

# ASSIST

## Smart valves based on active soft materials

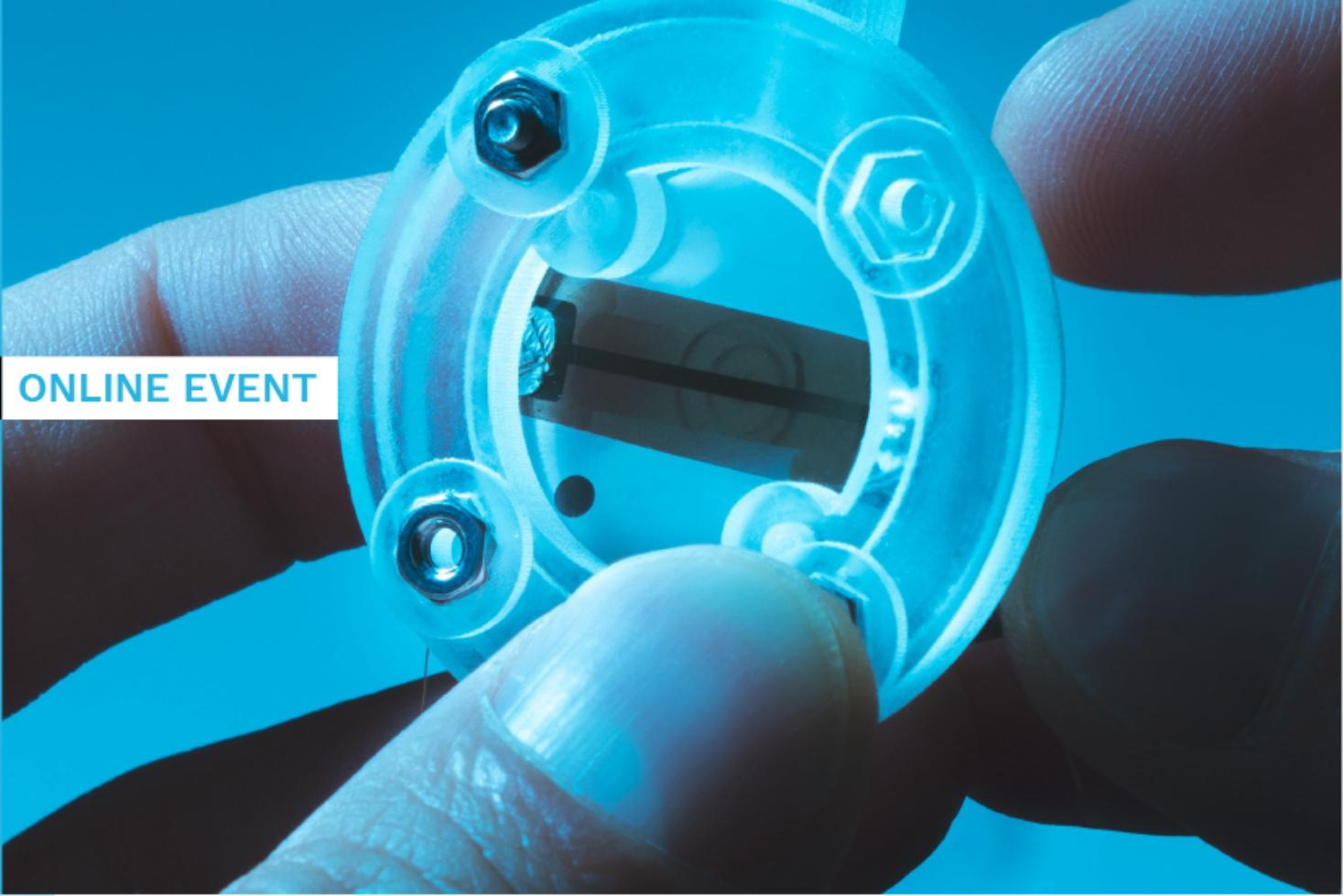
Project results and exploitation perspectives

15 October 2021 14:30 (CET)

Funded by



Partners



ONLINE EVENT

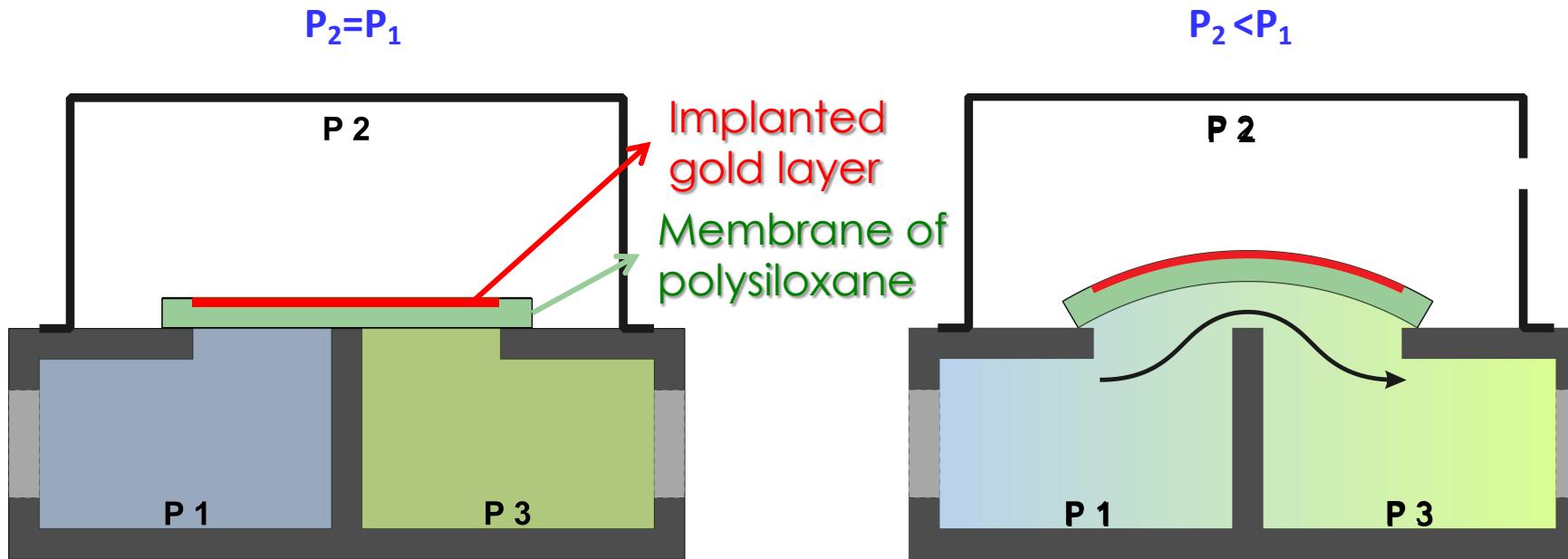
**Stretchable strain sensors:  
characterization and modelling of  
the electromechanical behaviour**

Claudia Marano, Elisa Piccoli  
*Polymer Engineering Laboratory*



dipartimento di chimica,  
materiali e ingegneria chimica  
'Giulio Natta'

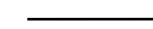
## ASSIST PROJECT'S SCOPE: PRESSURE SENSOR



$\Delta P$   
variation of pressure



membrane  
deformation



$\Delta R$   
variation of electrical resistance

POLIMI-CMIC ACTIVITY :

