Flexible and Wearable sensors for health monitoring applications

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Introduction

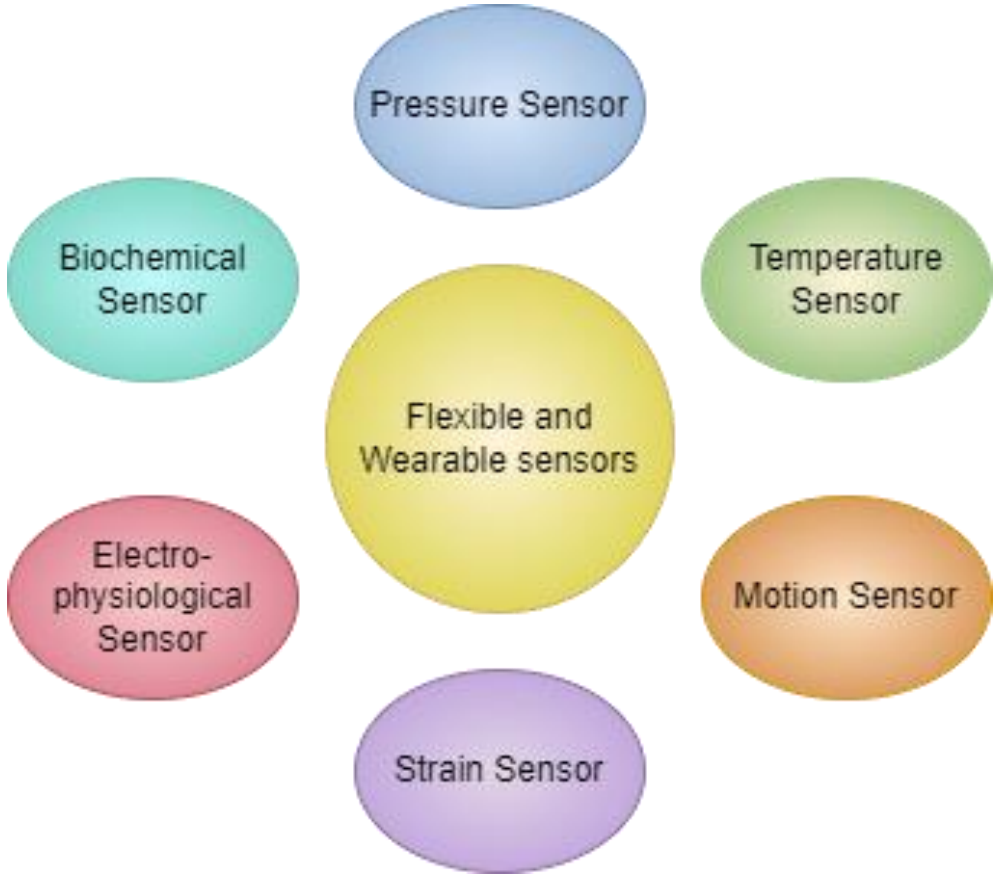
Wearable devices for continuous and remote health monitoring.

Requirements

- Light weight
- Flexible
- Biocompatible

Applications

- Pulse rate measurement
- Motion detection
- Glucose, pH and other biological indicators detection
- Physiological signal like EEG, EMG, ECG monitoring

