



Flexible Electro-Active Materials

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Flexible Electro-Active Materials

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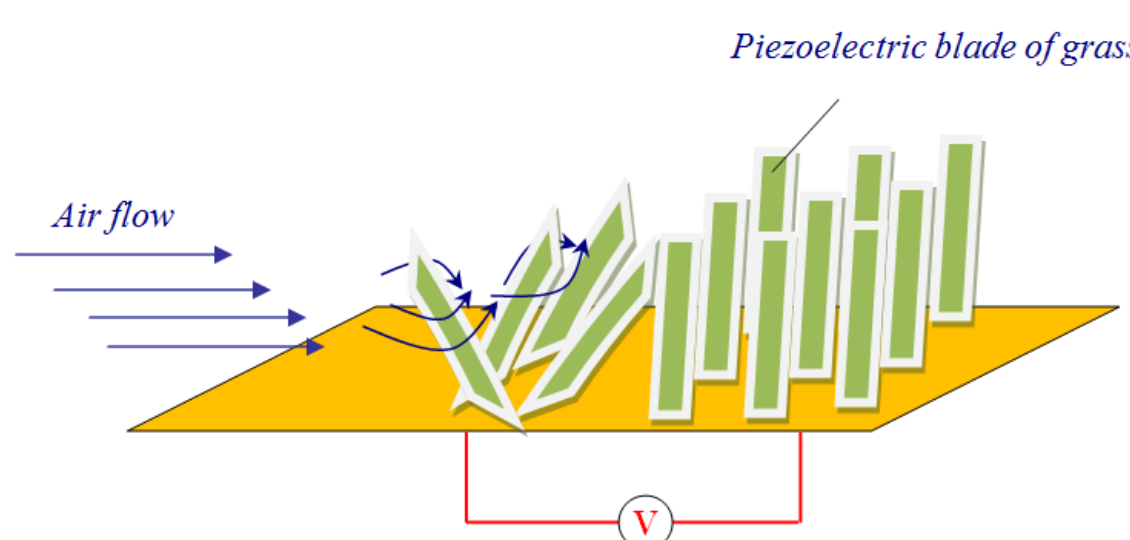
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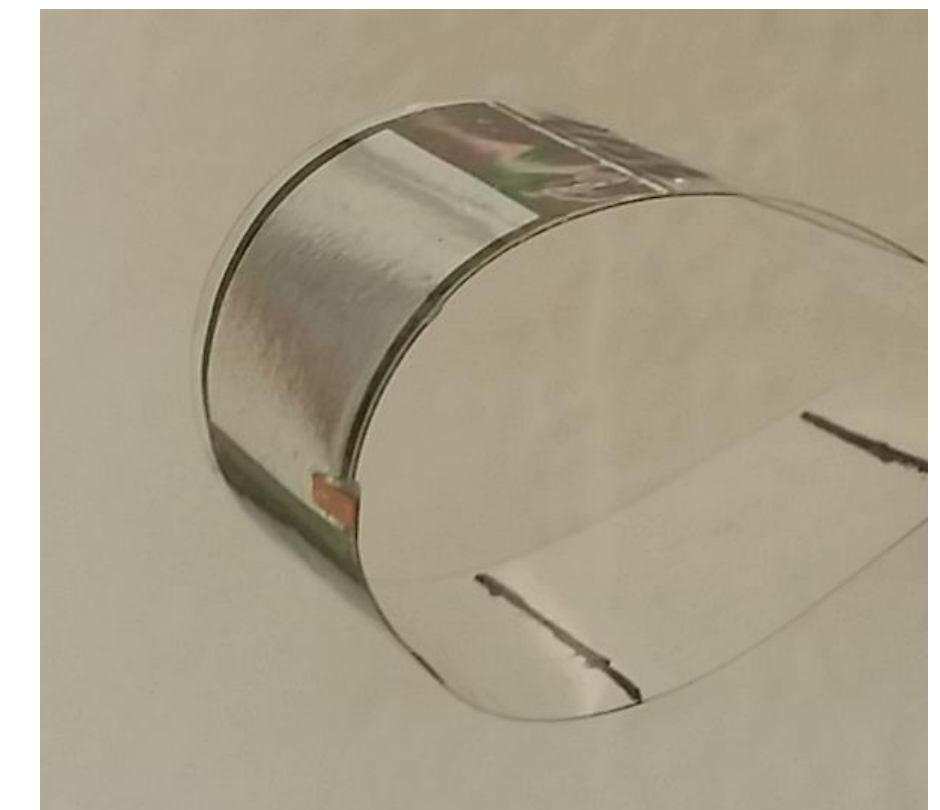
N-air-J and MIGAC projects

