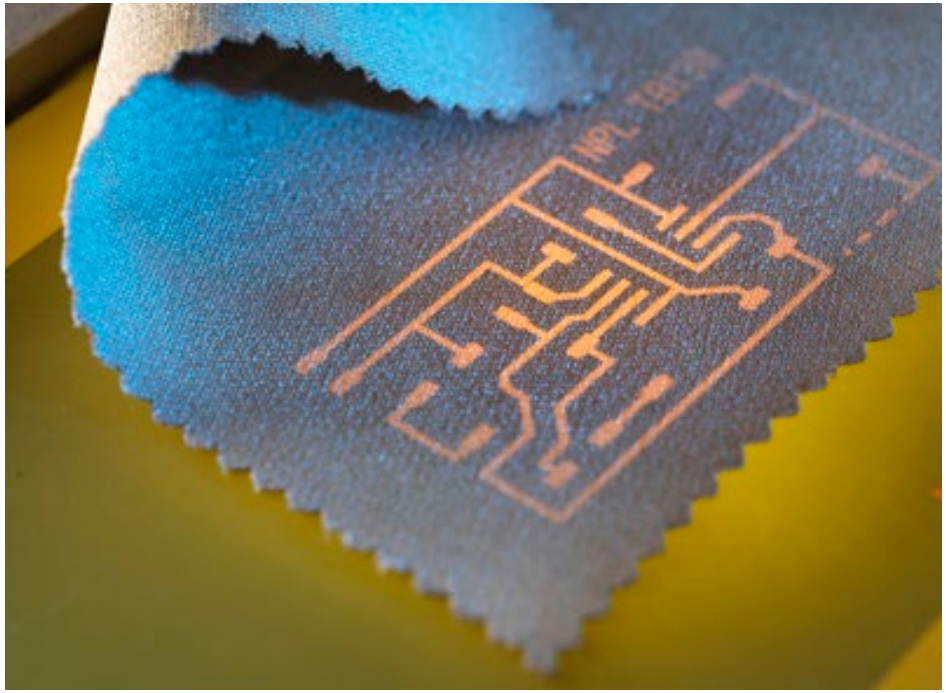
Sensors Converge

Self-sustainable textile sensors power sources based on a low-cost printing solution

June 20–22, 2023 | Santa Clara, CA

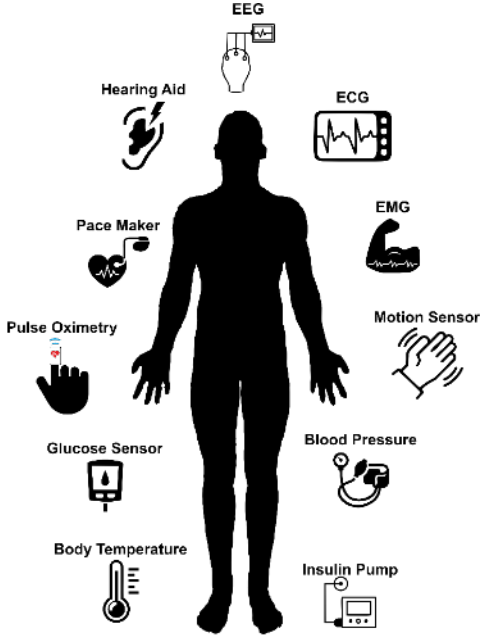
#SensorsConverge

Textile Electronics



Power Challenge

Sensor and communication devices



Rely on batteries

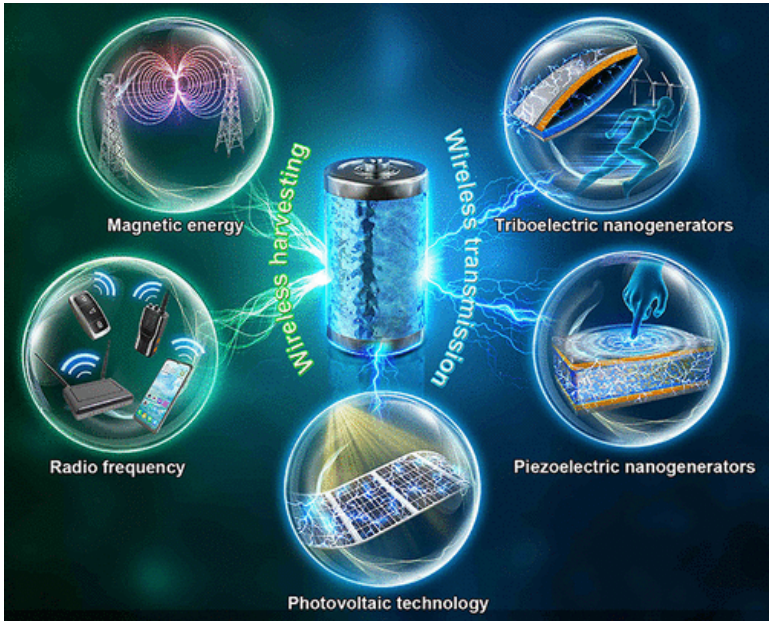
- Frequent recharging
- Limited lifetime
- Environmental hazard

Additional Problems

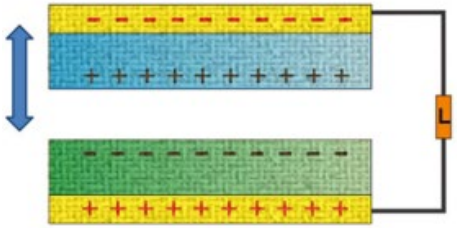
Self-sustainable Textile Power Supply Devices

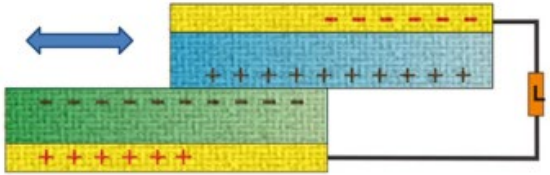
- From sources in the body
  - Triboelectric, Piezolectric, Thermoelectric