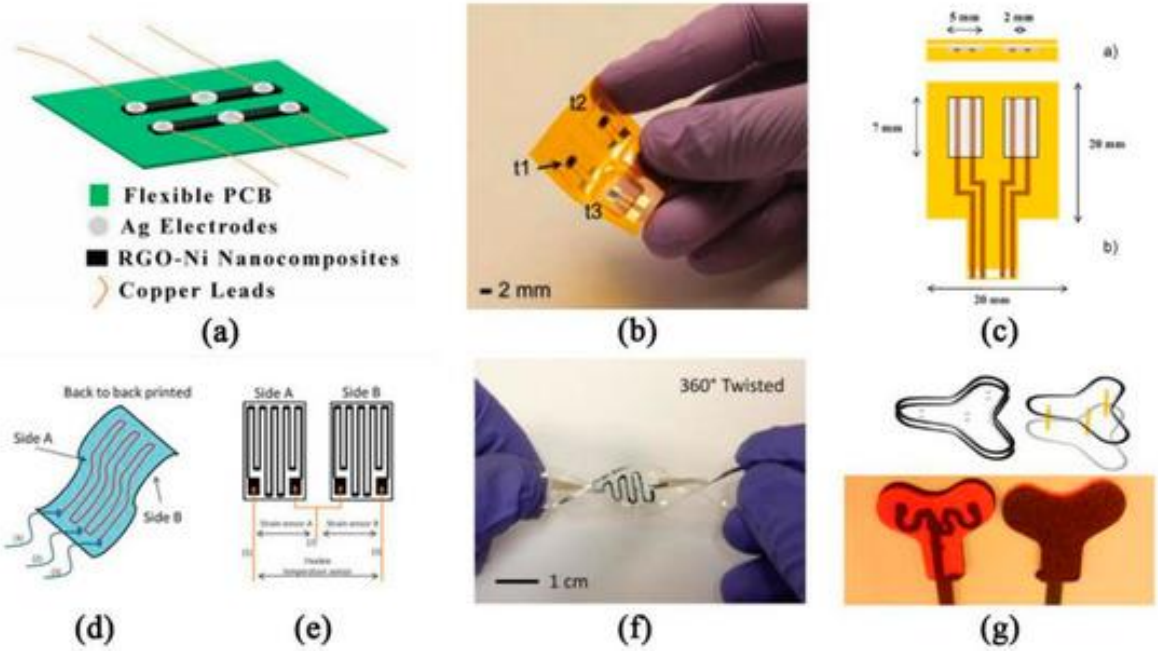


Temperature Sensors

Temperature sensors are vital for monitoring the body temperature. Temperature outside the normal range can be critical for the health.

Transduction mechanism

- Flexible resistance temperature detector (FRTD)
- Thermistors
- Thermocouple



Temperature Sensors

Flexible resistive temperature detector (FRTD)

Change in temperature cause a change in electrical resistance.

- Temperature coefficient of resistance (TCR) = $(\Delta R/R_0)/\Delta T$
- Sensitivity S = $\Delta R/R_0$

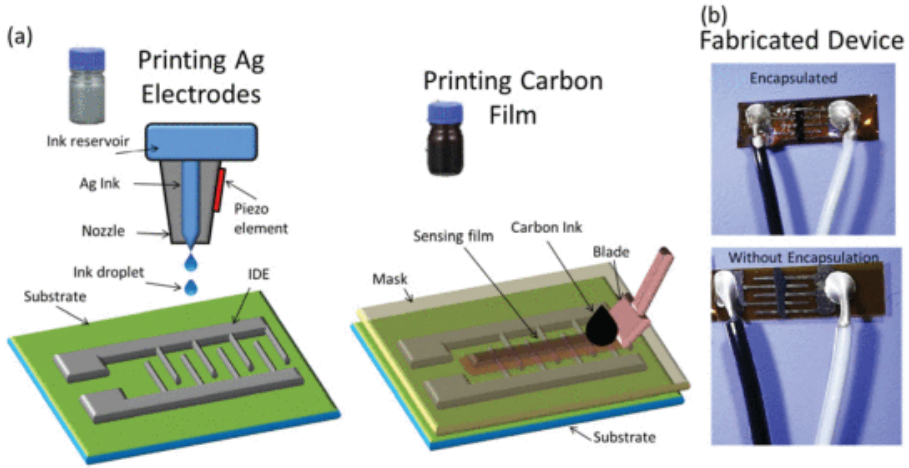
Active material - Metals like Ni, Cu, Pt

