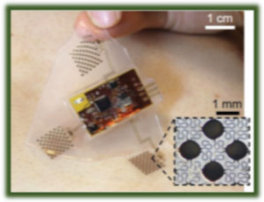
ENERGY DEVICES



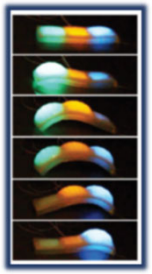
COMPUTING ELEMENTS



SENSORS AND BIOSENSORS




SOFT ACTUATORS



WEARABLE ELECTRONICS

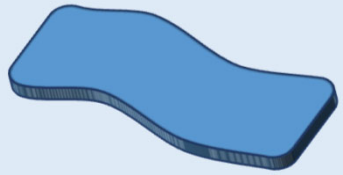
BIOMEDICINE

EEG

ENVIRONMENTAL MONITORING

SMART FARMING AND AGRICULTURE

## SOFT POLYMERIC MATERIALS



Softness
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Rubbers
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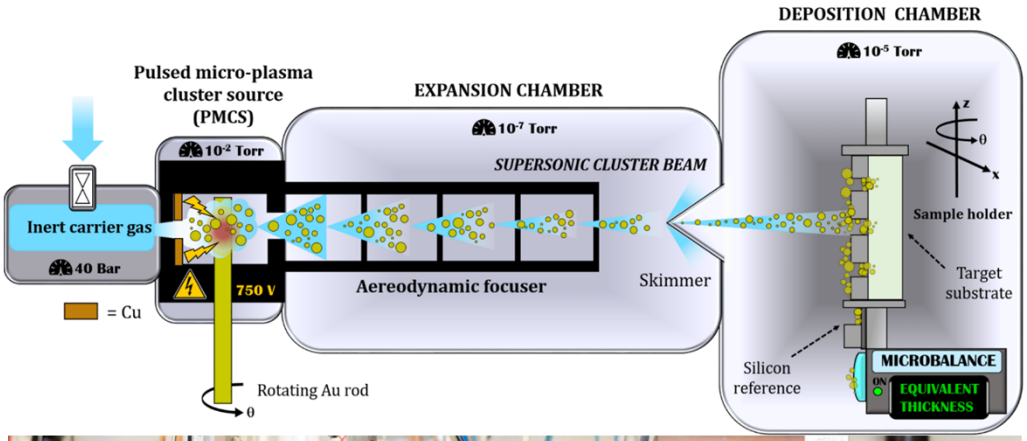
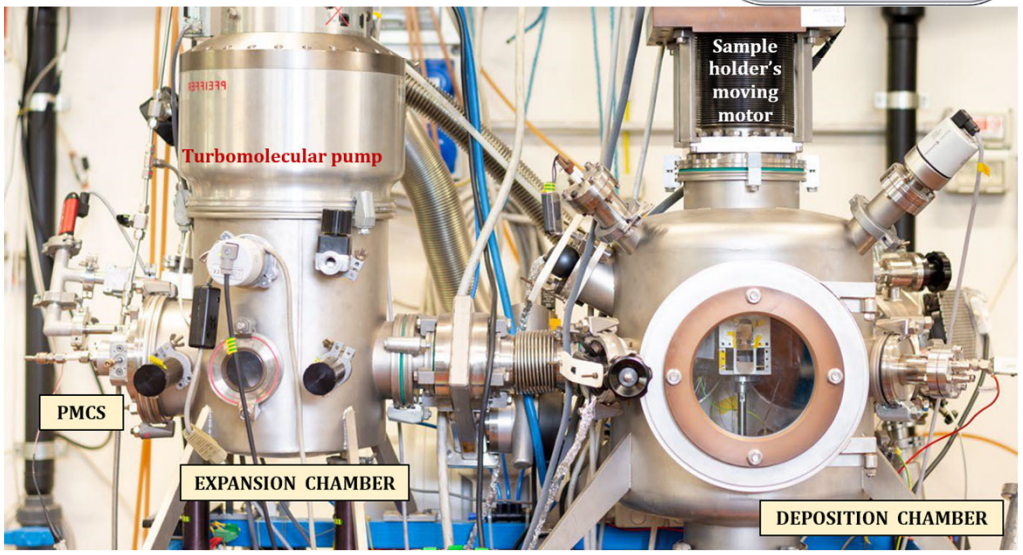
# SUPERSONIC CLUSTER BEAM IMPLANTATION




1) **Neutral clusters** generated by an inert gas plasma from a solid conductive precursor.

