# Flexible Electro-Active Materials

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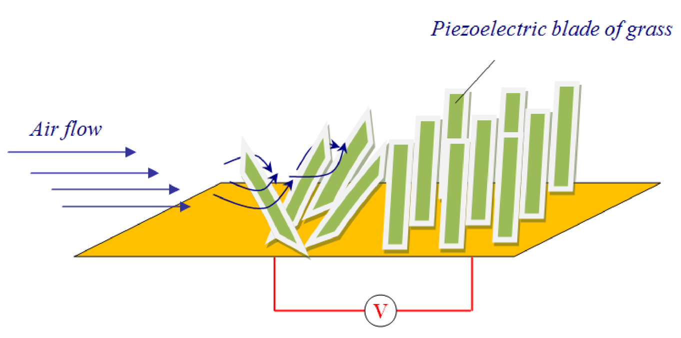
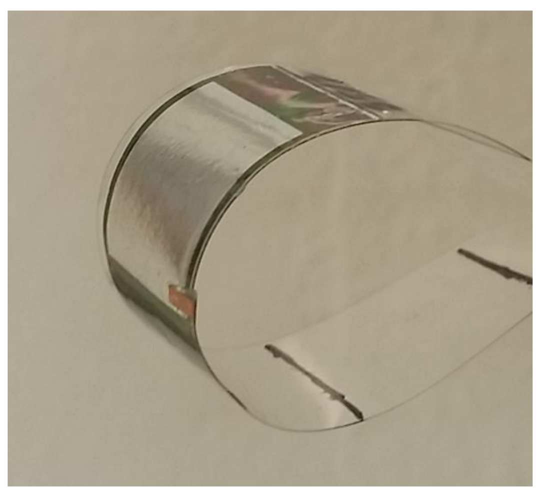
## N-*air*-J and MIGAC projects