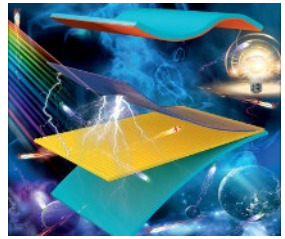
- From the surrounding environment
  - Radio Frequency, Photovoltaic, Ultrasonic

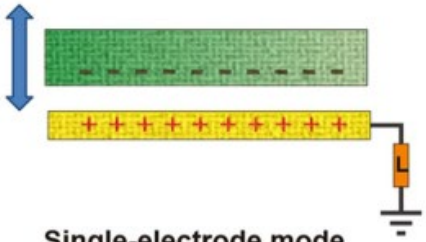


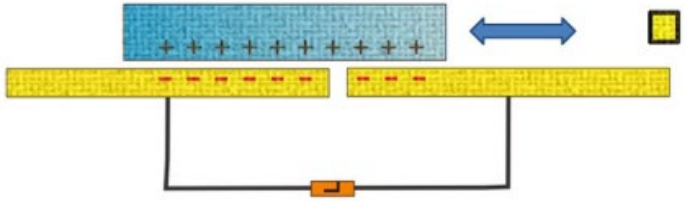
Triboelectric devices











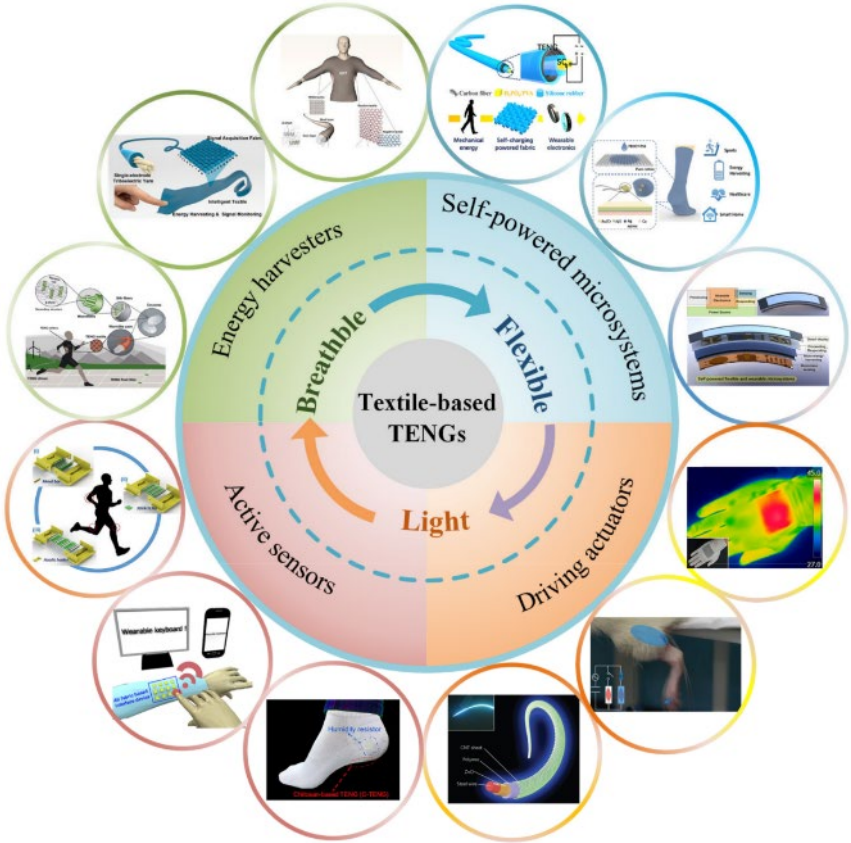
Triboelectric Material 1

Triboelectric Material 2

Electrode 1&2

Triboelectric devices

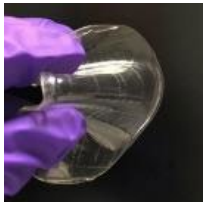
- Main Challenges:
  - Power densities low due to low effective contact area relating to their structure
    - fiber-TENG up to 953 mW/m^2
    - fabric-TENG up to 8920 mW/m^2
  - Complex fabrication process (particularly fiber-based TENGs)
  - Processes compatible with standard large-scale textile manufacturing
  - Metal electrode reduces flexibility