- membrane deformation
- $\Delta R = f(\text{membrane deformation})$

- membrane deformation
  - $\Delta R = f(\text{membrane deformation})$
- 

- membrane deformation

Material characterization



Material constitutive model



Finite Element modelling



Prediction of the membrane deformation for any  $\Delta P$

- membrane deformation

Material characterization



Material constitutive model



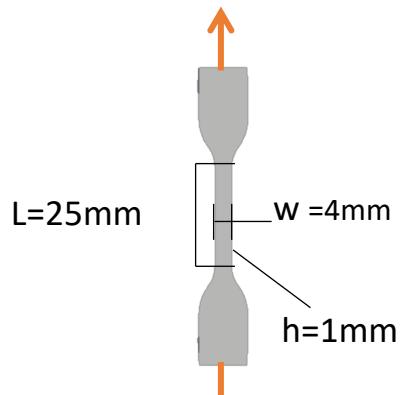
Finite Element modelling



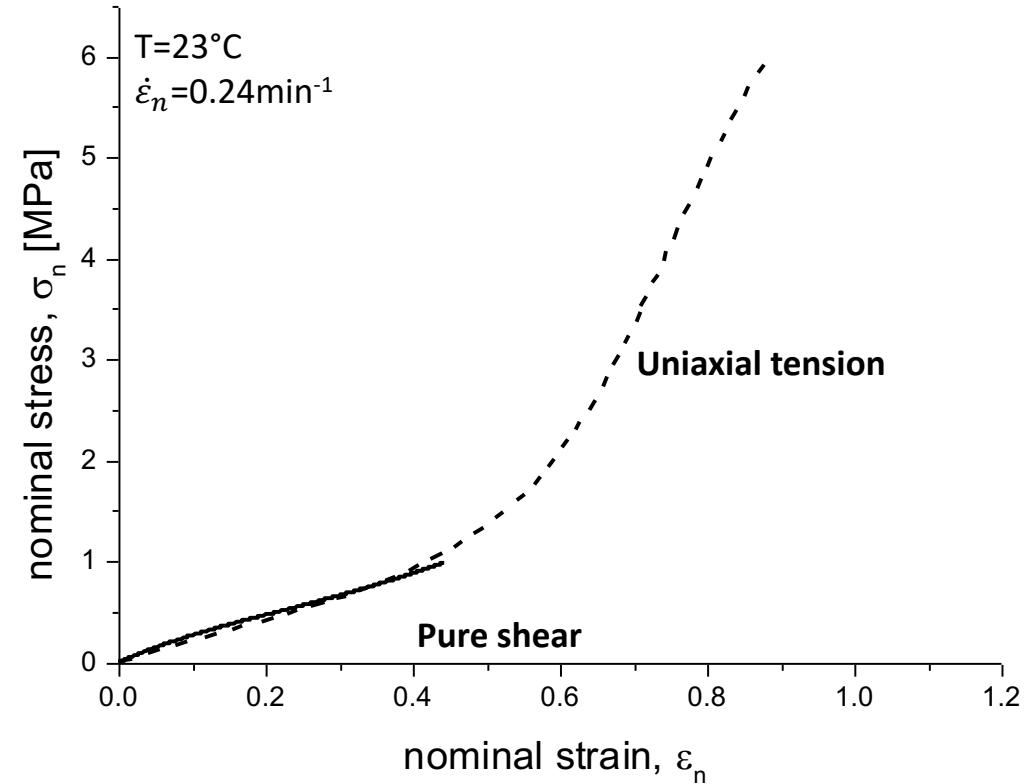
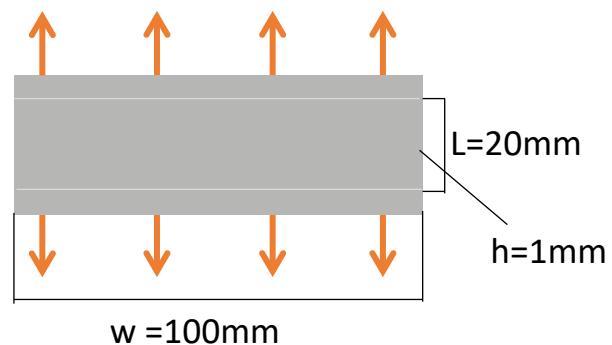
Prediction of the membrane deformation for any  $\Delta P$

## **EXPERIMENTAL TESTING FOR MATERIAL CONSTITUTIVE LAW DEFINITION (SYLGARD184 –DOW CORNING)**

### **Uniaxial tension**



### **Pure shear**

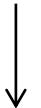


- membrane deformation

Material characterization



Material constitutive model



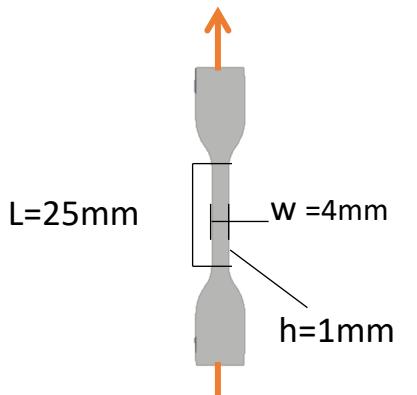
Finite Element modelling



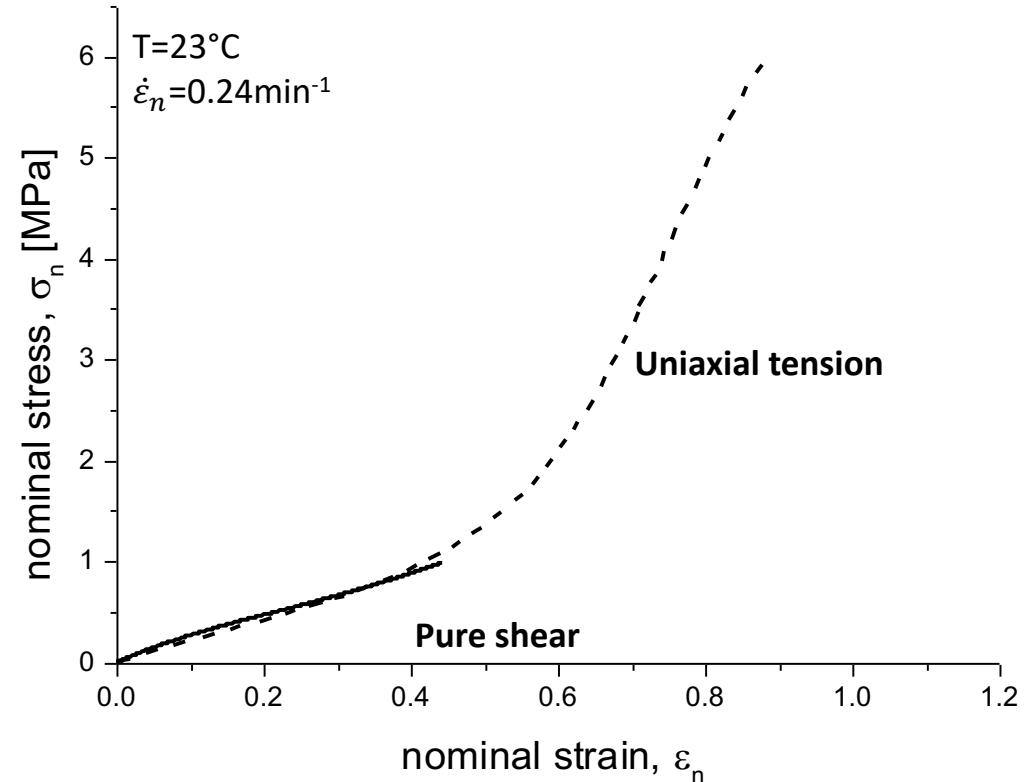
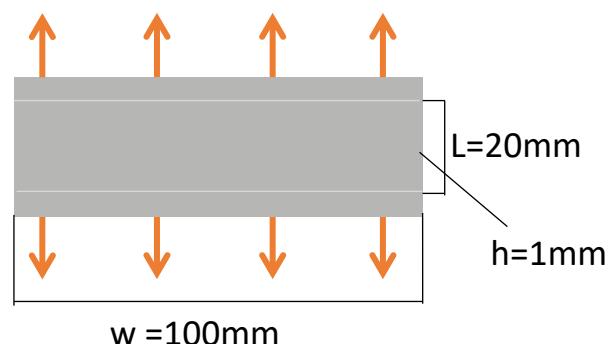
Prediction of the membrane deformation for any  $\Delta P$

## EXPERIMENTAL TESTING FOR MATERIAL CONSTITUTIVE LAW DEFINITION (SYLGARD184 –DOW CORNING)

### Uniaxial tension



### Pure shear



Constitutive model: *Ogden*  
3<sup>rd</sup> order of strain energy potential,  $U = \sum_{i=1}^N \frac{2\mu_i}{\alpha_i^2} (\bar{\lambda}_1^{\alpha_i} + \bar{\lambda}_2^{\alpha_i} + \bar{\lambda}_3^{\alpha_i} - 3)$