- **Aim:** Synthetic blade of grass to convert wind energy into electricity
- **Solution:** Use of flexible piezoelectric thin films
- **Support:** Financial support provided by the french region Pays de la Loire and RFI WISE



Others applications

- Energy harvesting from other ambient energy sources (wave energy, body motion)
- Smart sensors (biomedical, buildings, health care, IOT, smart cities)
- Actuators showing high displacements (centimeter range)



Flexible piezoelectric thin films

1

Lead zirconate titanate (PZT) films



PZT on Aluminium



PZT on PET

Fabrication process easily transferable to industry

→ **low cost: 280 €/m²**
0.5 cm × 4 cm beam = 5.6 cents 💰

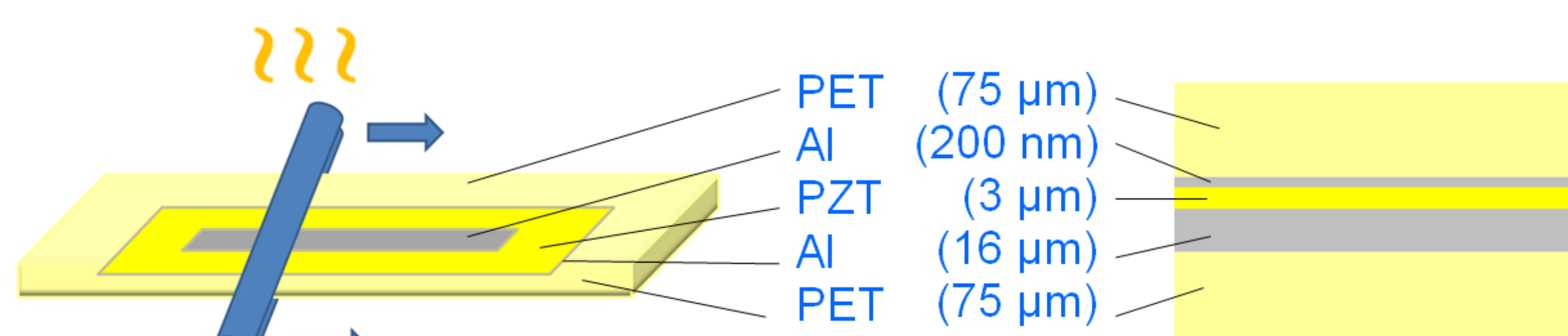


Cut able



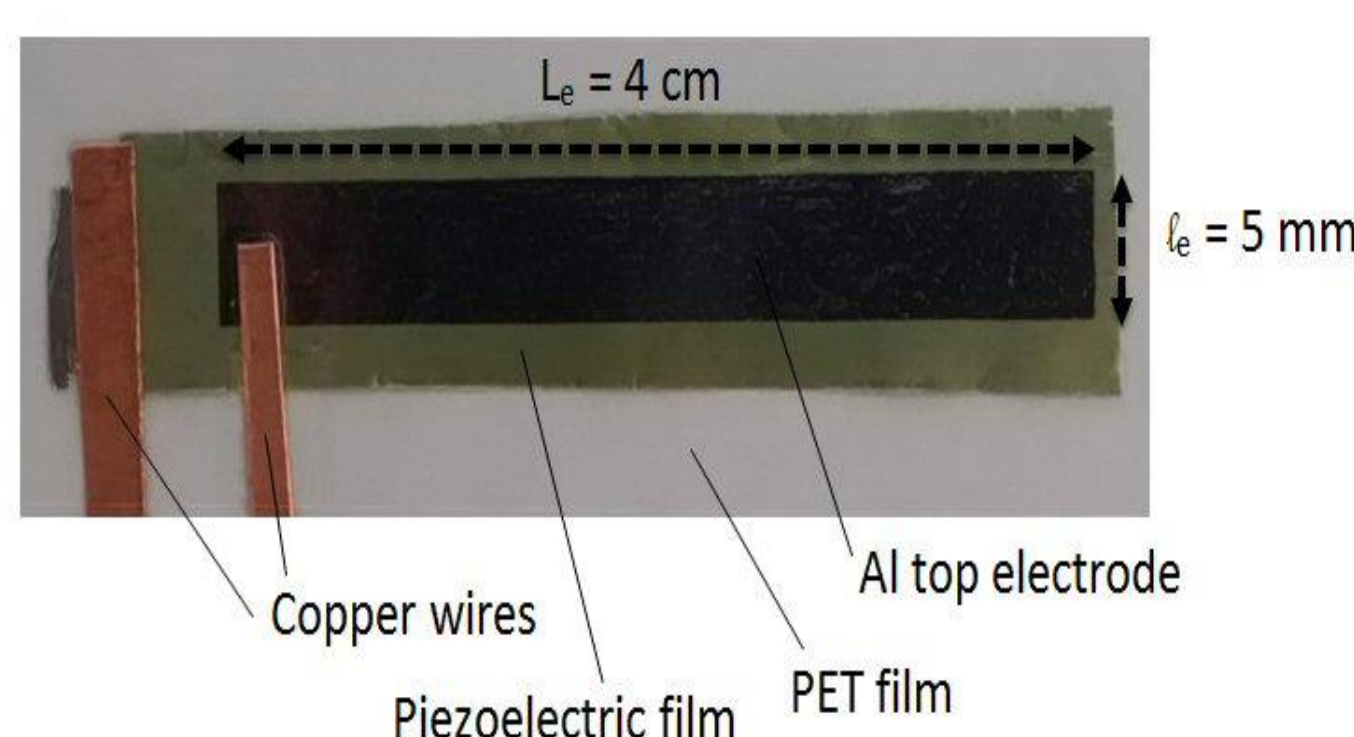
3D shape

Non conventional shapes