Carbon derivatives - CNT, graphene, quantum dots

Conducting polymers - PEDOT:PSS

Fabrication methods -

Laser Digital Printing (LDP)
Inkjet printing
Sputtering
Spin coating



Temperature Sensors

Thermistors

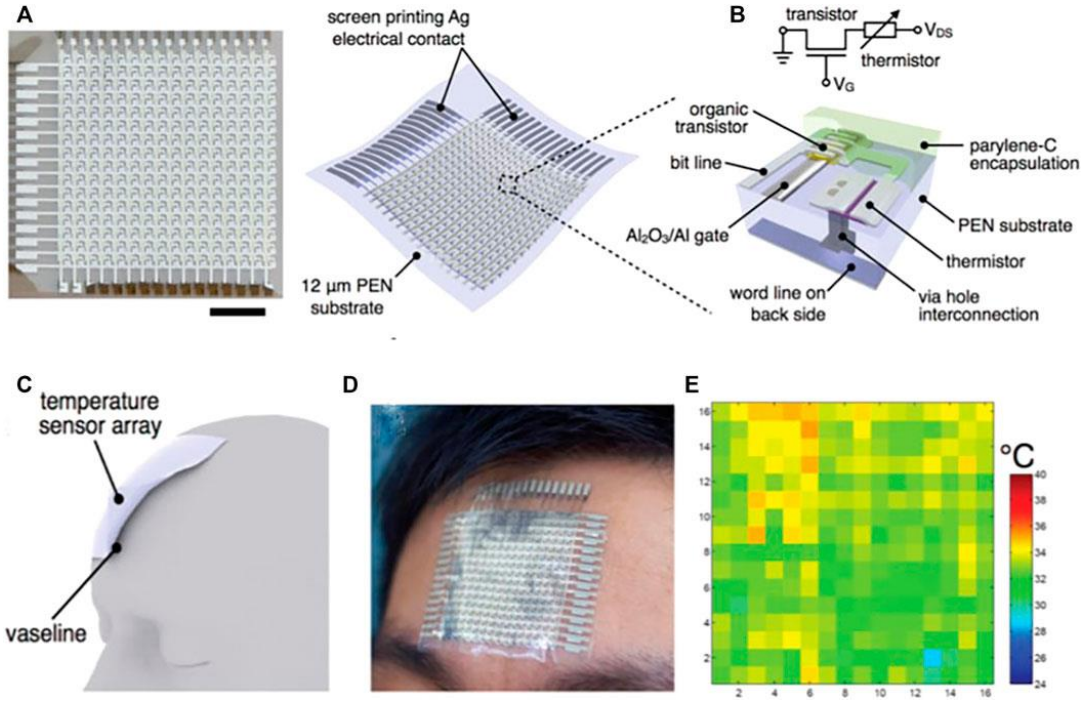
The resistance changes occurs due to change in temperature.

Active material - Metals like Pt, Cu, Ag, Au, AgNW
Carbon derivatives like rGO, CNT, graphene

Substrate - PI, PDMS, PET, PEN

Fabrication methods -

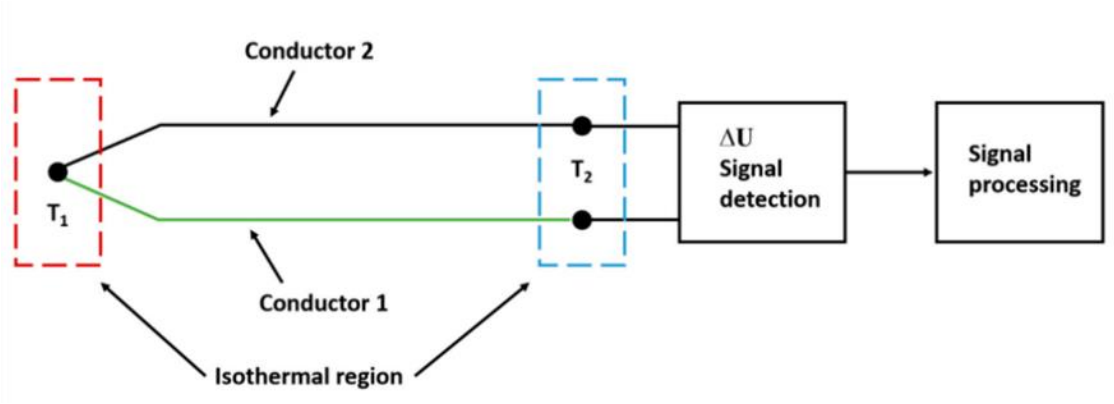
Inkjet printing
Sputtering
Spin coating



Temperature Sensors

Thermocouples

Seebeck effect - production of emf in two dissimilar conductors when the junctions are maintained at different temperatures.