- ***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***

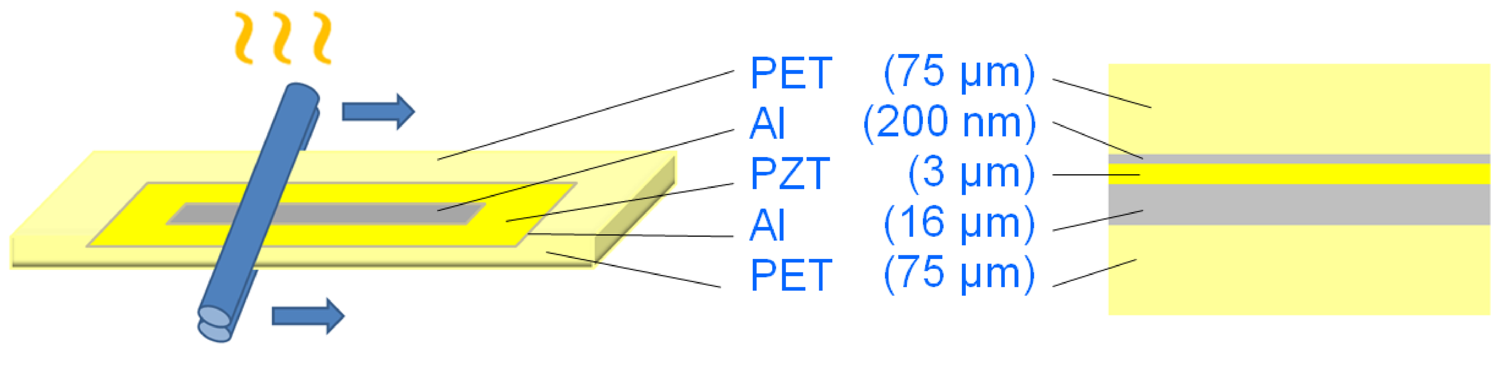
➡ ***low cost: 280 €/m²***

***0.5 cm × 4 cm beam = 5.6 cents***

Cut able

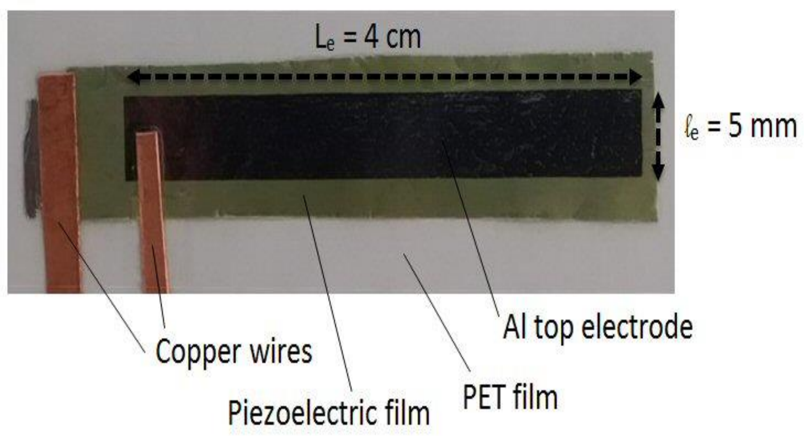
3D shape

***Non conventional shapes***



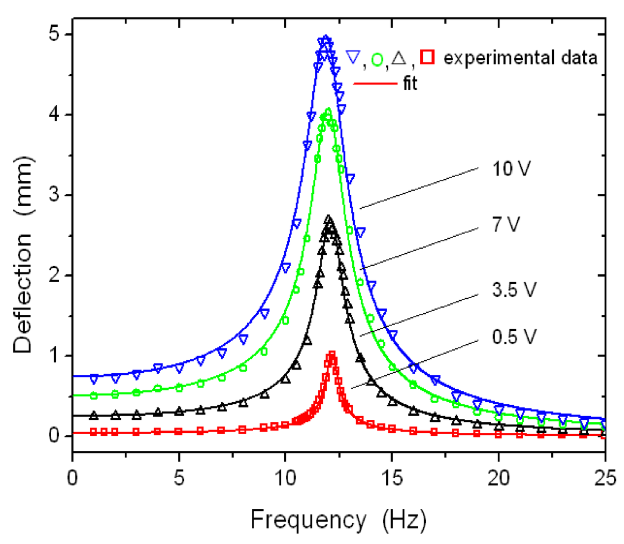

*Preparation of the composite by lamination of the PET*

*Sectional view of the composite*

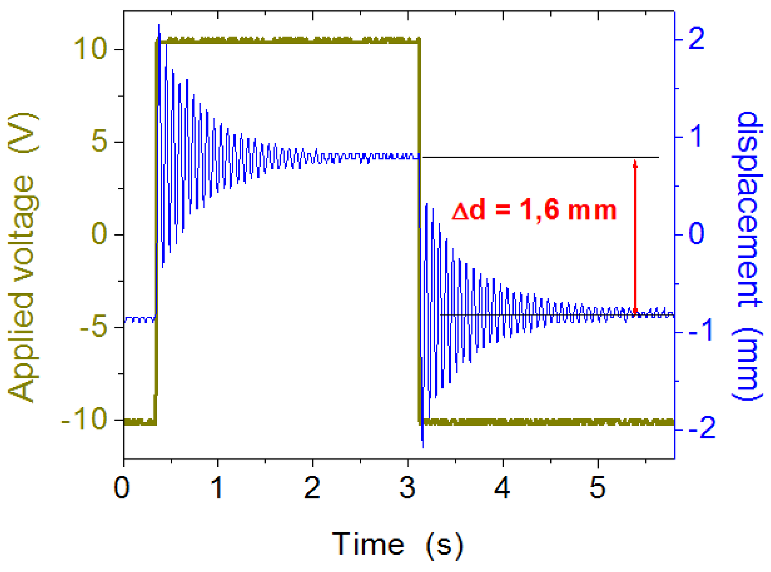



➡ ***Flexible and watertight***

## High bending mode actuation properties (2)




Sinusoïdal electrical excitations

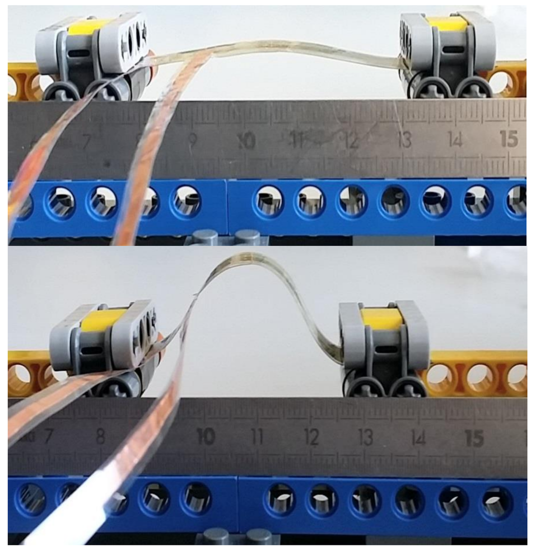



ON/OFF " mode

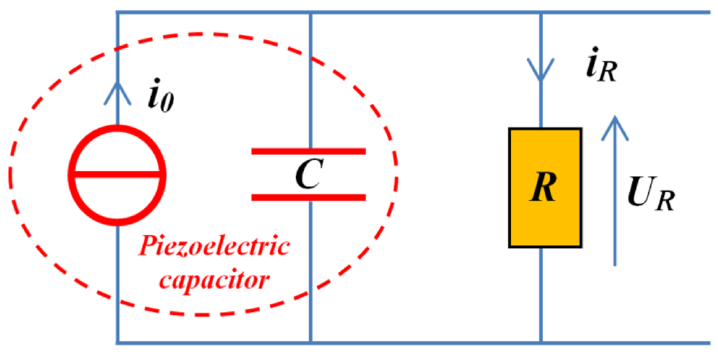
➡ ***milimetric deflections at low applied voltages***