Solution processing strategy

Solution-based dielectric materials

PDMS



Teflon

Solution-based conductive materials

Metallic inks

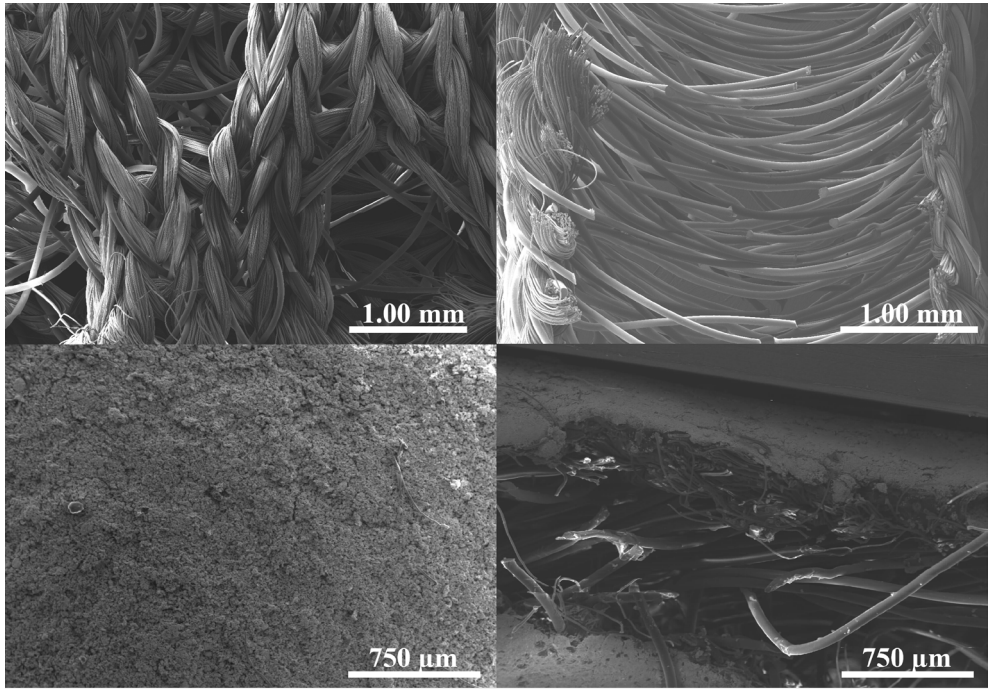
Carbon structures

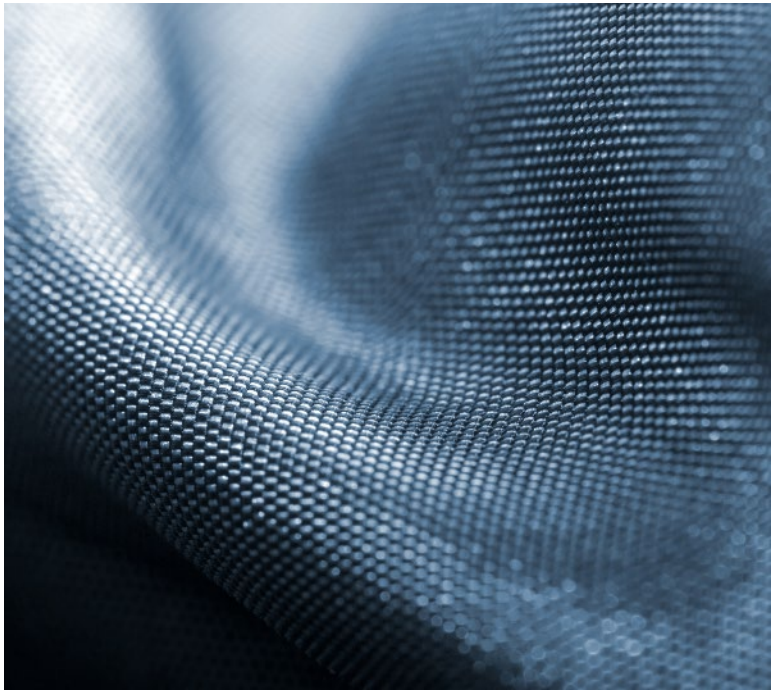
Negative triboelectric

Positive triboelectric

Electrode

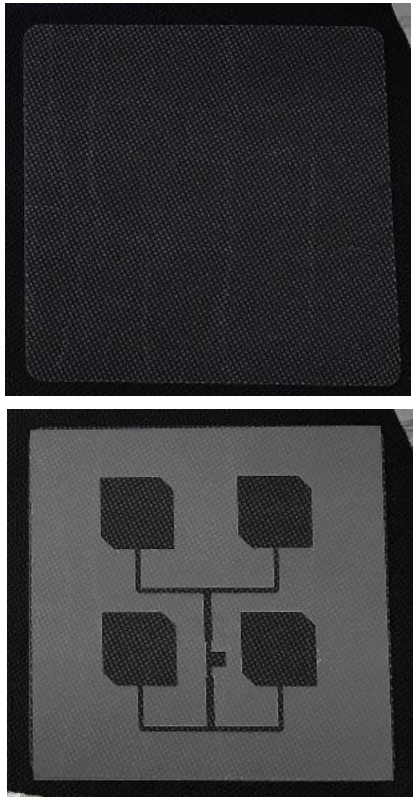
Porosity and Permeability

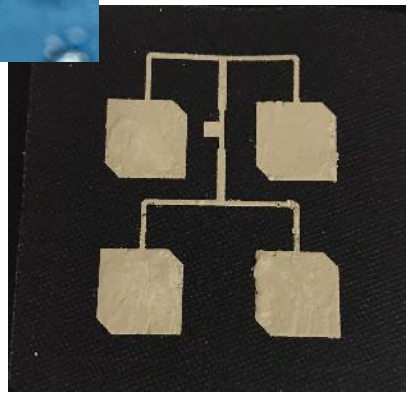




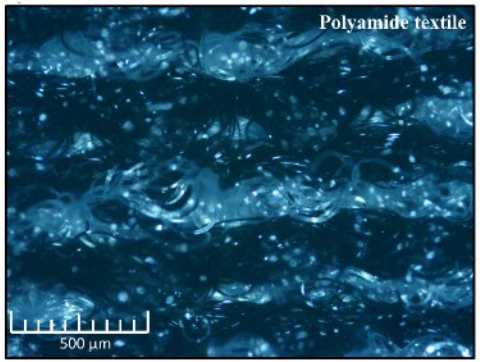