- membrane deformation

Material characterization



Material constitutive model

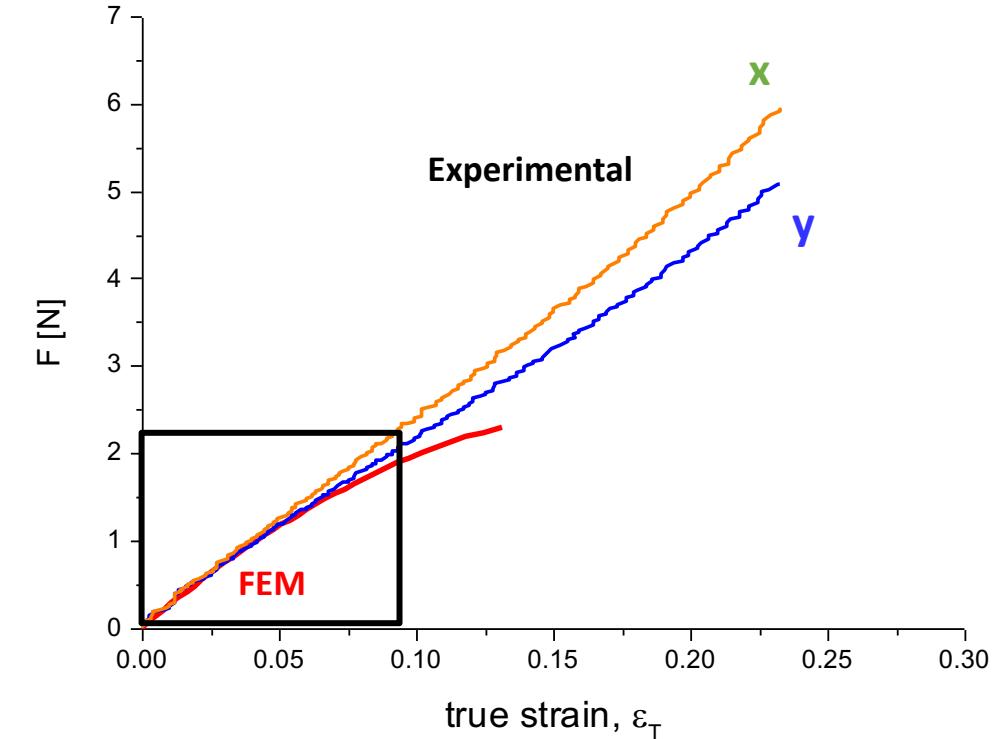
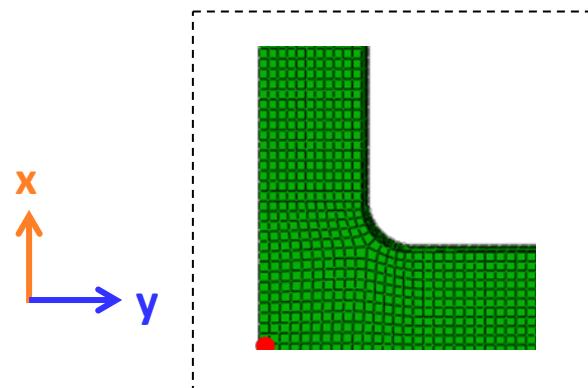
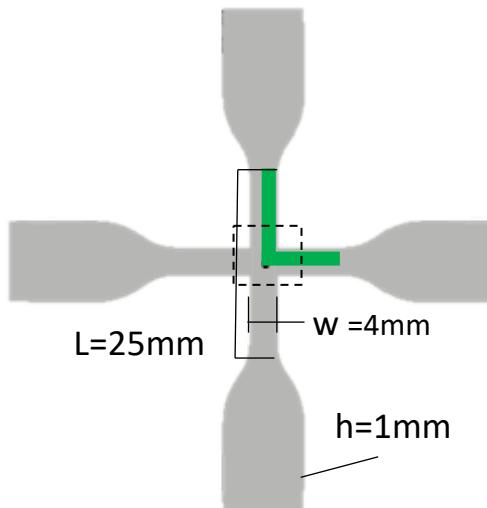