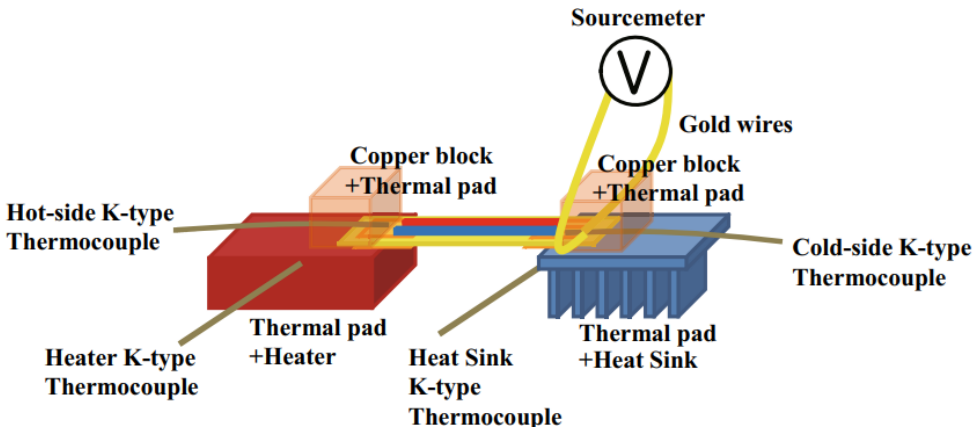


Active material - alloy films

- nickel-aluminum-silicon-manganese alloy film,
- nickel-aluminum alloy film,
- p-Sb2Te3 film, n-Bi3Te3 film, Bi-Te film and Sb-Te film

Fabrication methods -

Sputtering
Spin coating

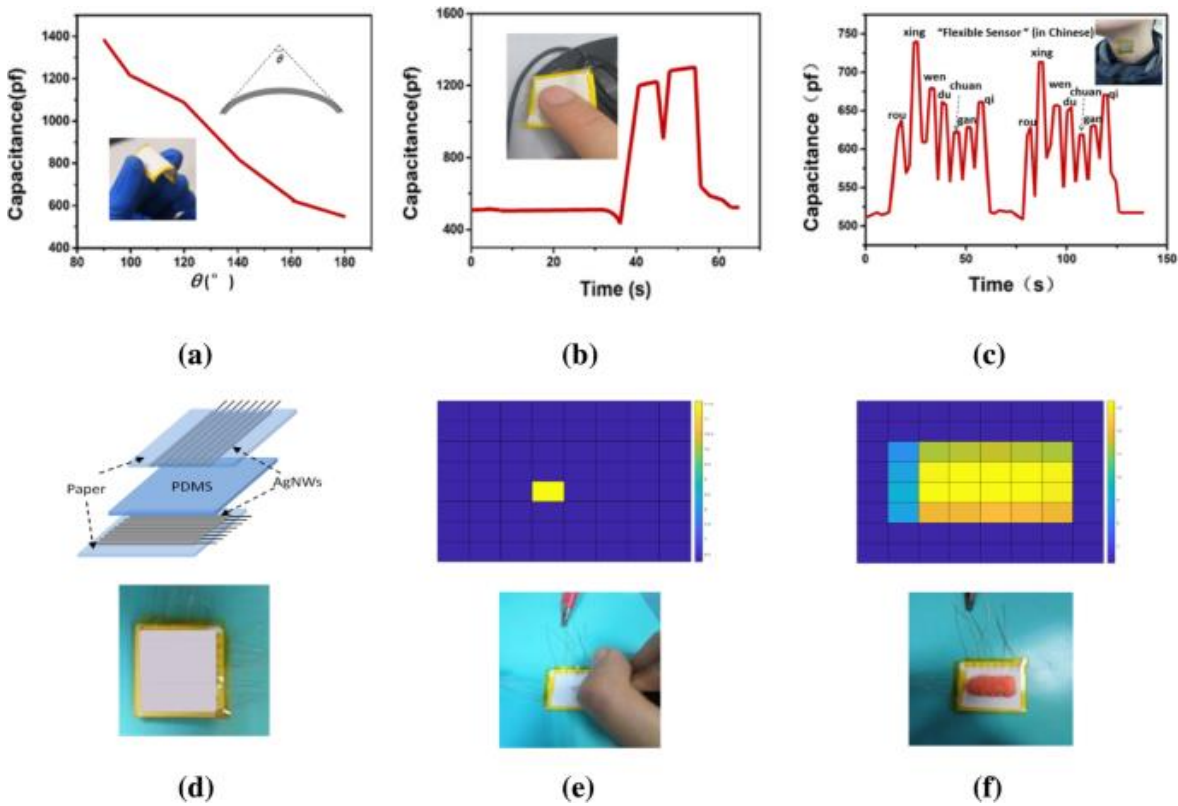


Pressure Sensors

Pressure sensors can be used for determining pulse, blood pressure or external pressure applied on e-skin or prosthetics.

