## ASSIST Smart valves based on active soft materials **Project results and exploitation perspectives ONLINE EVENT** 15 October 2021 14:30 (CET) Funded by Fondazione CARIPLO Regione Lombardia POLITECNICO

Stretchable strain sensors: characterization and modelling of the electromechanical behaviour





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r

 $H_i$ 

0

Isotropic materials

 $m = \delta / \Delta x$ 

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J

 $\Delta x$ 

 $k_n$ 

 $k_{\vartheta}$ 

 $k_e$ 

Linear and angular momentum, and electric conduction balance equations

$$\int_{H_{\mathbf{x}}} \mathbf{f}(\mathbf{x}, \mathbf{x}', \mathbf{u}, \mathbf{u}', \theta, \theta') dV_{\mathbf{x}'} + \mathbf{b}(\mathbf{x}, t) = \mathbf{0} \quad \text{for} \quad \mathbf{x} \in \Omega_{\mathbf{x}}$$

$$\int_{H_{\mathbf{x}}} m(\mathbf{x}, \mathbf{x}', \mathbf{u}, \mathbf{u}', \theta, \theta') dV_{\mathbf{x}'} + c(\mathbf{x}, t) = 0 \quad \text{for} \quad \mathbf{x} \in \Omega$$

$$\int_{H_{\mathbf{x}}} f_I(\mathbf{x}, \mathbf{x}', \phi, \phi') dV_{\mathbf{x}'} + \omega(\mathbf{x}, t) = c_e \dot{\phi}(\mathbf{x}, t) \quad \text{for} \quad \mathbf{x} \in \Omega,$$

Numerical Prediction: Isotropic rectangular lamina



#### Numerical Prediction: Electrical conduction in bodies with evolving discontinuities



Numerical Prediction: tensile loading of SIL540080T



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#### Anisotropic materials: main feature of the model

anisotropic electrical conductivity function of the ligament orientation



$$k_e(\psi) = k_{e2} + (k_{e1} - k_{e2}) \cos^n \psi$$

Identification of the micro-conductivities  $k_{e1}$  and  $k_{e2}$ as function of the macro-conductivities  $K_{ell}$  and  $K_{e22}$ 

$$\begin{cases} \delta^2 (3k_{e1} + k_{e2})\pi h = 16K_{e11} \\ \delta^2 (k_{e1} + 3k_{e2})\pi h = 16K_{e22} \end{cases}$$

$$k_{e1} = \frac{2(3K_{e11} - K_{e22})}{\pi h \delta^2}; \qquad k_{e2} = \frac{2(3K_{e22} - K_{e11})}{\pi h \delta^2}$$

 $\pi h \delta^2$ 

**Numerical Prediction:** Anisotropic rectangular lamina



 $5\pi/6$ 

Electric potential

Numerical Prediction: propagation of crack in anisotropic lamina

**Electric potential** 

 $\phi/\phi_{ma}$ 



## Further improvements for modelling valves sensors

- 3D kinematic out of plane loadings
- Electro-mechanical response to dynamic loadings
- Exploiting stretchable strain sensors with electro and mechanical anisotropy

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