2) **Supersonic expansion** of the gas beam and **size selection** of the clusters (3-10 nm).

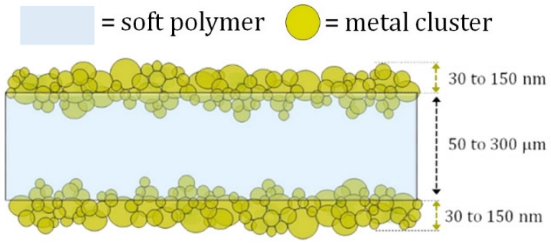
3) Deposition of **cluster-assembled layers** (from few to hundreds of nm) on the target substrate.

*Wegner et al., J. Phys. D. Appl. Phys., 2006*
*Ghisleri et al., J. Phys. D. Appl. Phys., 2014*

# SUPERSONIC CLUSTER BEAM IMPLANTATION

Solid conductive precursor
No pre-treatments

→ **Versatility:**
different metals and/or carbon
different (thermolabile) substrates




Cluster-assembled structure

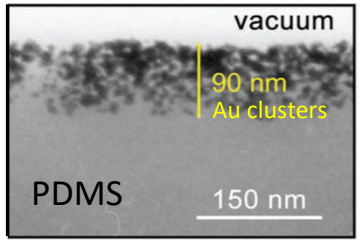
→ **Lightness and high porosity**

In-situ monitoring tools

→ **Tuneable thickness and conductivity**

Clusters implantation in soft substrates

→ **Nanocomposite layer:**
robust adhesion, resiliency to deformation, high interfacial area




*(Corbelli et al., Adv. Mater., 2011)*

High collimation of the supersonic beam

→ **Micro-patterning with stencil masks**

Moving and rotating sample-holder

→ **Patterning of large areas and 3D objects**

Solvent-free and room-temperature

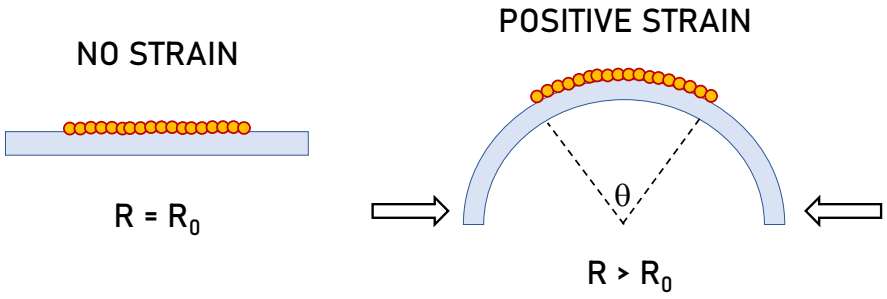
→ **Environmental sustainability**

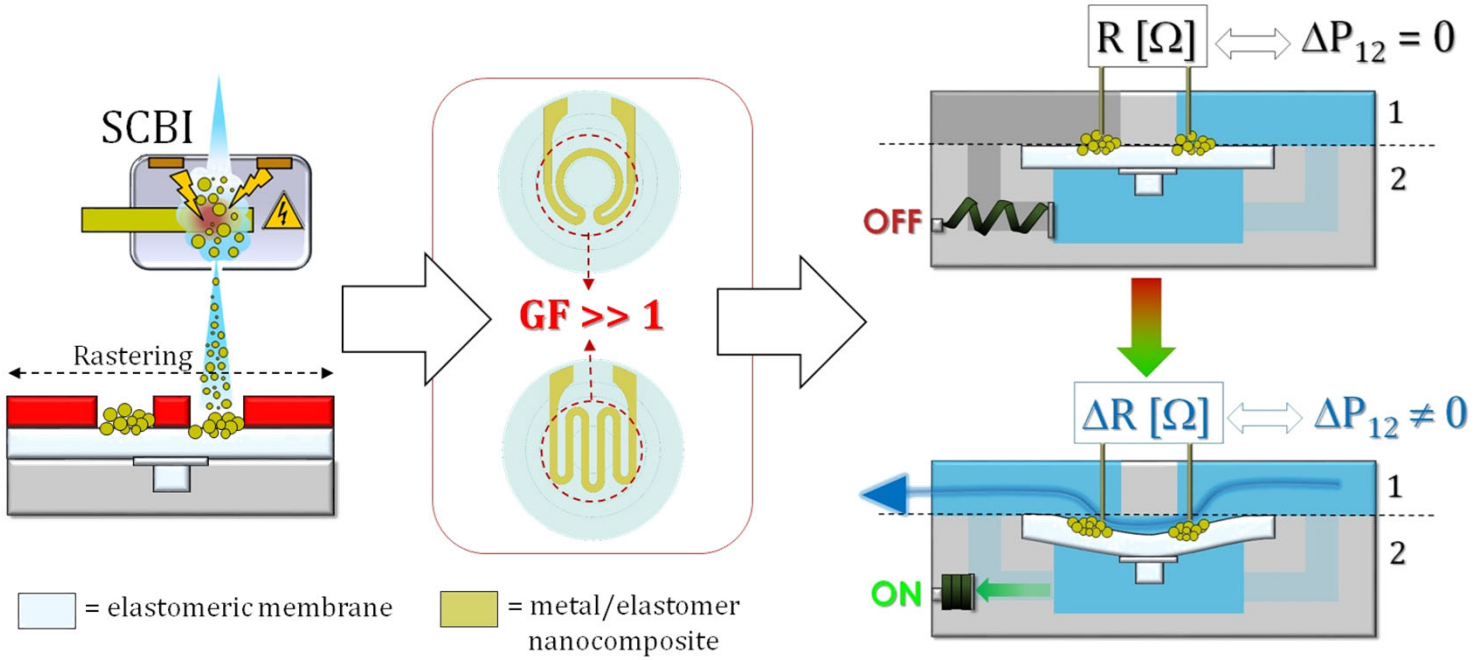
Successfully employed on hydrogels and ionogels, thermoplastics, rubbers, PDMS, paper, natural polymers