Transduction mechanism

- Capacitive
- Piezoelectric
- Piezoresistive

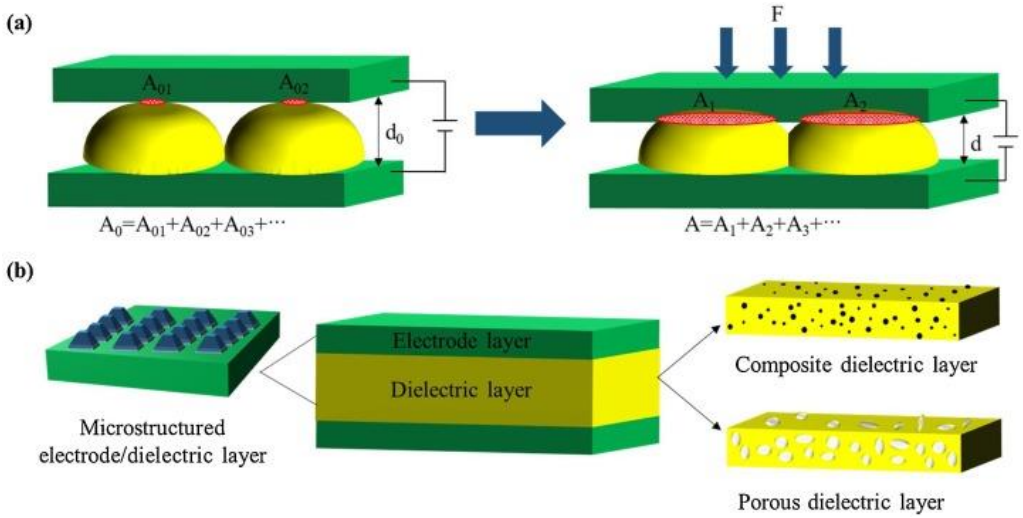


Pressure Sensors

Capacitive Pressure sensor

$$C = \varepsilon_r \varepsilon_0 A/d$$

Where ε_r is the relative permittivity, A is the plate area and d is the gap between plates.



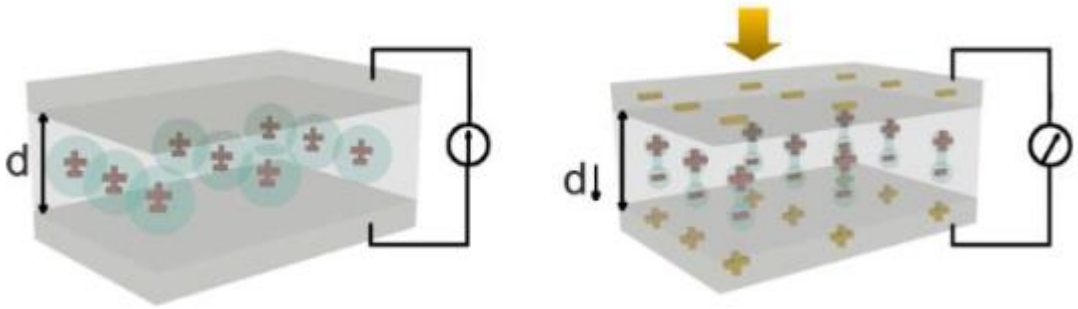
Active material - dielectric material - PDMS, PU, organosilicon elastomer, polystyrene, PET, woven-spacer structures

Microstructures are created to enhance sensitivity.

Pressure Sensors

Piezoelectric Pressure sensor

Piezoelectric effect - The application of external pressure that cause deformation generates current and vice versa.



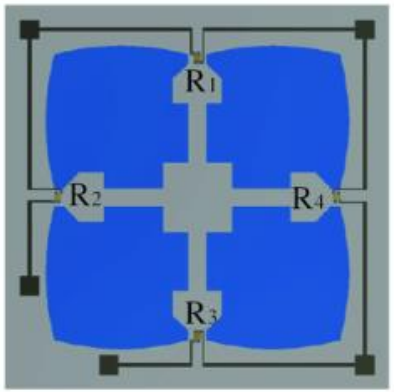
Active material - P(VDF-TrFE)),barium titanate (BaTiO3), lead zirconate-titanate (PZT), and zinc oxide (ZnO)

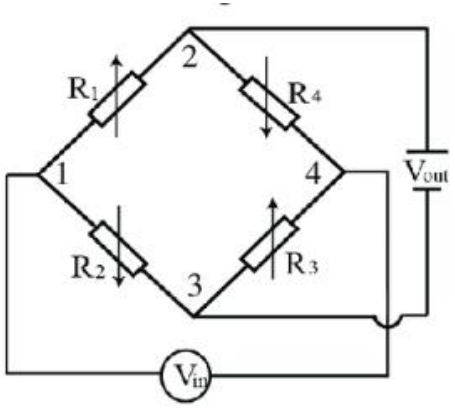
Pressure Sensors

Piezoresistive Pressure sensor

Piezoresistance - Deformation in the structure cause change in electrical resistance.