Porosity and Permeability

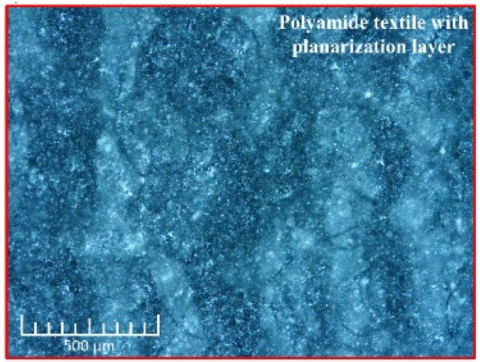
Adhesive layer

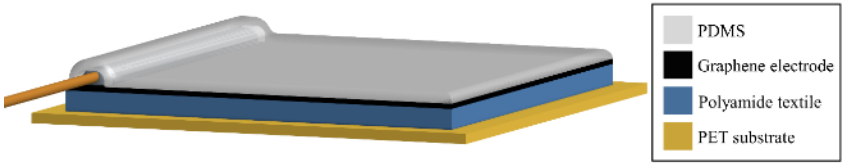


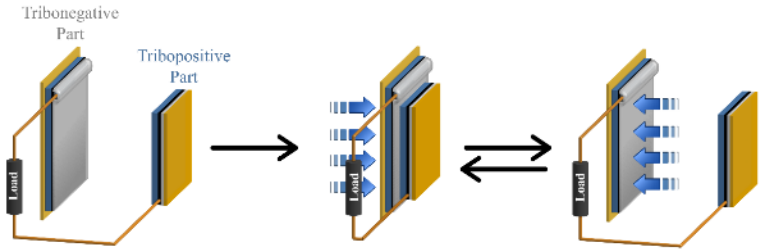


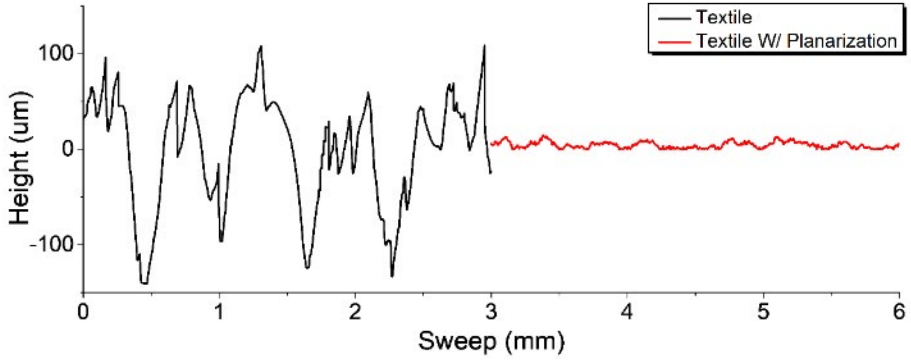
Planarization

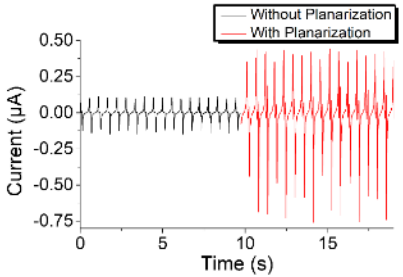


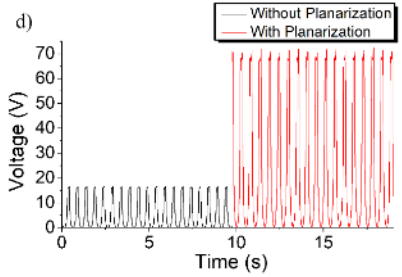




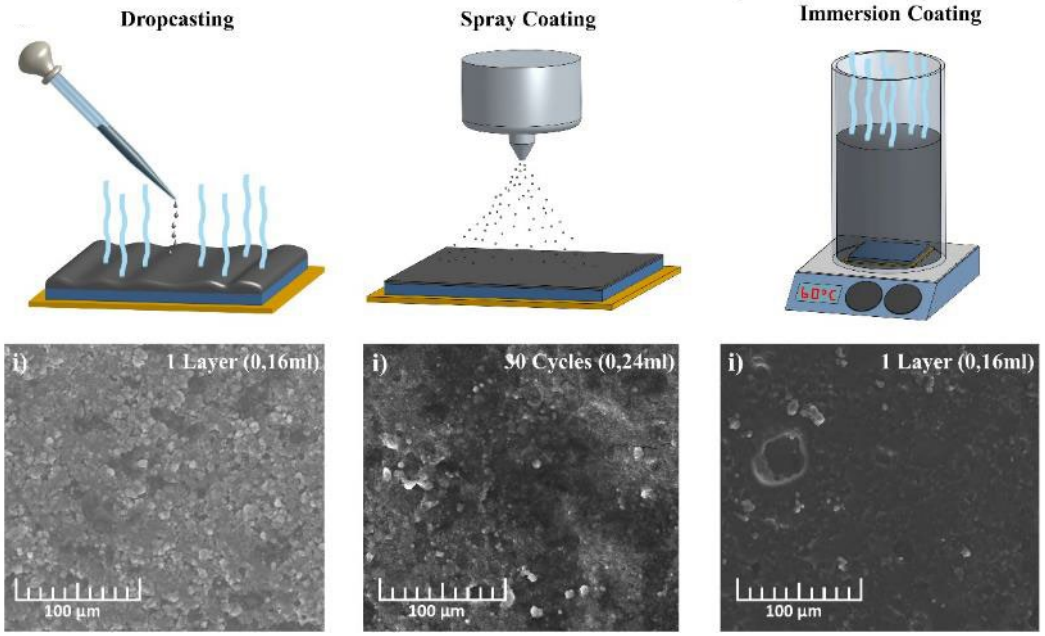


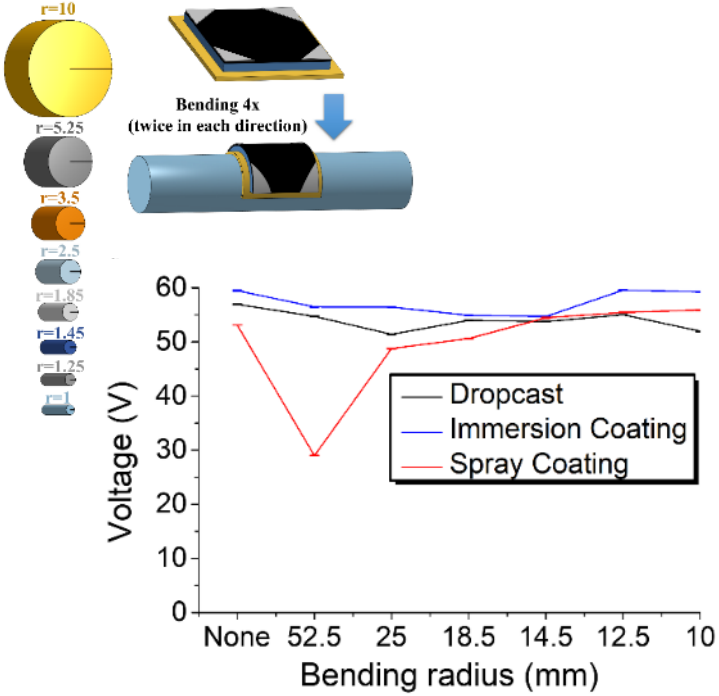




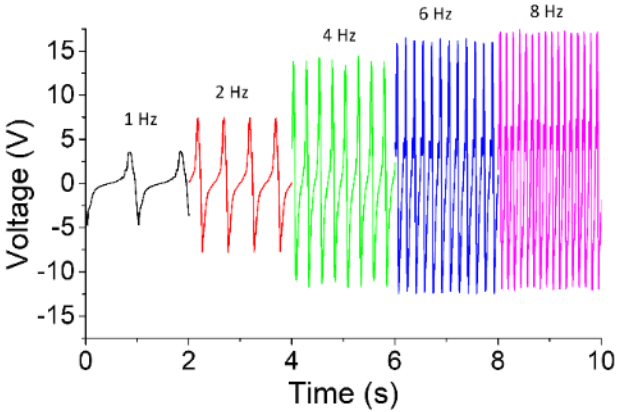