→ Supercapacitors, strain sensors, electro-mechanical soft actuators, electrochemical cells…

# GOAL OF THE ASSIST PROJECT

**SMART FLUIDIC VALVES** based on a
**NANOCOMPOSITE STRAIN-SENSITIVE MEMBRANE**




1. Custom-designed elastomer membrane

2. Metallization with SCBI

3. On-line employment in a fluidic channel

**Fluid pressure**

↓

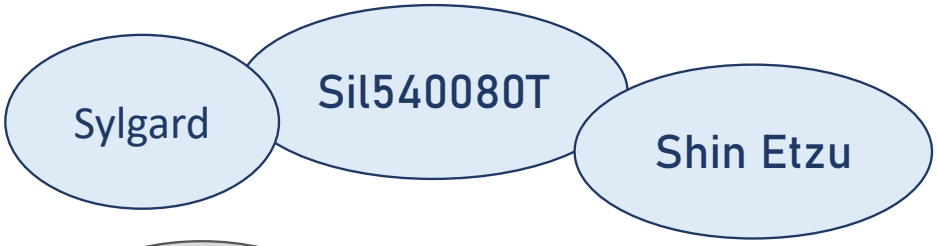
**Membrane deformation**

↓

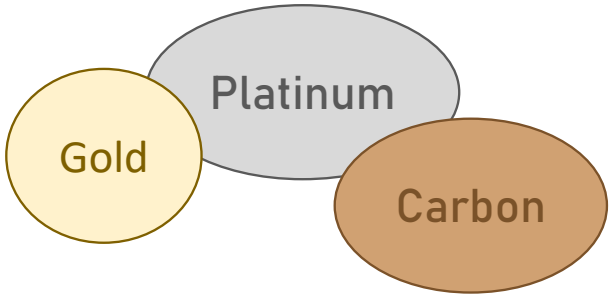
**Resistance variation**

# UNIMI ACTIVITY

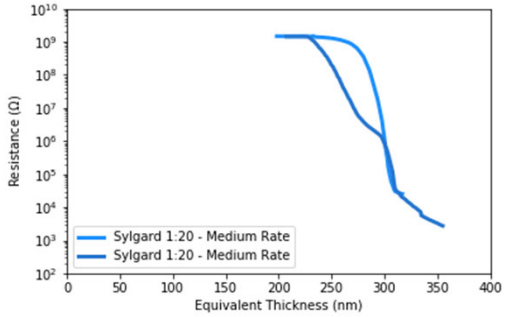
1) SELECTION OF THE **ELASTOMER** MATERIAL




2) IDENTIFICATION OF THE **CONDUCTIVE SPECIE** AND THE **DEPOSITION PROTOCOL**




3) **FABRICATION** OF THE NANOCOMPOSITE SAMPLES




## 2 OBJECTIVES

a) Production of <u>dumbbell samples</u> for tensile electro-mechanical tests → Modelling