Preparation of the composite by lamination of the PET

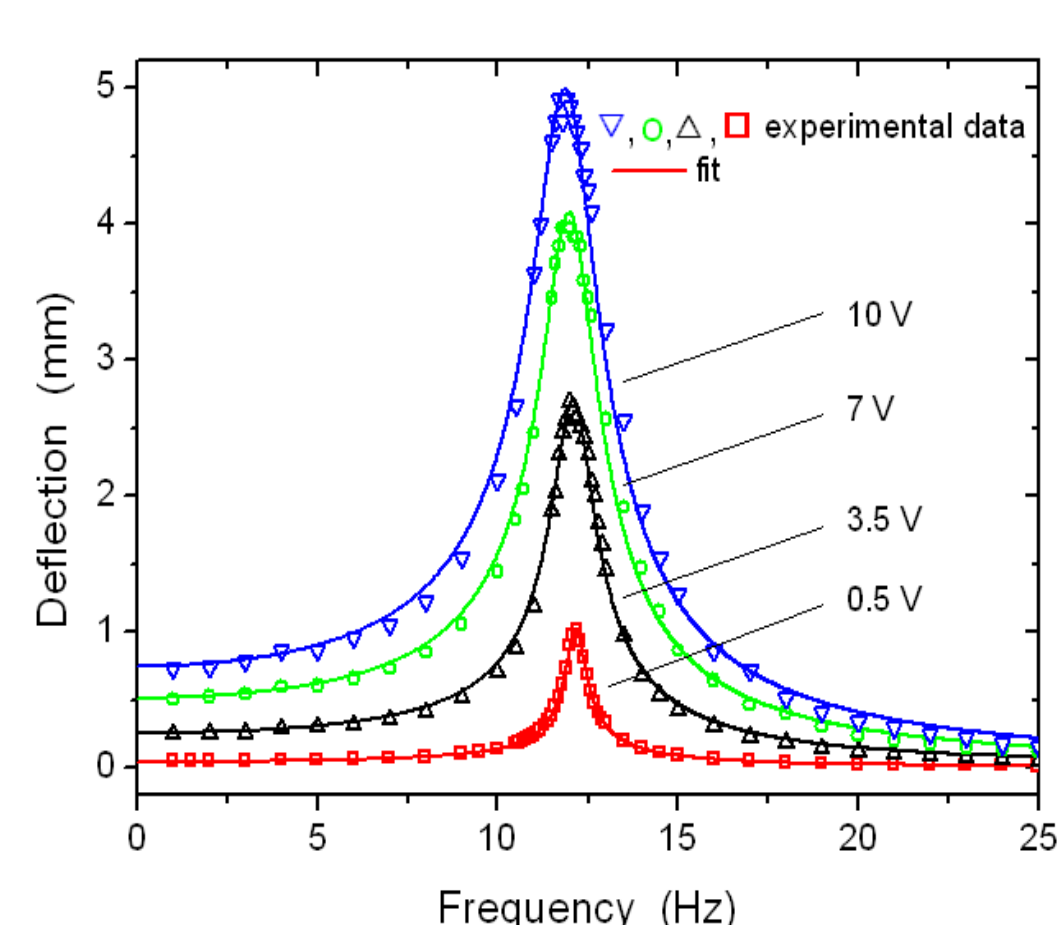
Sectional view of the composite



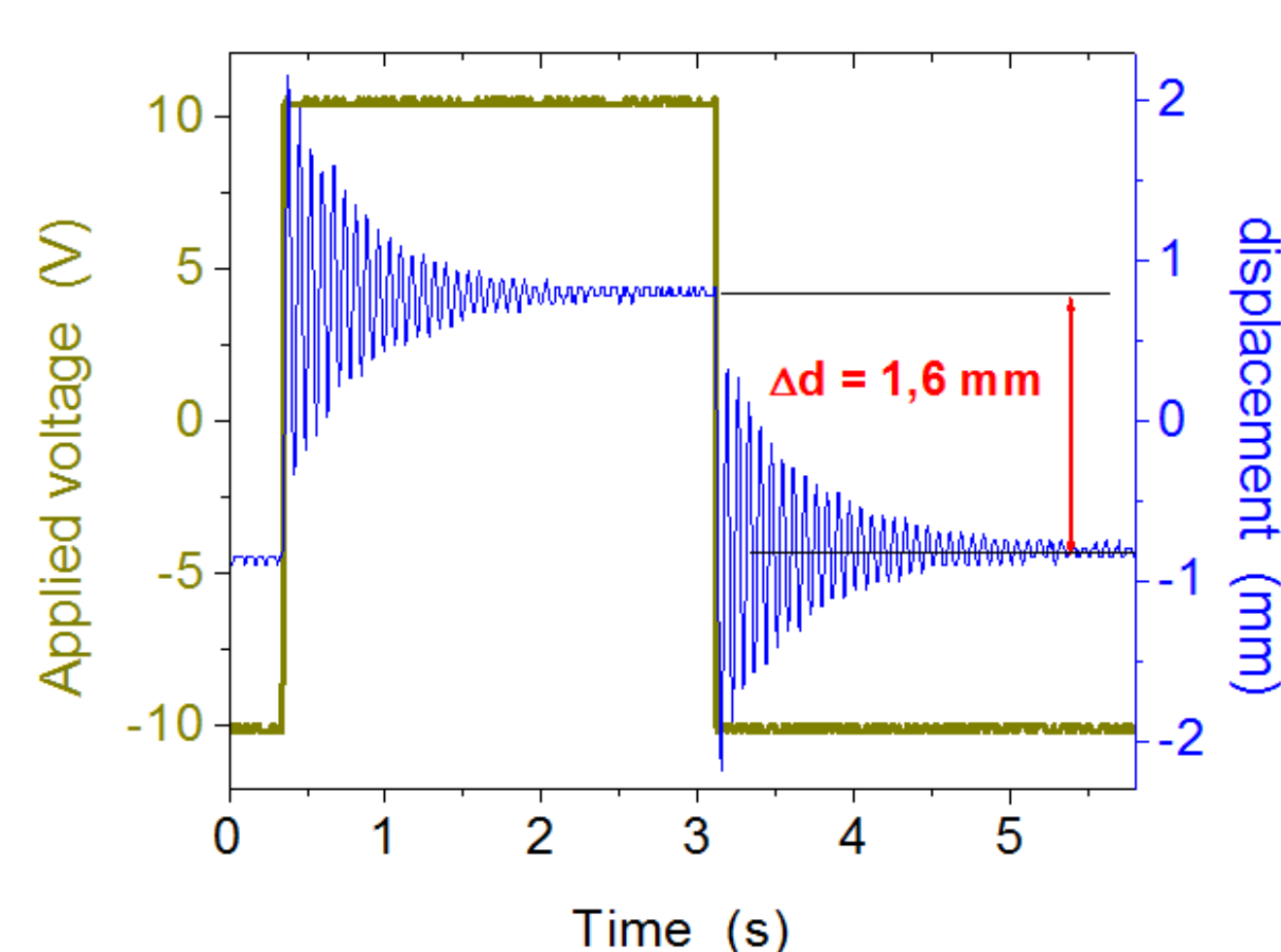
→ **Flexible and watertight**

High bending mode actuation properties

2



Sinusoidal electrical excitations