Finite Element modelling



Prediction of the membrane deformation for any  $\Delta P$

### MODEL VALIDATION WITH EQUI-BIAXIAL TENSILE TEST



Element type: C3D8RH  
# Elements: 7650  
# Node: 17742

- membrane deformation

Material characterization



Material constitutive model



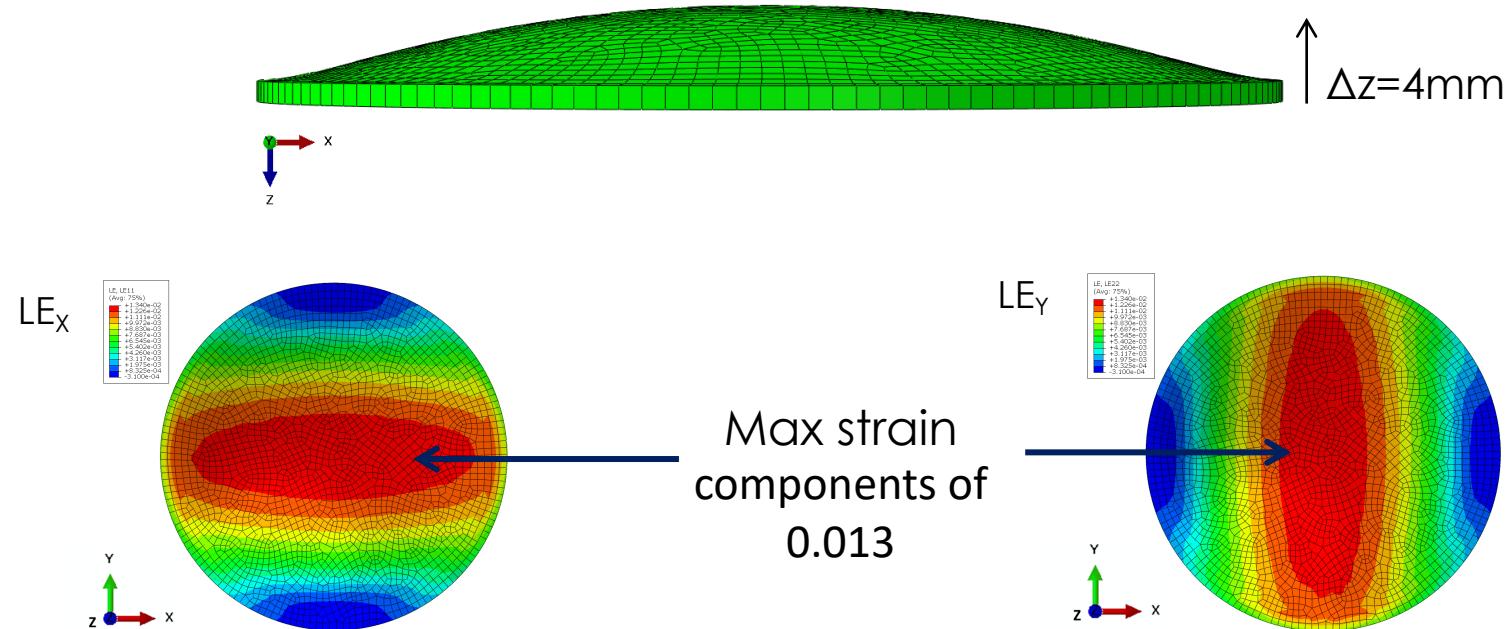
Finite Element modelling



Prediction of the membrane deformation for any  $\Delta P$

## POLYSILOXANE MEMBRANE MODELLING (FEM)

Applied pressure as in the valve:  $P = 0.01 \text{ MPa}$



Element type: C3D8RH  
# Elements: 2535  
# Node: 5232

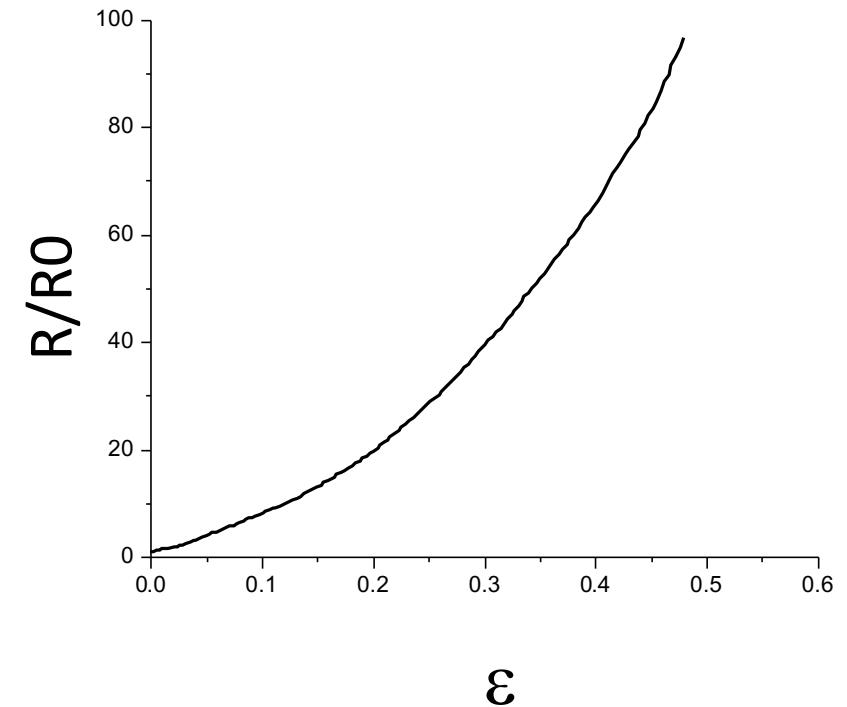
- membrane deformation
- $\Delta R = f(\text{membrane deformation})$

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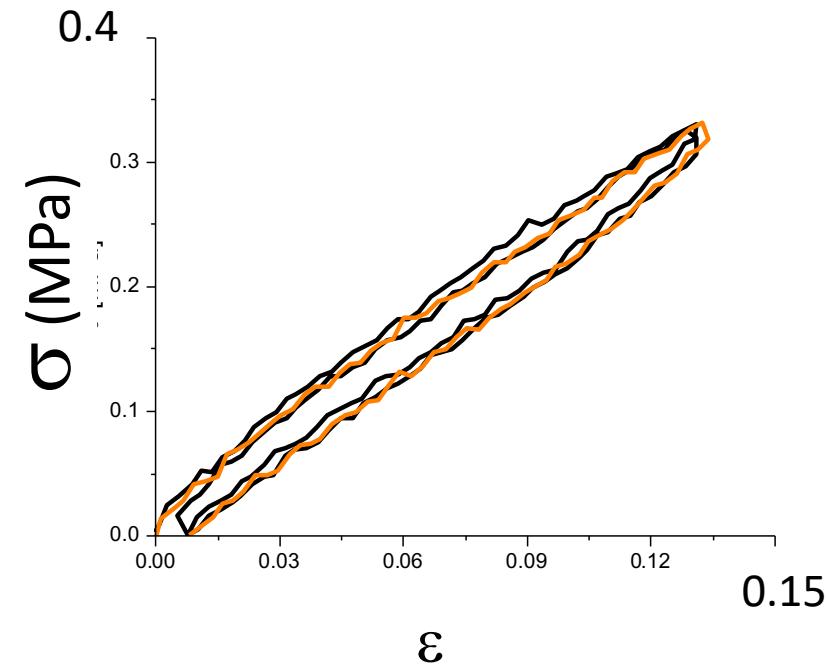
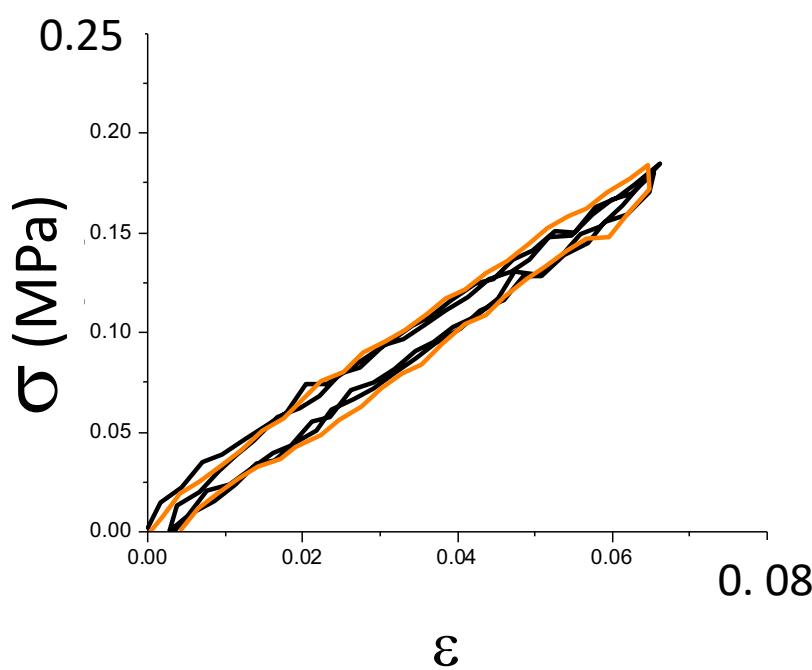
Gold implanted on PDMS-SIL540080T