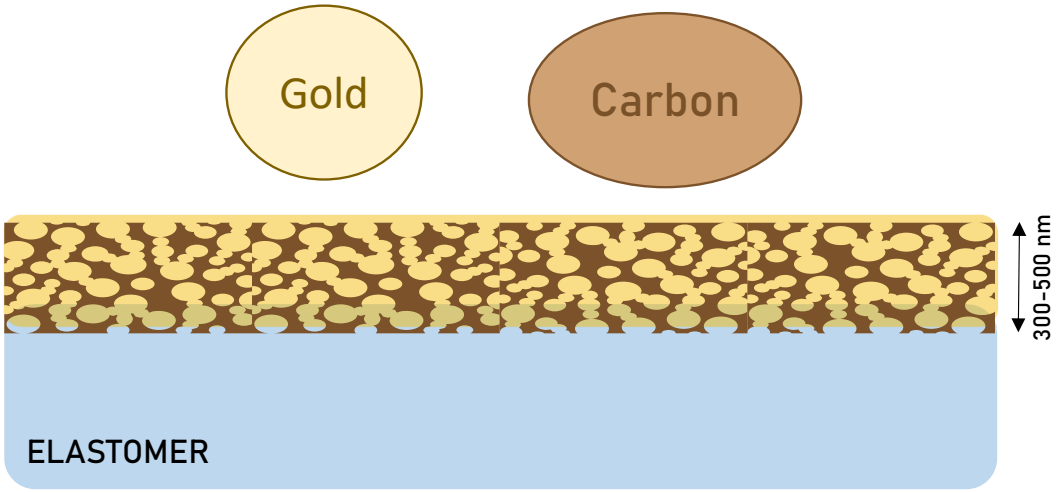
b) <u>Metallization of custom membranes</u> to test their sensitivity at different pressure values in a real fluidic system

# SUCCESSFUL PROTOCOL

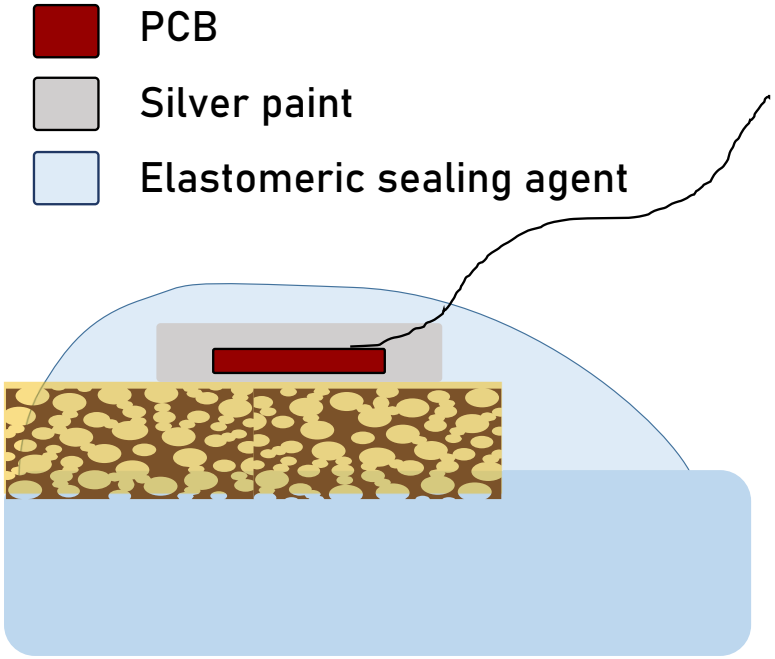
1) IDENTIFICATION OF THE **ELASTOMER** MATERIAL