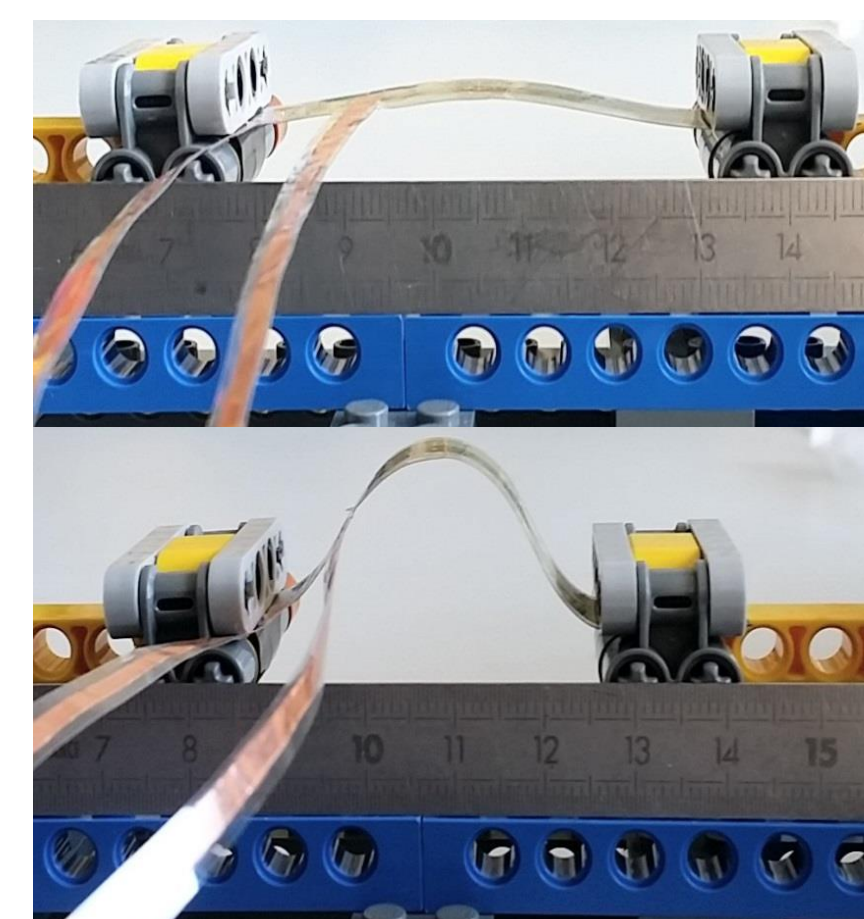
ON/OFF " mode

→ **milimetric deflections at low applied voltages**

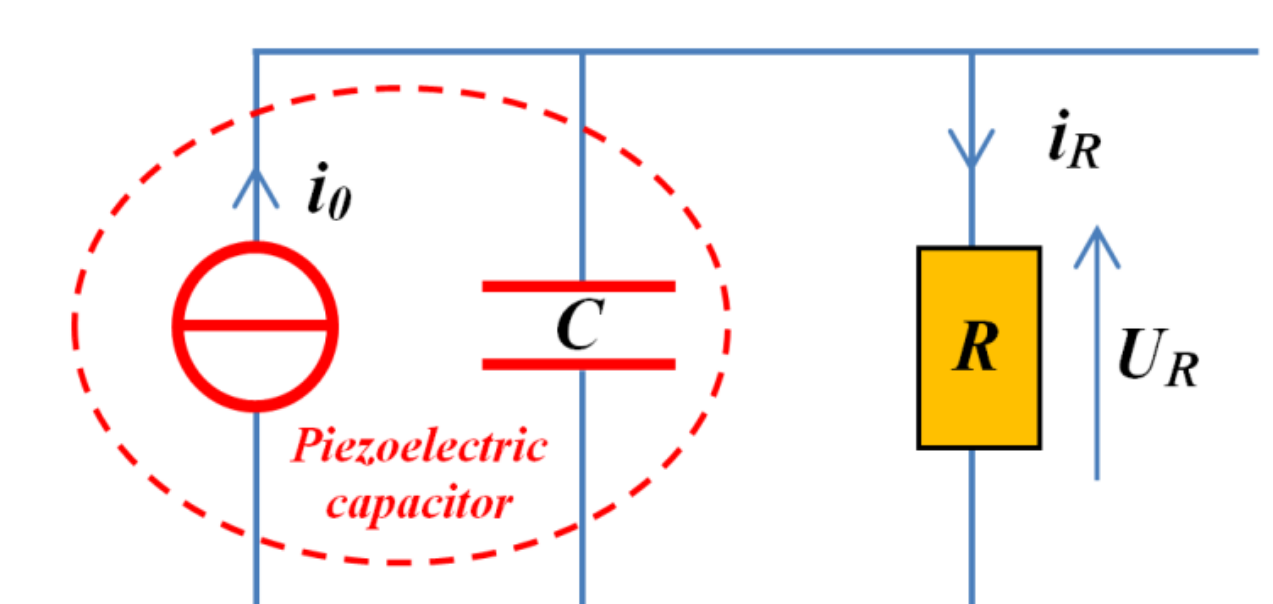
Energy harvesting

3

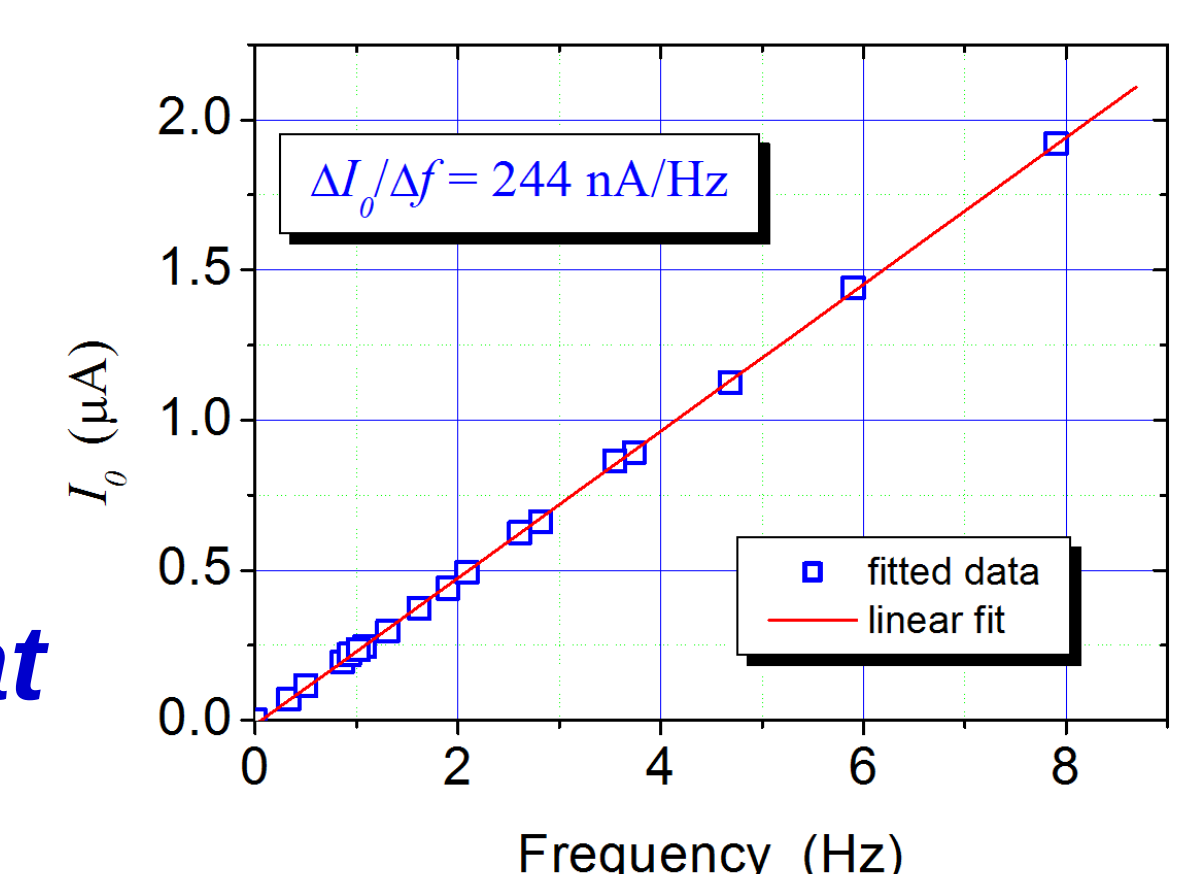
Mechanical excitation of the piezoelectric blade