STRAIN INDUCED RESISTANCE CHANGE

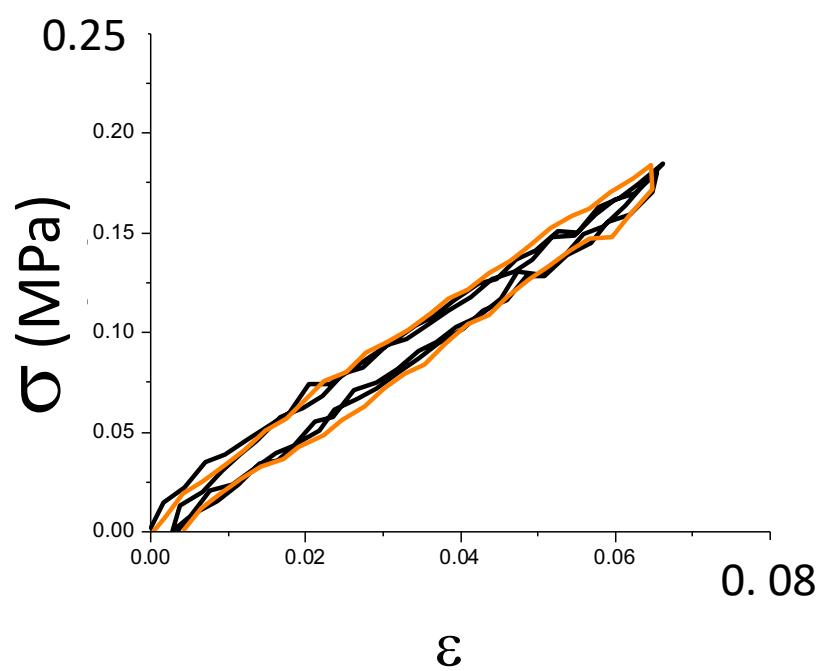


## PDMS-SIL540080T: characterization mechanical behaviour

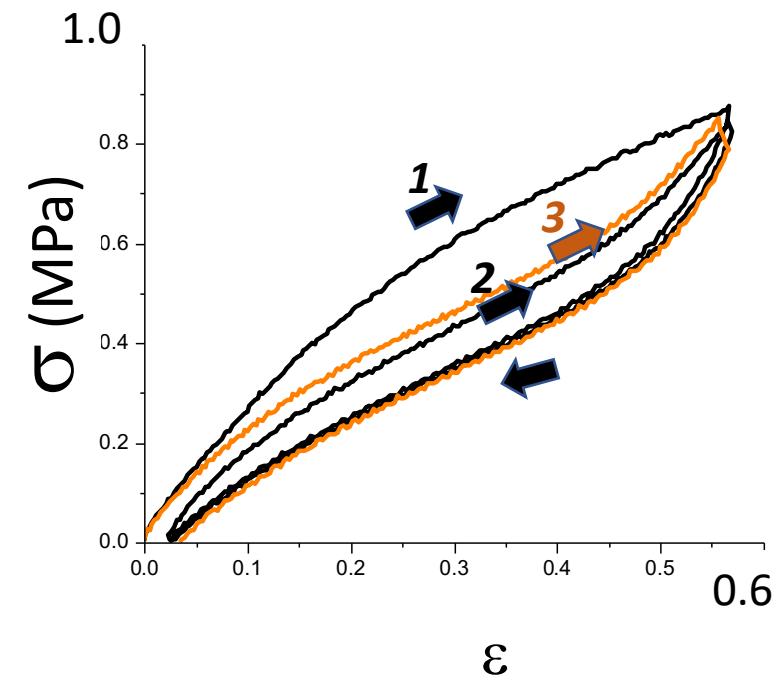
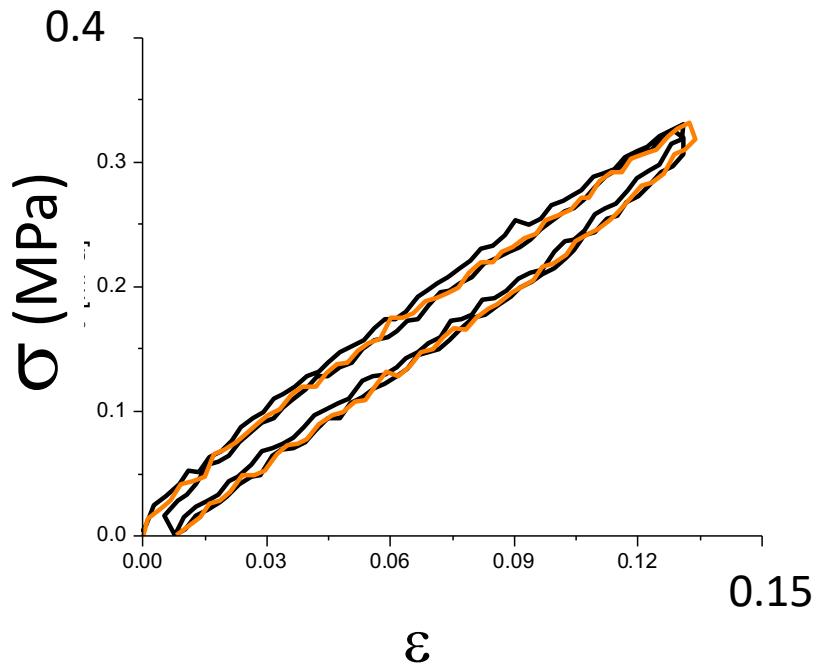


- cycle 1, 2  
- cycle 3, after 5 days

# PDMS-SIL540080T: characterization mechanical behaviour

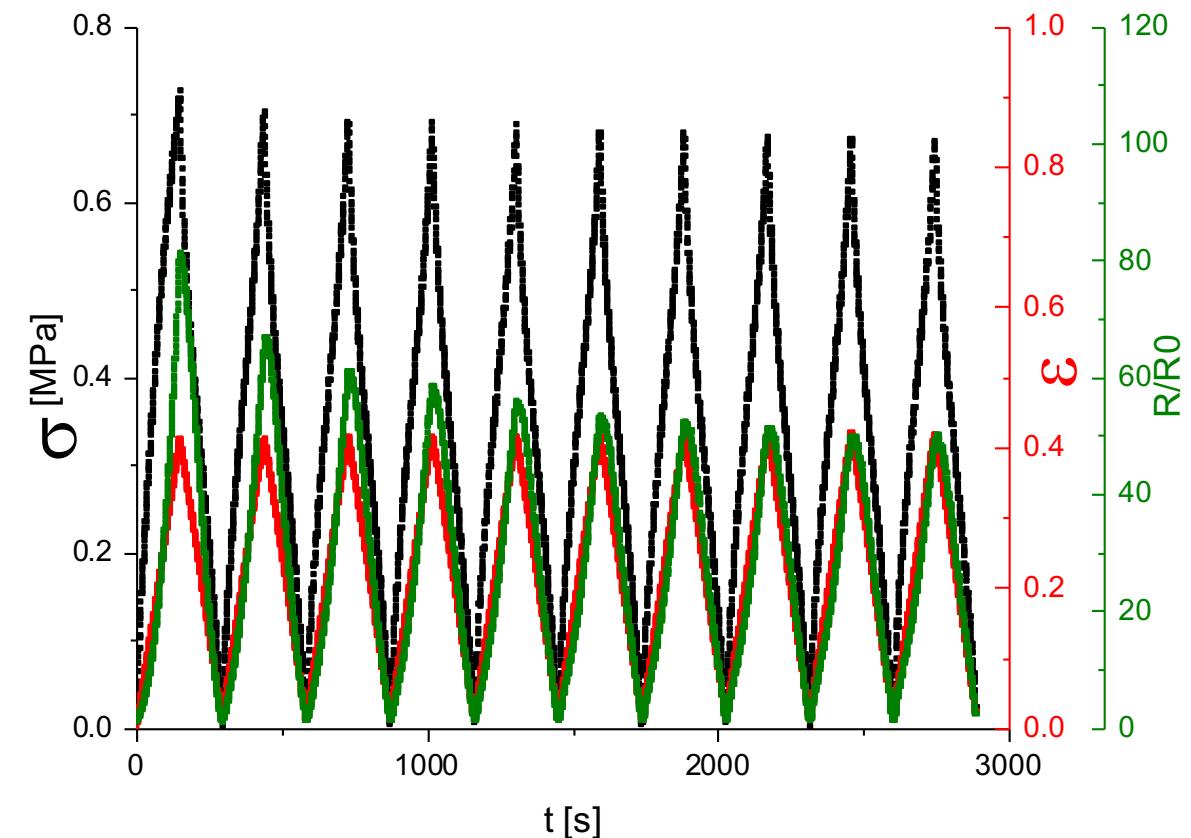
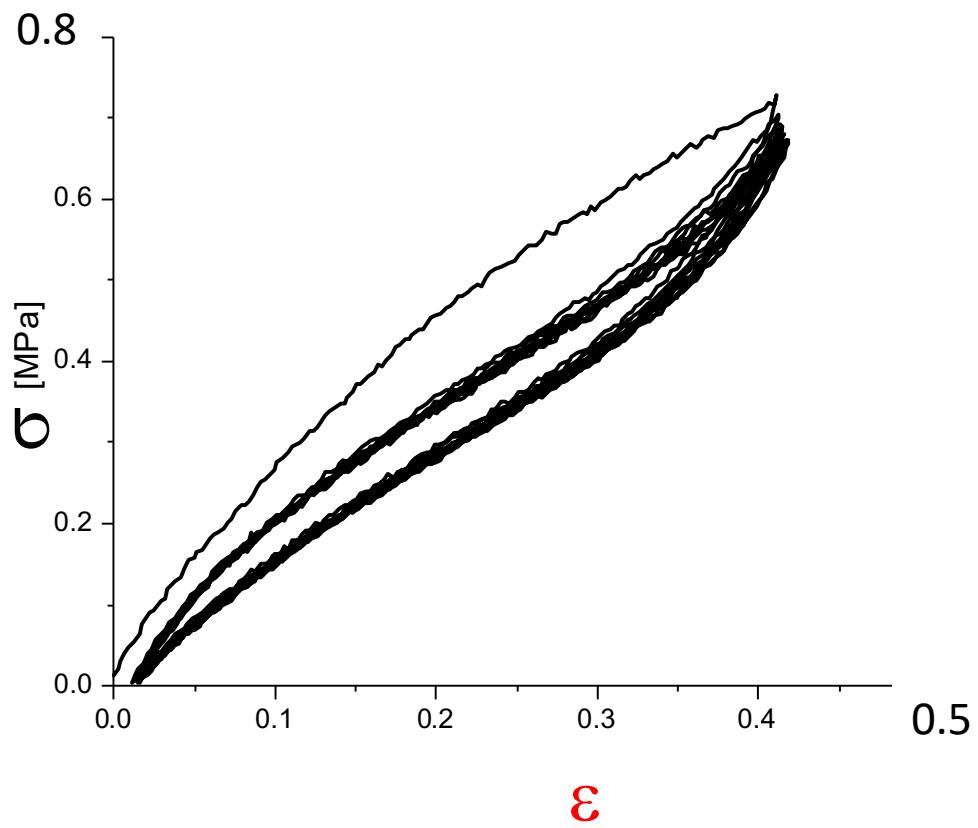