2) **Au-CARBON DOUBLE LAYER**

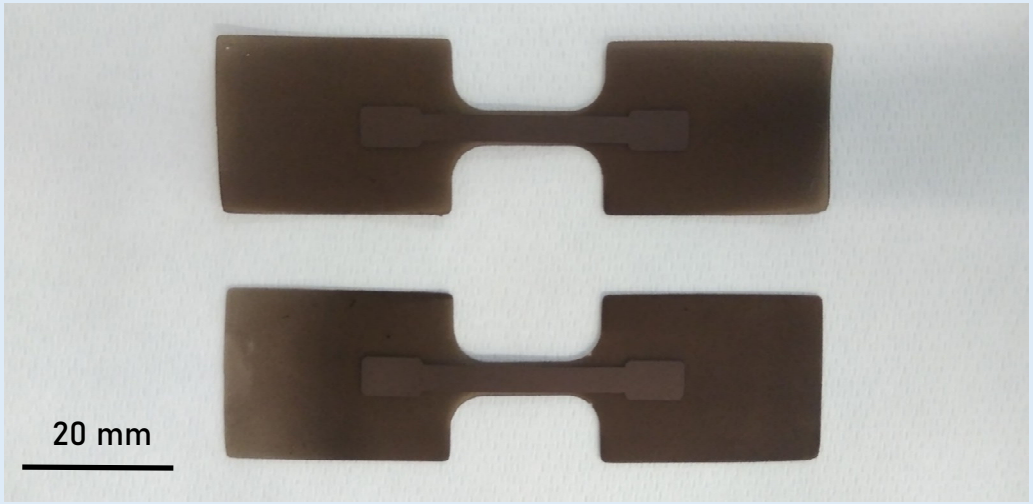
The porous carbon layer is filed by the conductive Au clusters