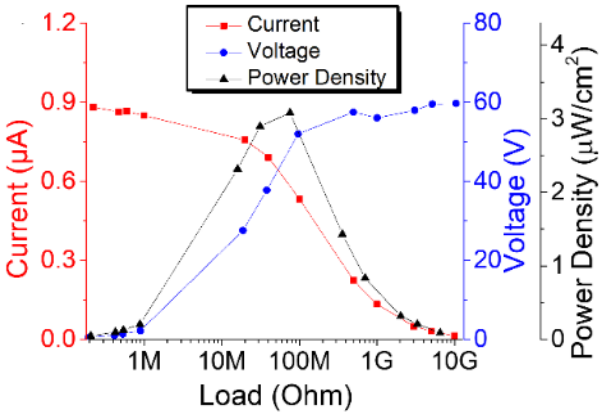
Deposition

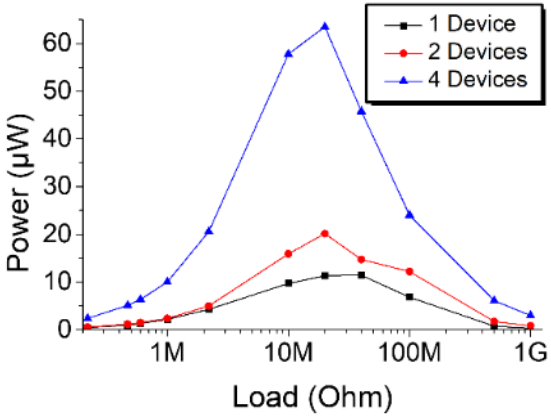

Dropcasting
Spray Coating
Immersion Coating
60°C
i)
1 Layer (0,16ml)
100 µm
i)
30 Cycles (0,24ml)
100 µm
i)
1 Layer (0,16ml)
100 µm


r=10
r=5.25
r=3.5
r=2.5
r=1.85
r=1.45
r=1.25
r=1
Bending 4x
(twice in each direction)
Voltage (V)
60
50
40
30
20
10
0
None
52.5
25
18.5
14.5
12.5
10
Bending radius (mm)
Dropcast
Immersion Coating
Spray Coating