## Energy harvesting (3)

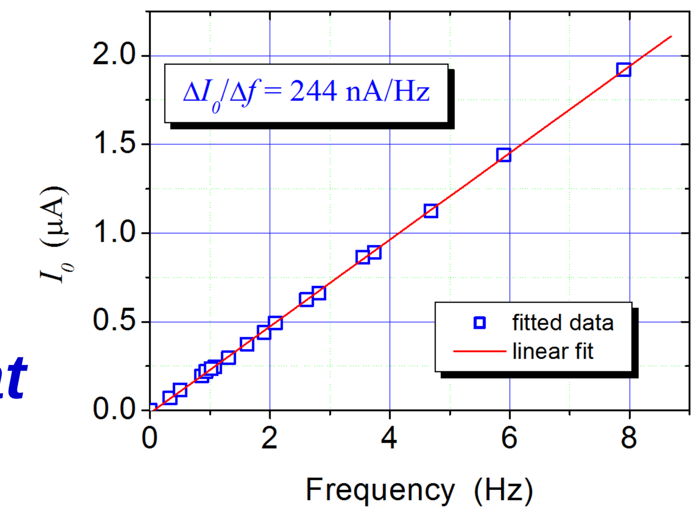
Mechanical excitation of the piezoelectric blade



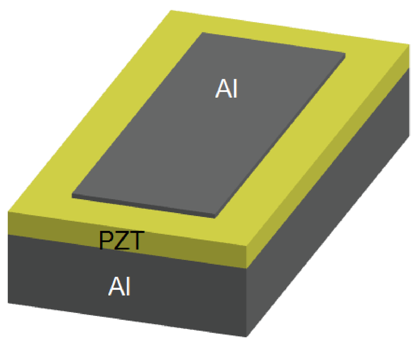
Scheme of the equivalent circuit of the energy harvesting device :




Piezoelectric current

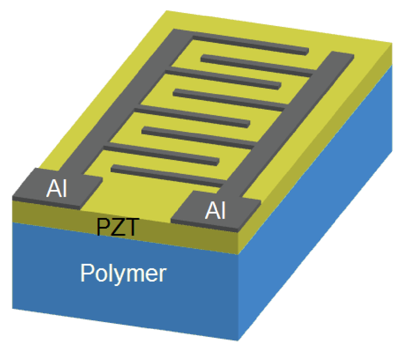



***Harvesting device working at very low frequencies***

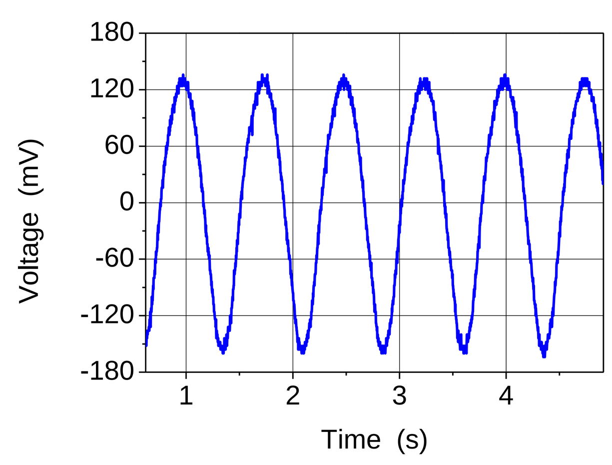


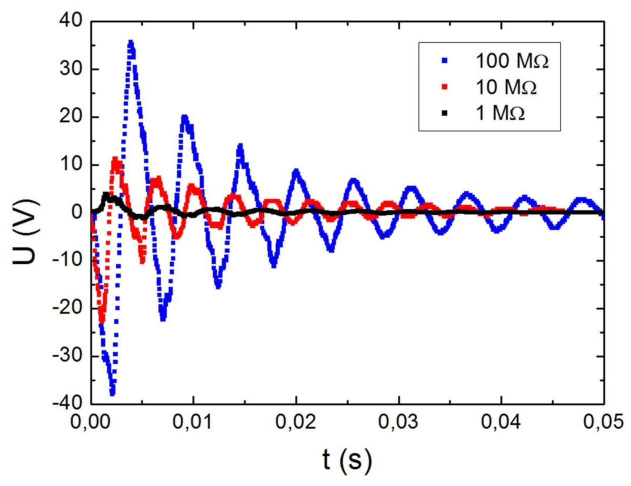

MIM structure

***Output voltage X 100***




IDE structure




## Flexoelectric polymers for large curvature sensing (4)

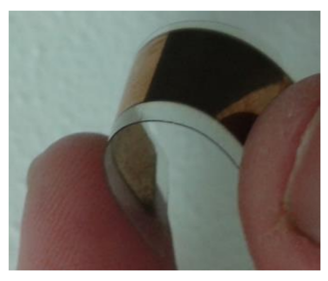
**Flexoelectricity:** Mechanical-to-electrical coupling between strain gradient (curvature) and electrical polarization $P_{flex}$ in every solid dielectrics → Flexoelectric effect in soft polymer films may be used for the development of low cost and easy to implement elastomer-based large curvature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

***Strain gradient***

***Curvature***

$$P_{flex} = \mu \cdot \frac{\partial S}{\partial x} = \mu \cdot C$$

***Flexoelectric coefficient $\mu$***



**Polyurethane (PU) film**

**PU thin films (e=6 µm) deposited onto Al foil /PET flexible cantilever**
**→ *direct* sensing of large curvature (80 m⁻¹) = radius of curvature (~ 1 cm)**