- cycle 1, 2  
- cycle 3, after 5 days



- membrane deformation
- $\Delta R = f(\text{membrane deformation})$

*implanted gold/PDMS-SIL540080T: electro-mechanical behaviour characterization*



POLIMI-CMIC ACTIVTY :

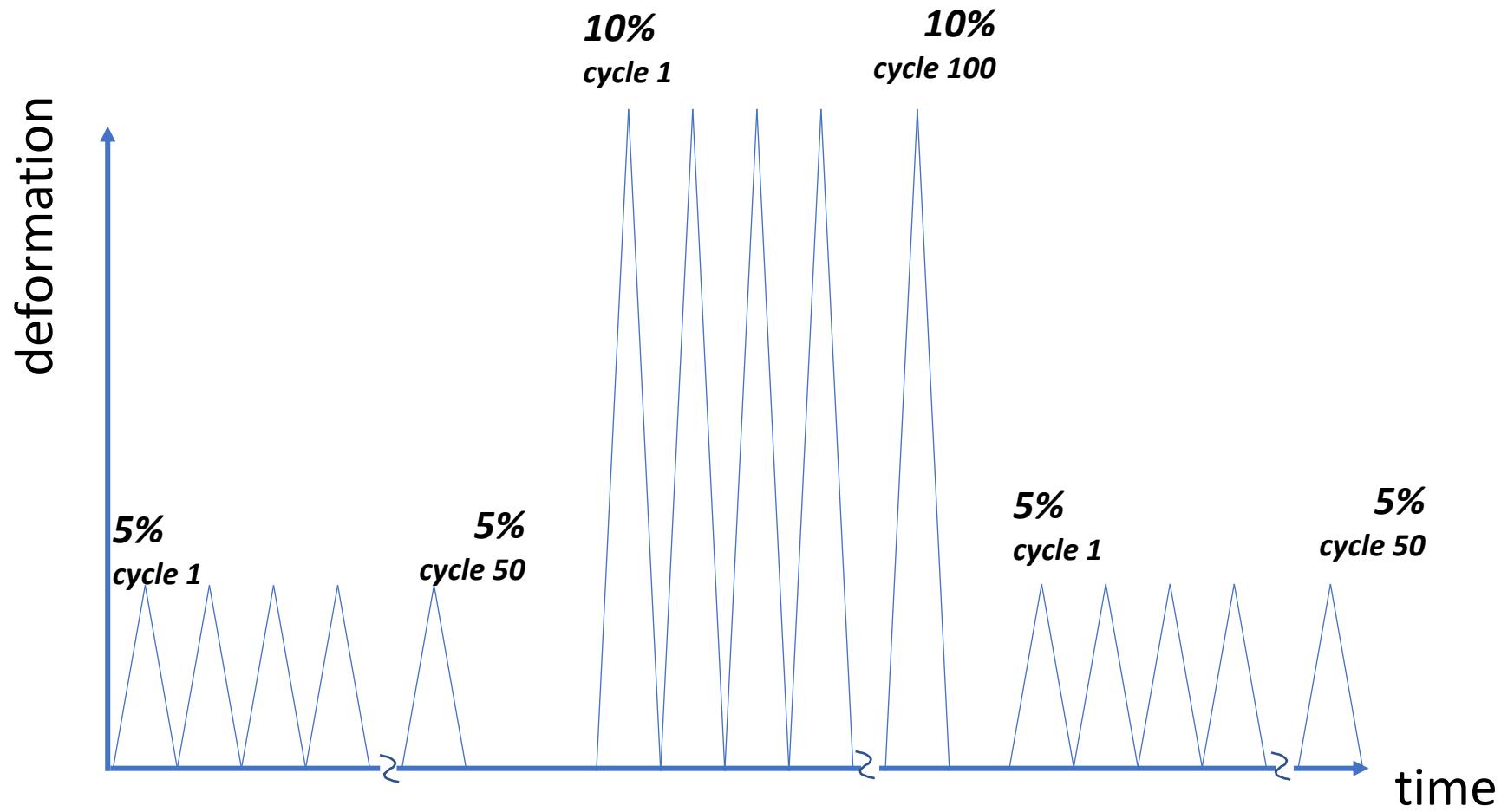
- membrane deformation
  - $\Delta R = f(\text{membrane deformation})$
- 