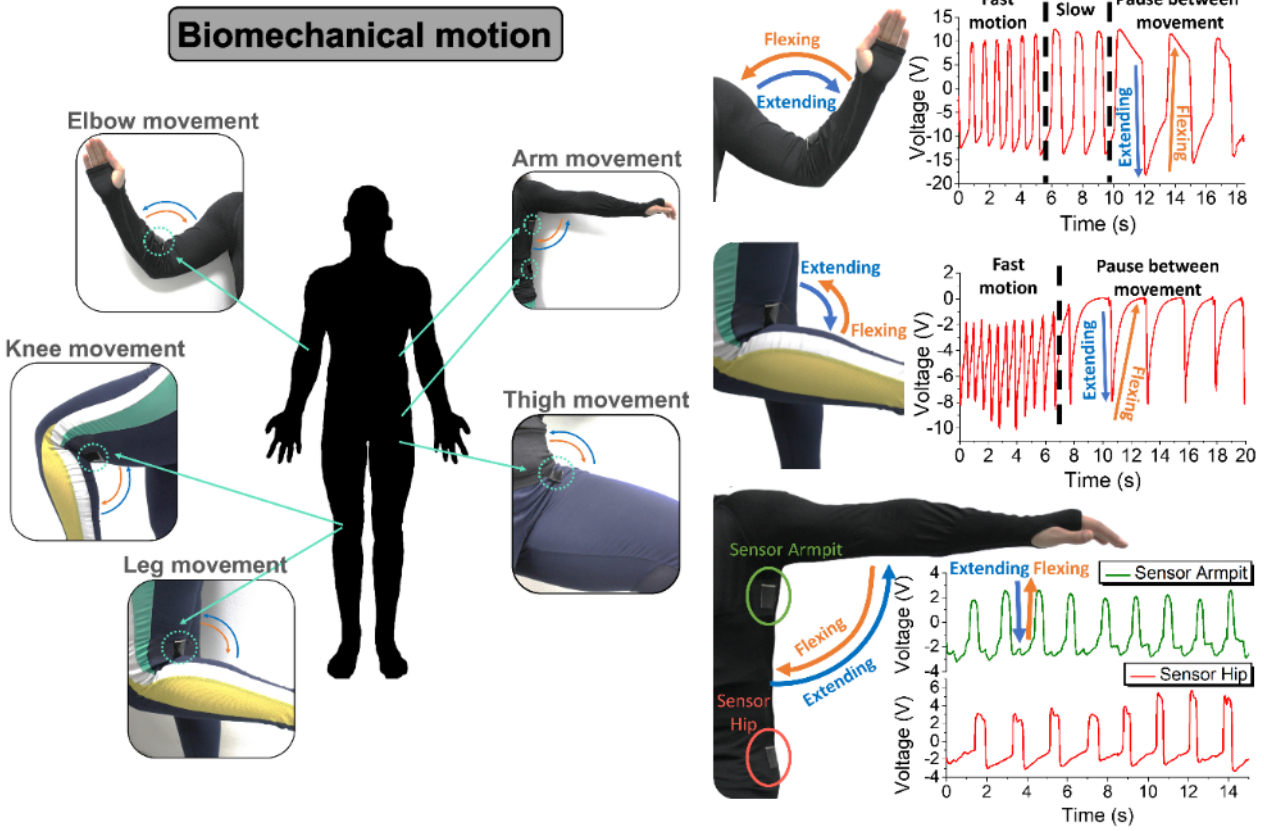
Frequency and Area Dependency







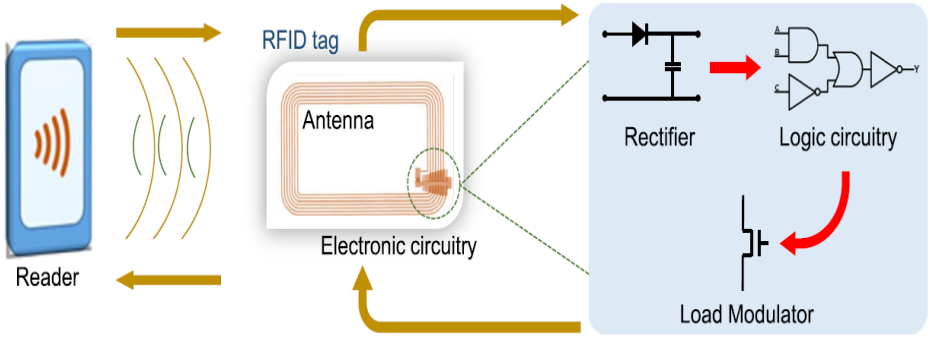
Biomechanical Sensor



Radio Frequency Energy Harvesters

- Ambient RF Energy Sources

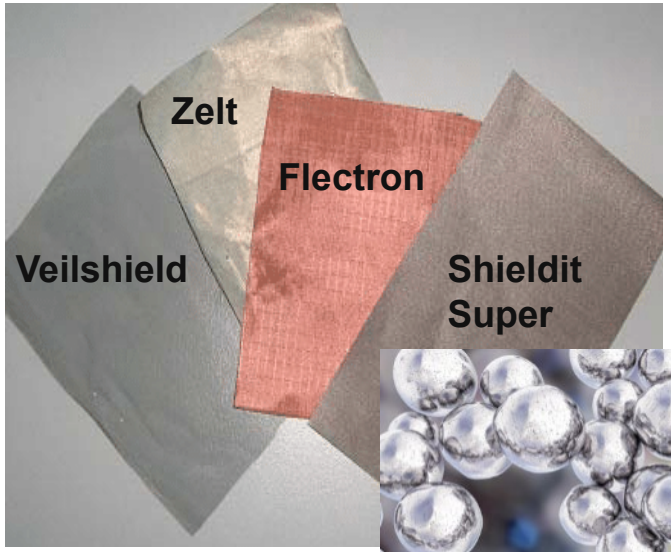
- Operation

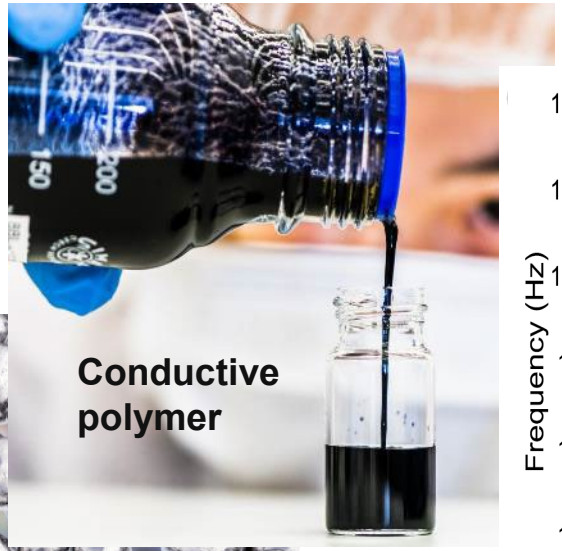


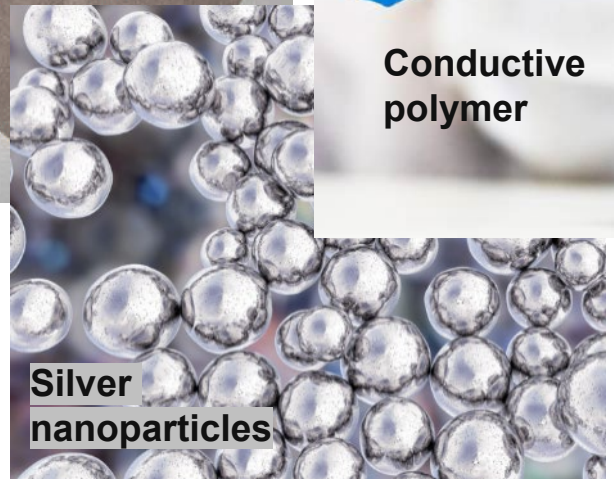
Flexible Textile Antennas - Dielectric

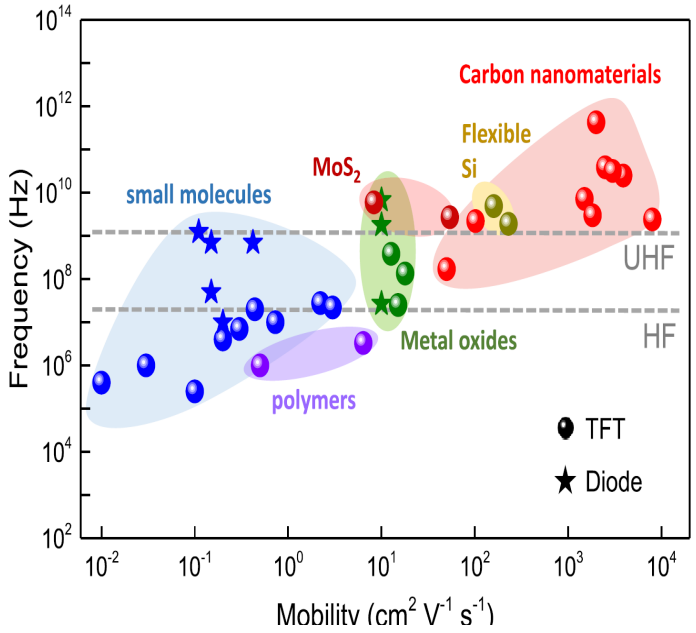
Sustainable Fabrics