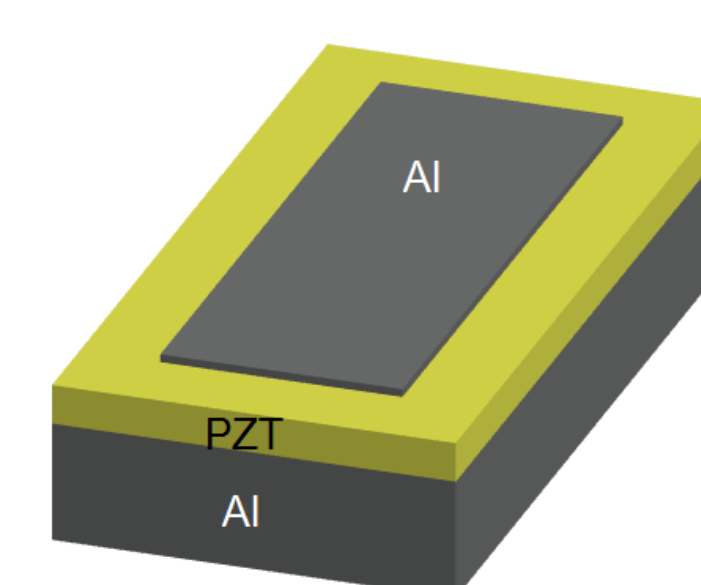
Scheme of the equivalent circuit of the energy harvesting device :



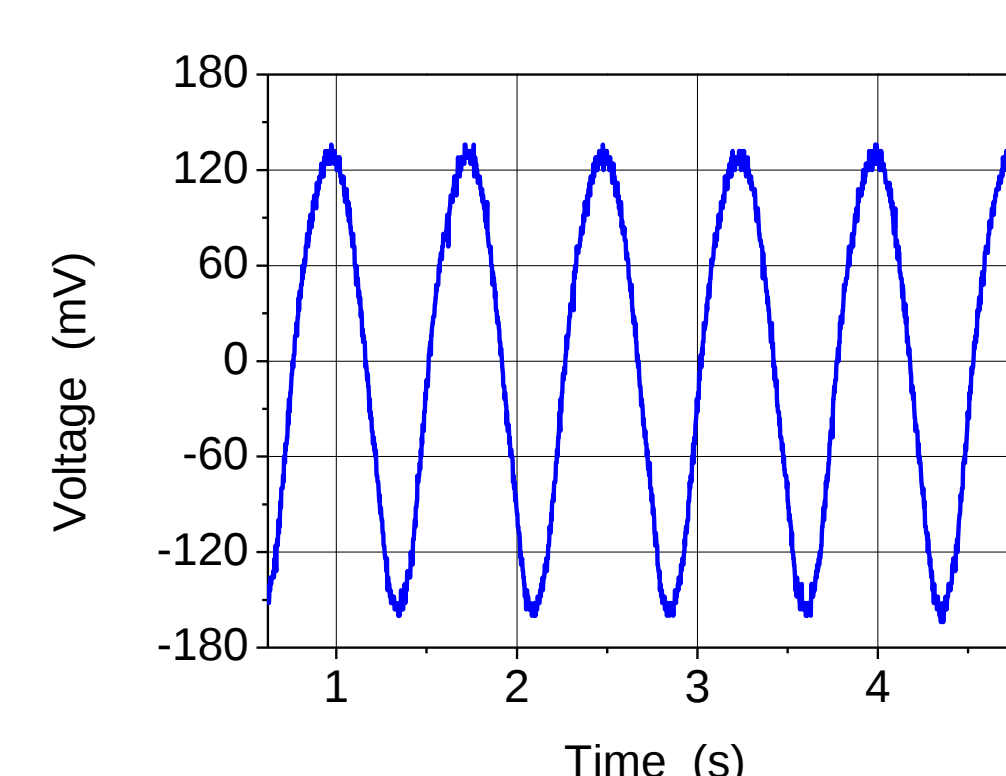
Piezoelectric current



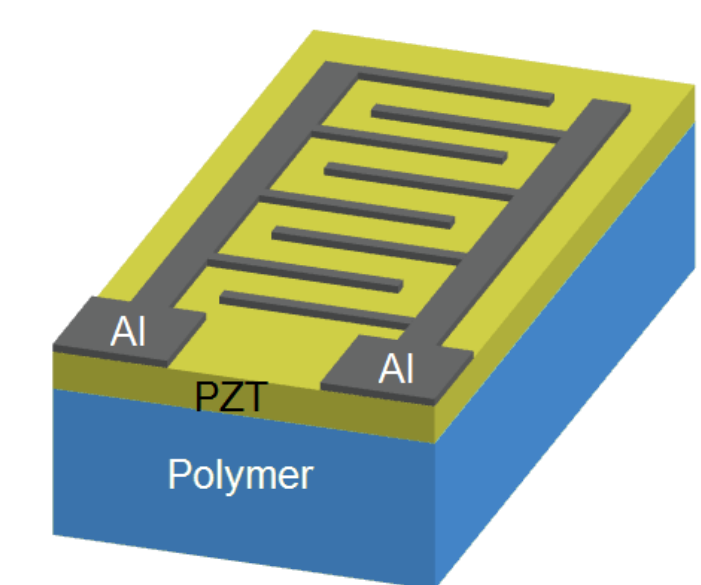
Harvesting device working at very low frequencies