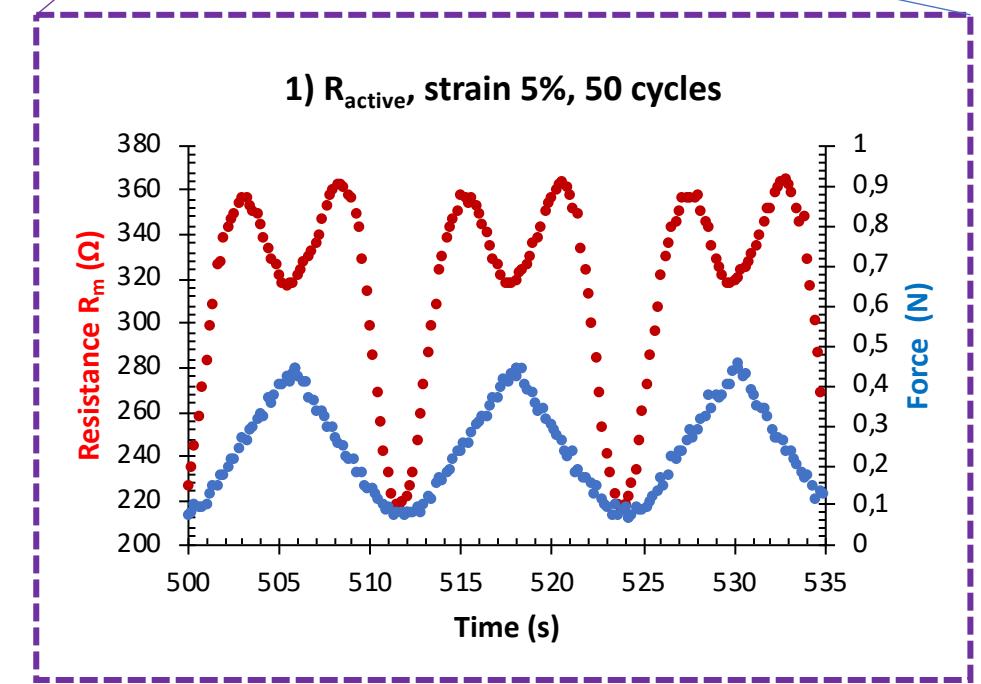
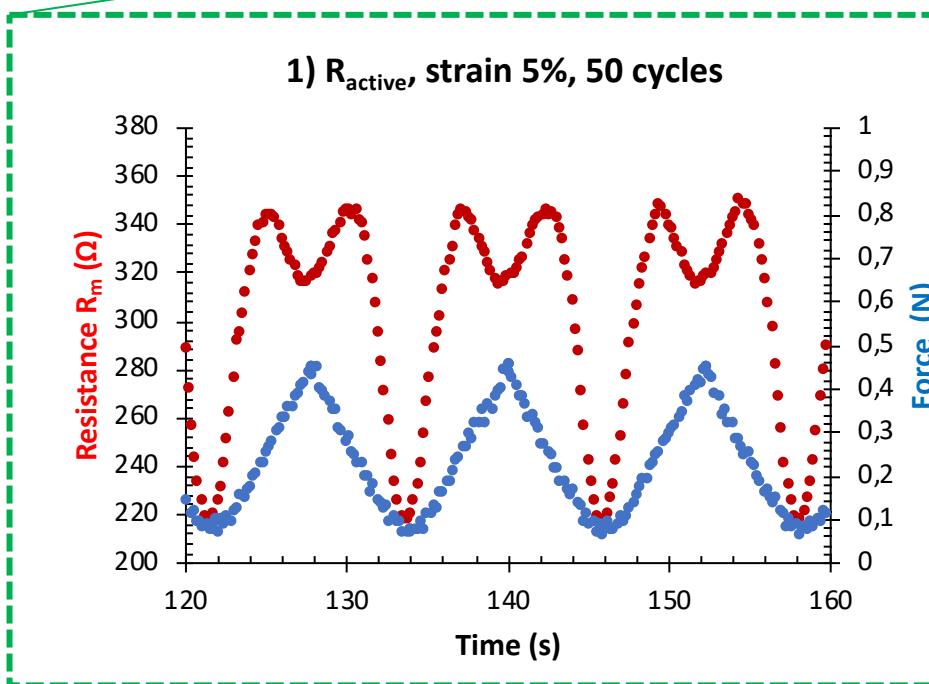
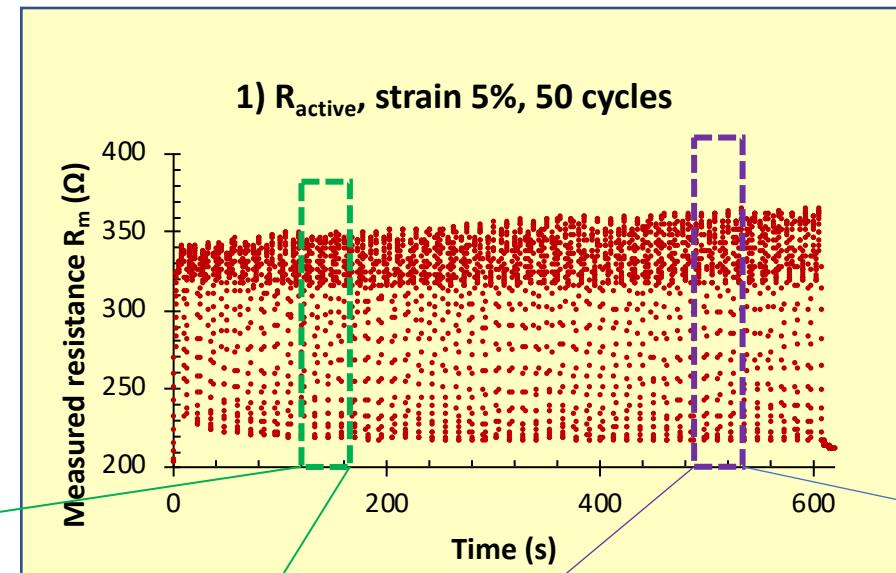
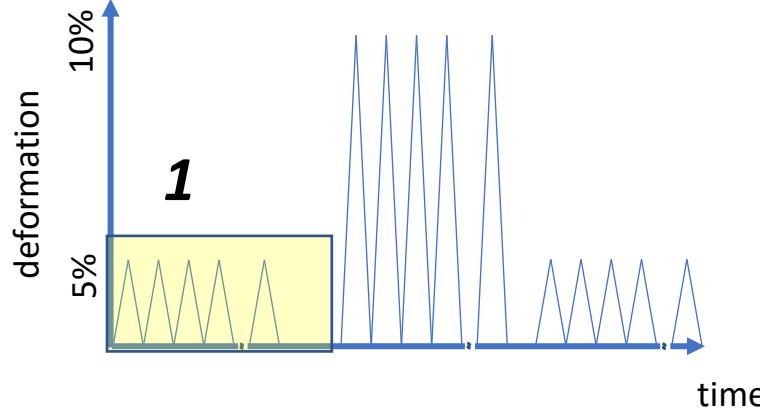
*deposited carbon- gold/PDMS-SIL540080T: electro-mechanical behaviour characterization*

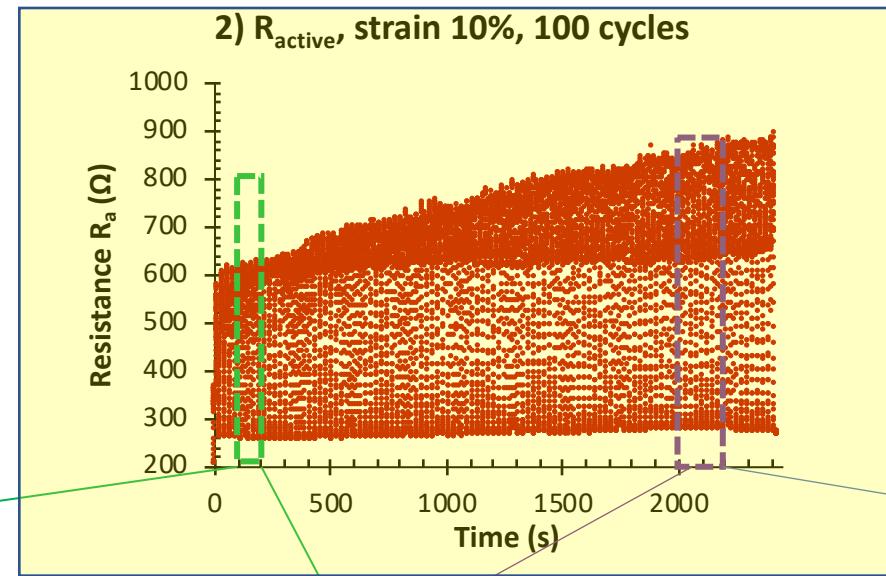
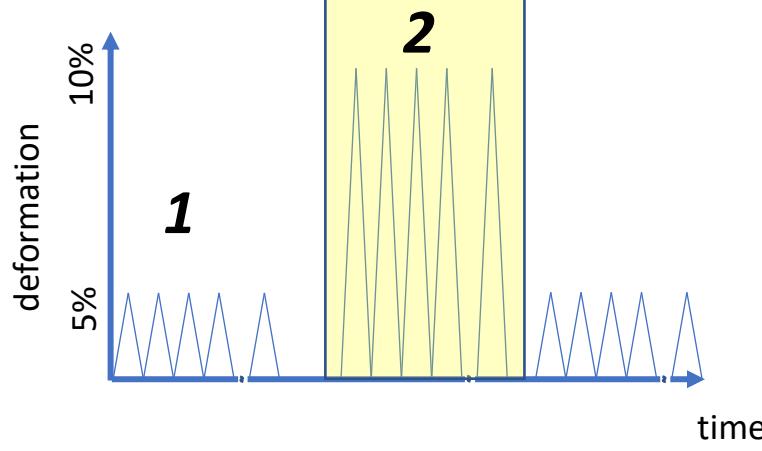