Flexible Textile Antennas - Conductor

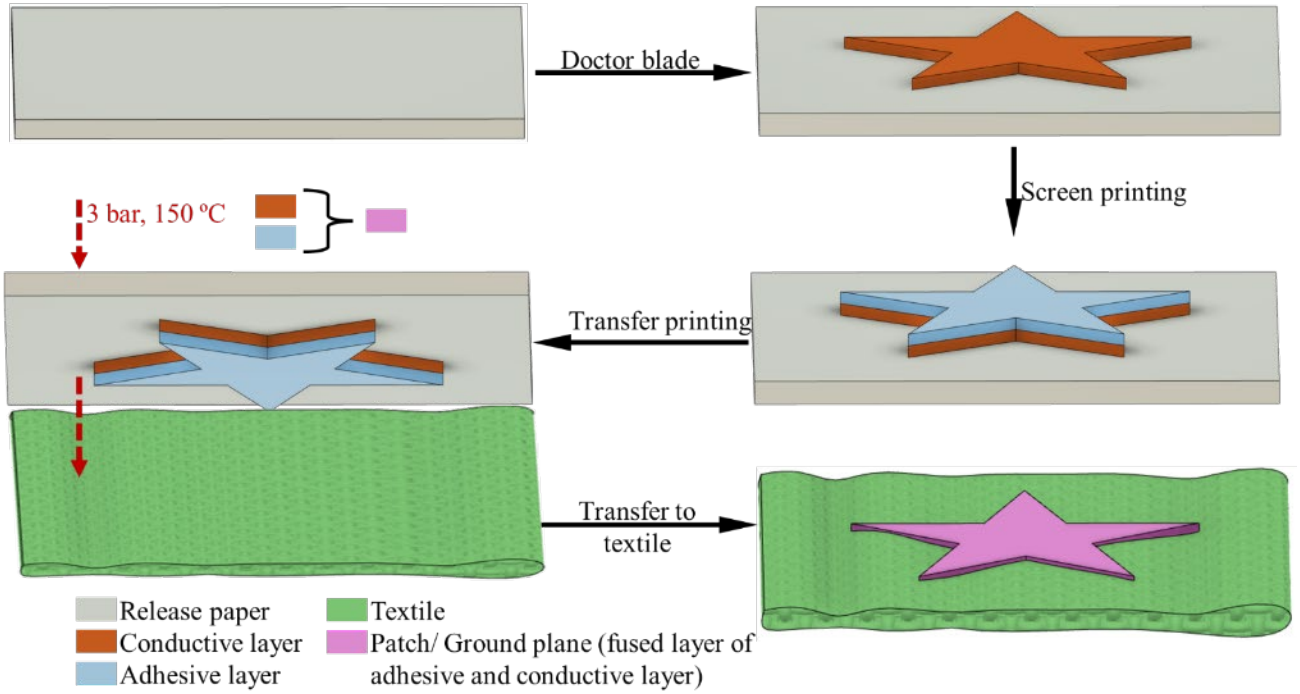




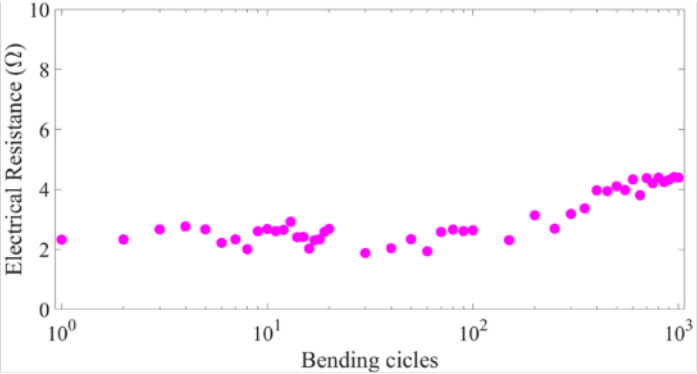


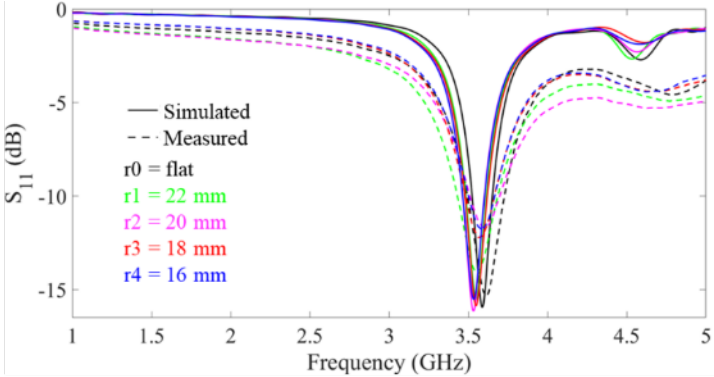


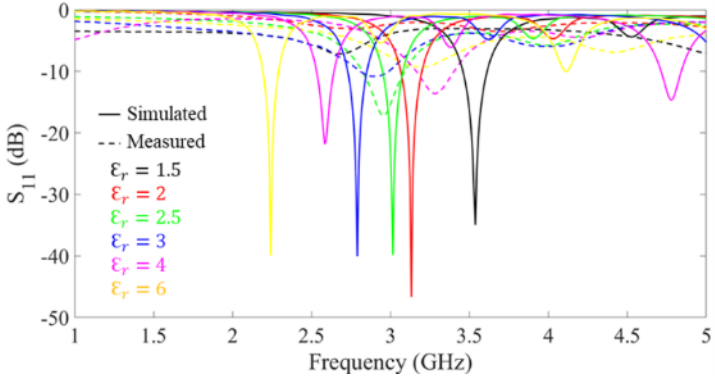
Printed Antenna

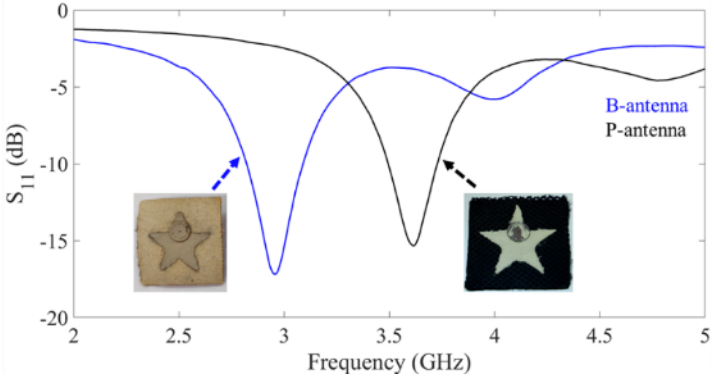


Output

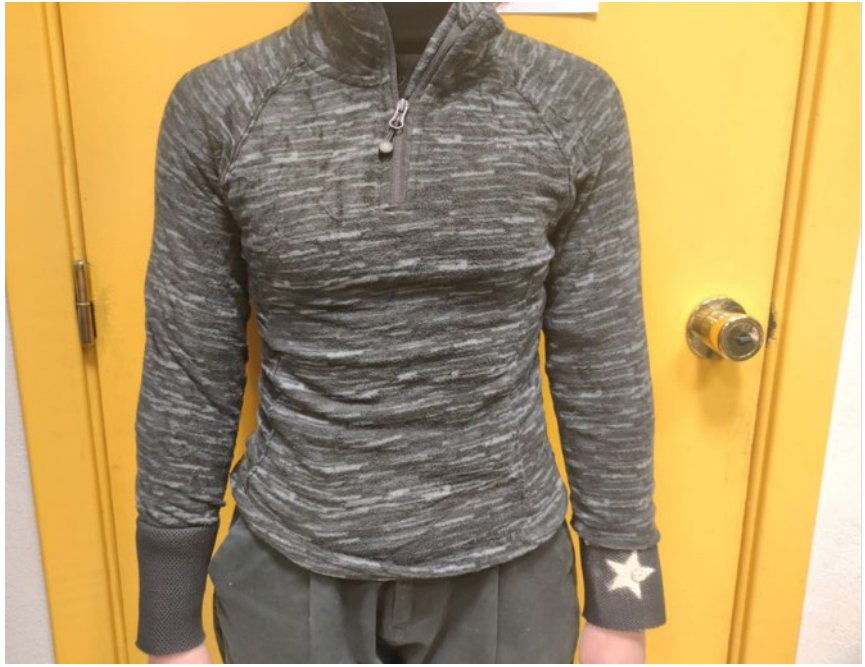

Electrical Resistance (Ω)
Bending cicles

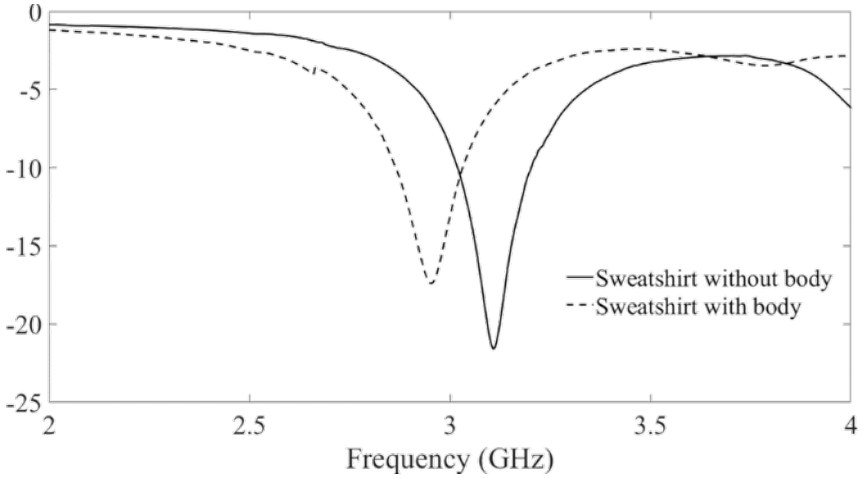

Simulated
Measured
r0 = flat
r1 = 22 mm
r2 = 20 mm
r3 = 18 mm
r4 = 16 mm
S11 (dB)
Frequency (GHz)


Simulated
Measured
εr = 1.5
εr = 2
εr = 2.5
εr = 3
εr = 4
εr = 6
S11 (dB)
Frequency (GHz)


B-antenna
P-antenna
S11 (dB)
Frequency (GHz)

Wearable Antenna





Acknowledgments

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  - Ismael Domingos
  - Joana Tavares

- Collaborators
  - Monica Craciun (U. Exeter)
  - Pedro Pinho (Telecommunications Institute)

- Funders