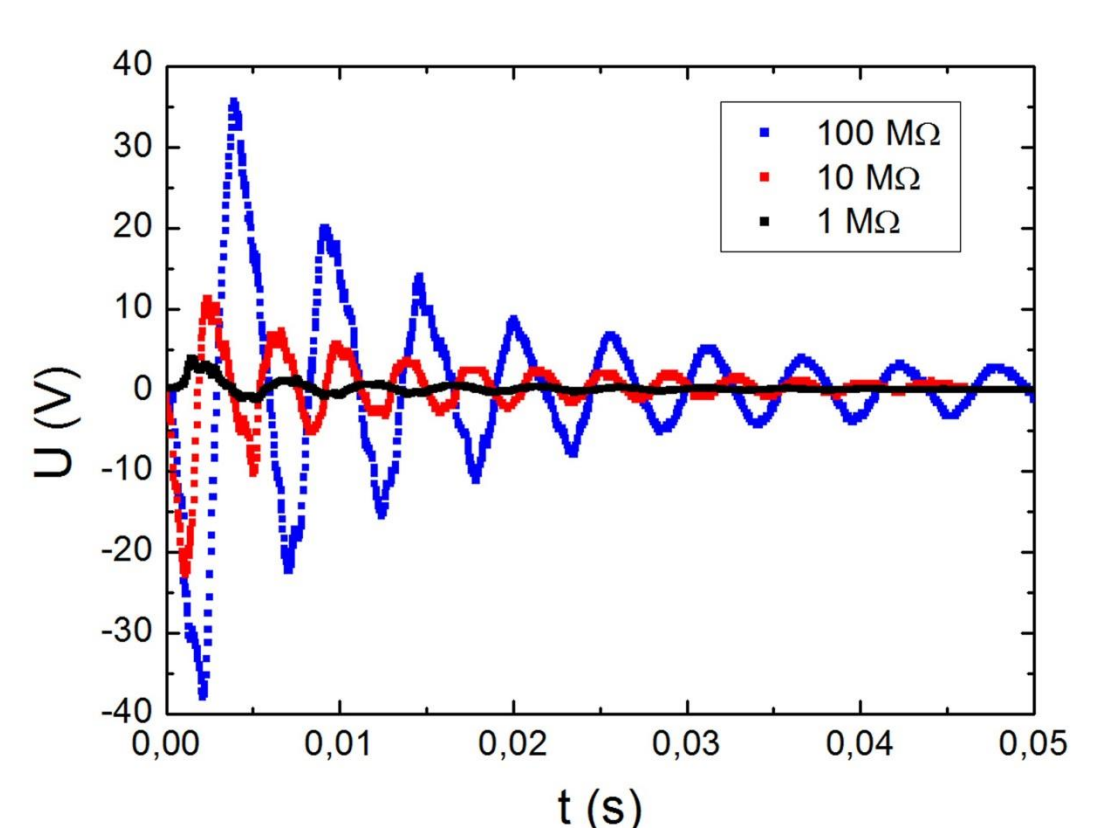
MIM structure



Output voltage X 100



IDE structure



Flexoelectric polymers for large curvature sensing

4

Flexoelectricity: Mechanical-to-electrical coupling between strain gradient (curvature) and electrical polarization P_{flex} in every solid dielectrics → Flexoelectric effect in soft polymer films may be used for the development of low cost and easy to implement elastomer-based large curvature sensors on highly flexible metallic structures

Strain gradient

Curvature

$$P_{flex} = \mu \left(\frac{\partial S}{\partial x} \right) = \mu C$$

Flexoelectric coefficient μ



Polyurethane (PU) film

PU thin films ($e=6 \mu m$) deposited onto Al foil /PET flexible cantilever → direct sensing of large curvature ($80 m^{-1}$) = radius of curvature ($\sim 1 cm$)