- membrane deformation
- $\Delta R = f(\text{membrane deformation})$

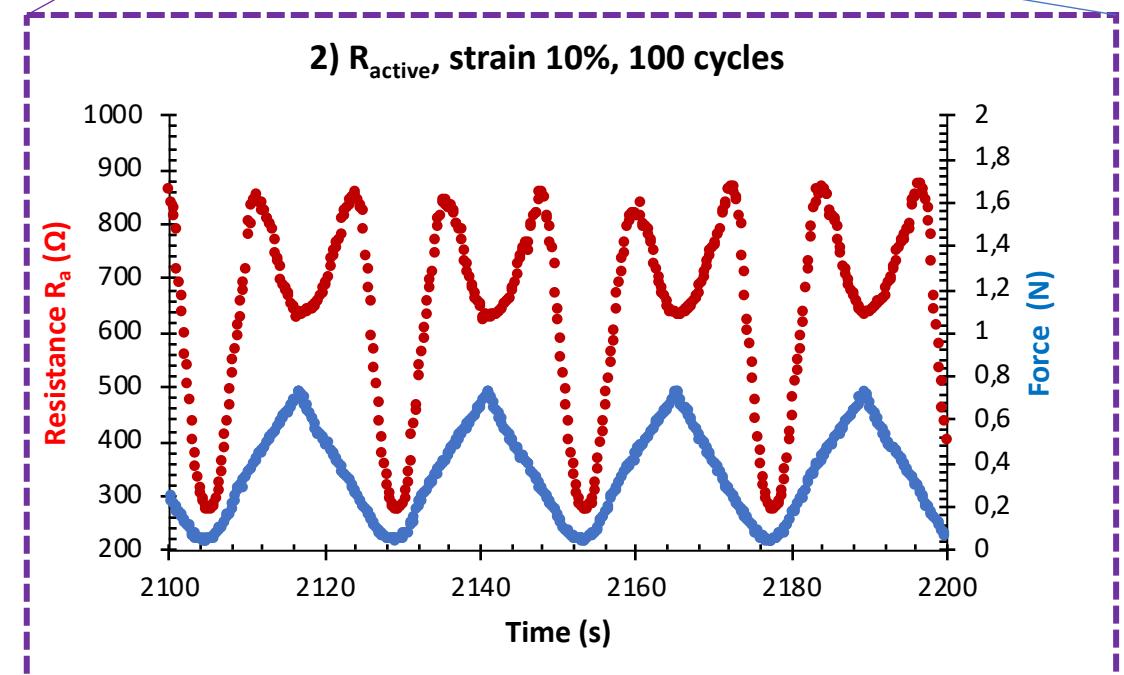
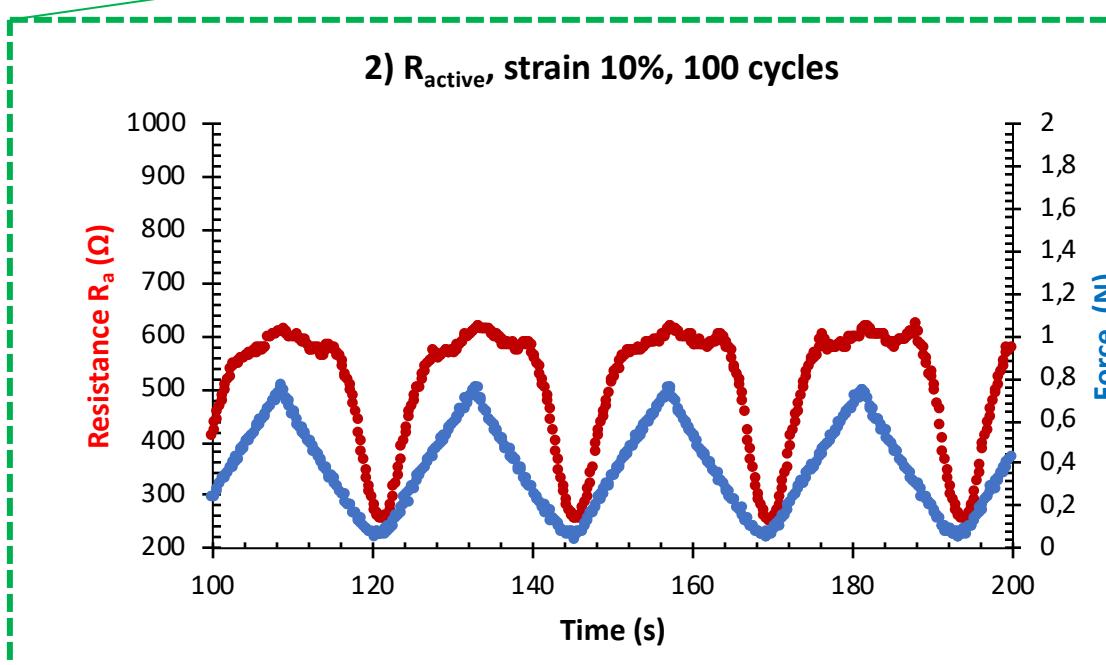
*deposited carbon- gold/PDMS-SIL540080T: electro-mechanical behaviour characterization*

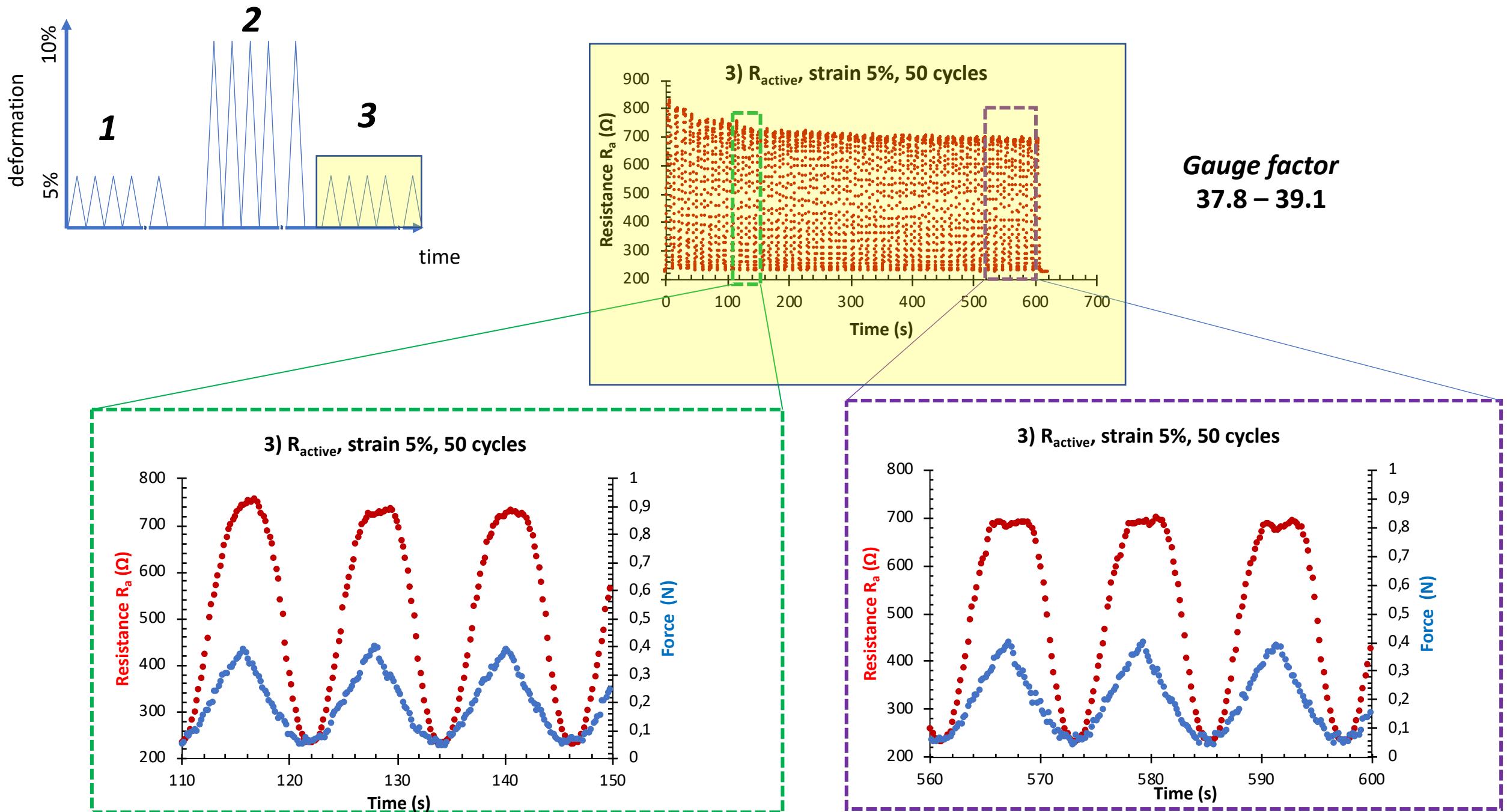






**Gauge factor**  
12.8 – 21.4





## *Goals achieved*

- *PDMS constitutive equation for membrane FEM modeling*
- *Resistance/deformation correlation in*
  - *PDMS/ implanted gold*
  - *PDMS/ deposited carbon-gold*

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## *Further developments*

- *Resistance-strain correlation for more complex loading histories*