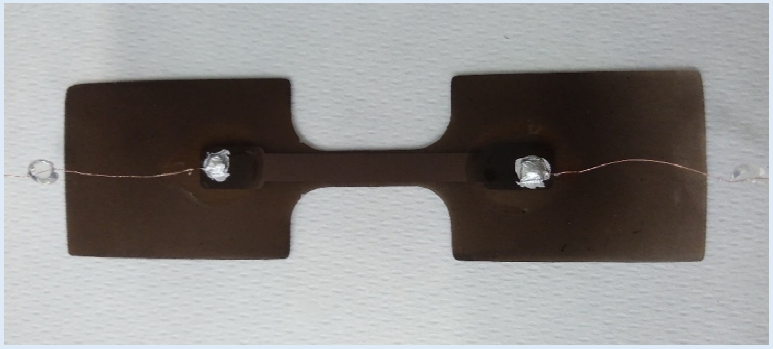


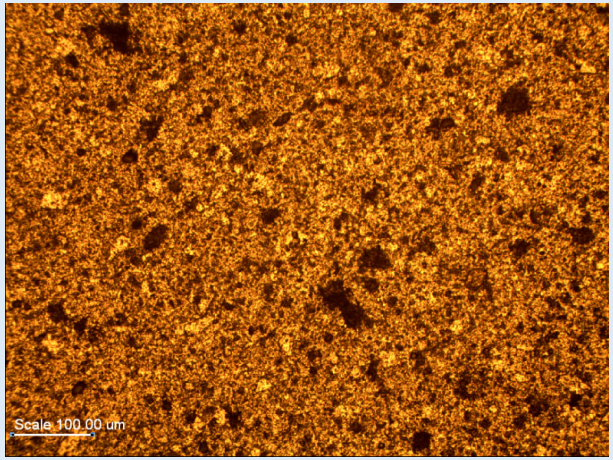

**SOFT CONTACTS and SEALING**



# Dumbbell for Tensile Tests at Polimi

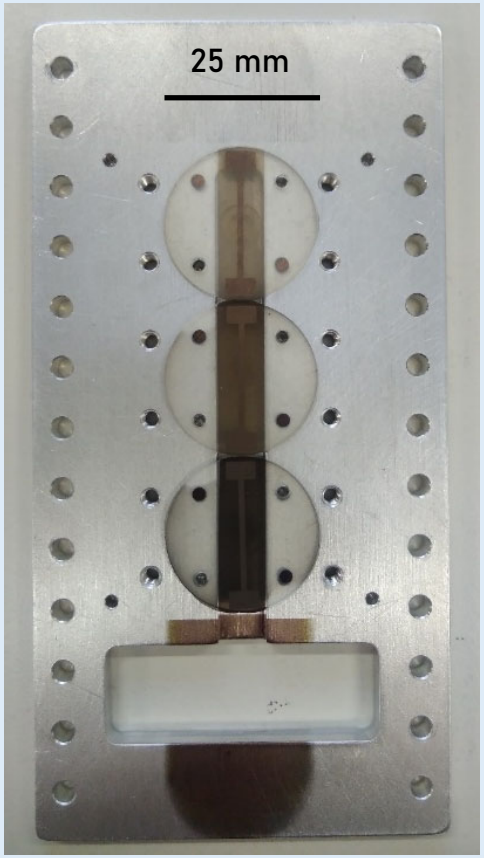


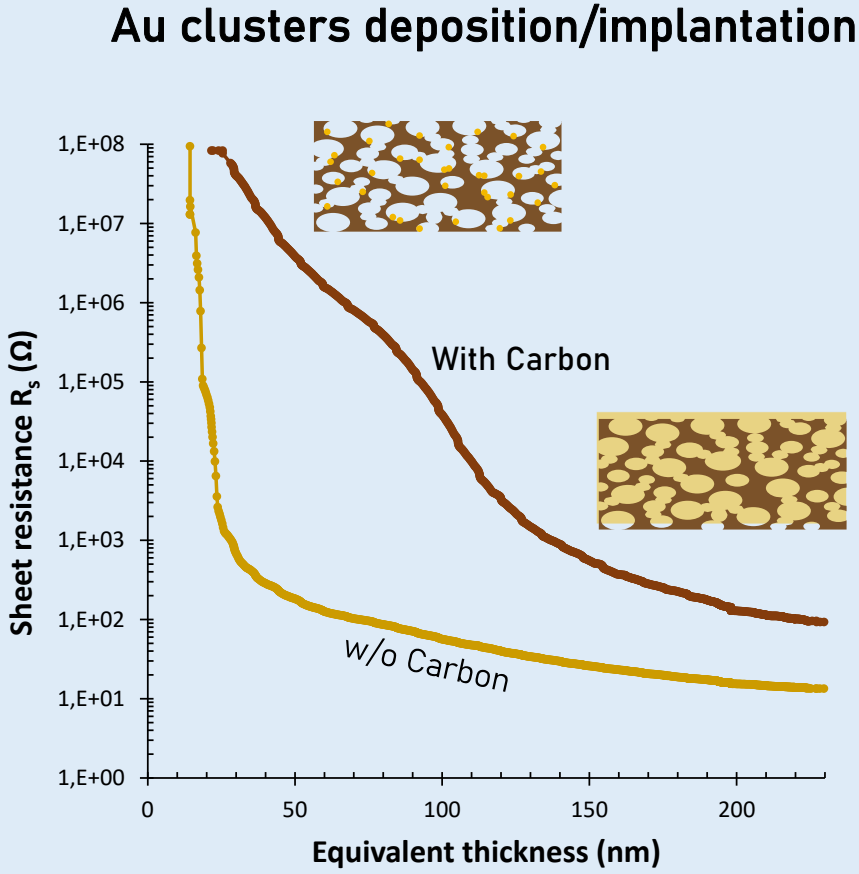



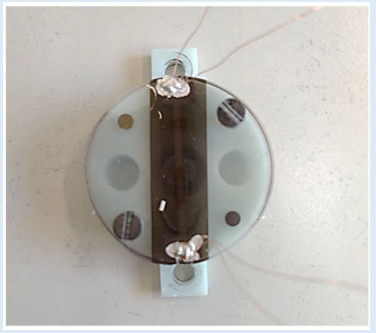


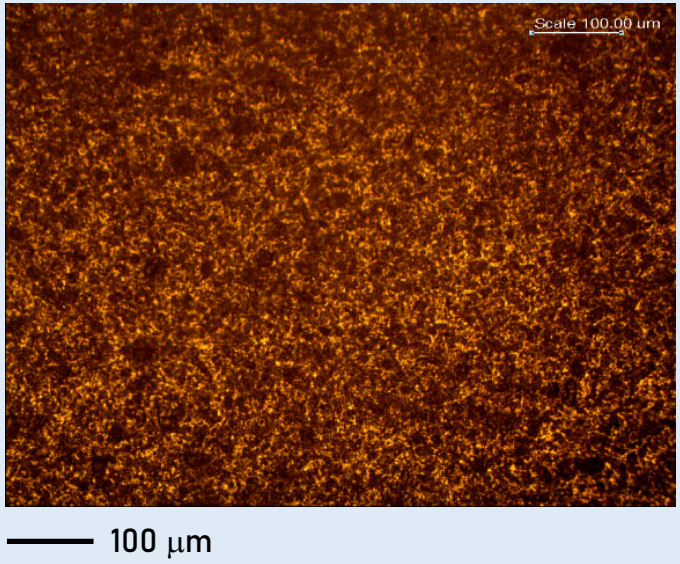

100 μm

# SENSORIZED MEMBRANES FOR PRESSURE TESTS



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## THANKS TO ALL THE PARTNERS AND THE FINANCERS


## UNIMI and CIMaINa

Paolo Milani
Tommaso Santaniello
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Sara Moon Villa
Marco Piazzoni