Active material - metallic particles, metal NW
carbon-based materials including carbon black, CNTs, and reduced graphene oxide (rGO)





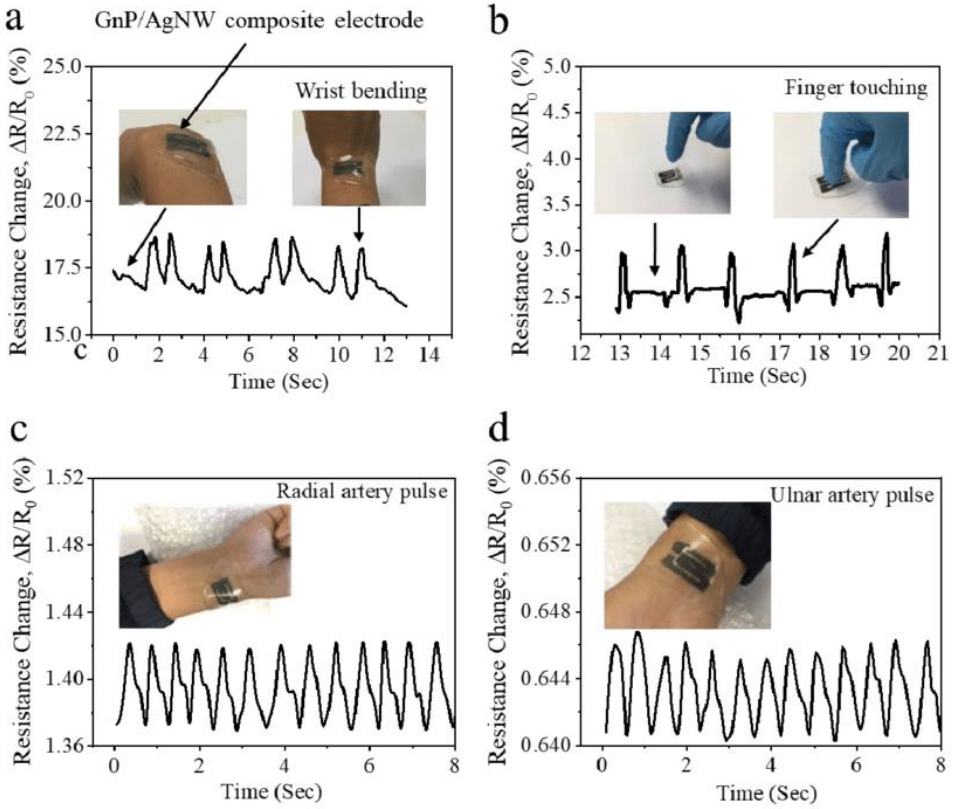
Strain Sensors

Strain is the relative change in the length of a structure under stress.
Strain sensors convert mechanical stimuli into optical or electrical signals.

Application - Recognize the posture or gesture
Continuous blood pressure monitoring
Artificial tactile sensation
Vocal-cord vibrations
Pulse
Respiration

Transduction mechanism

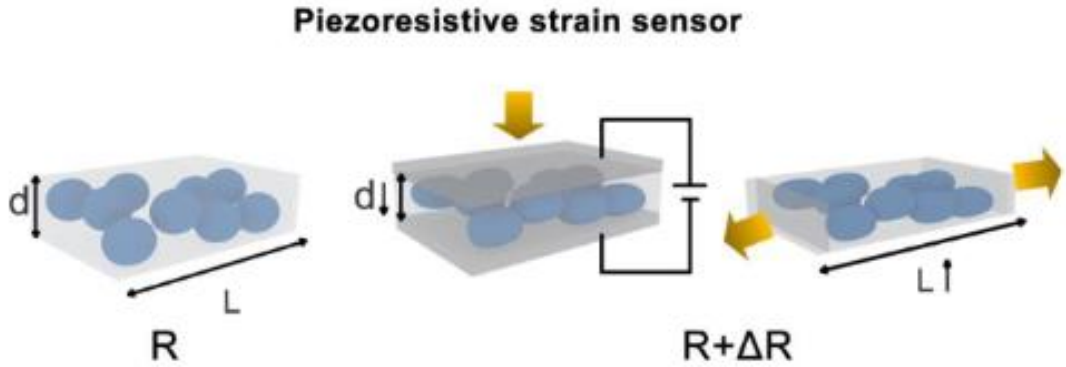
- Piezoresistive
- Capacitive
- Piezoelectric



Strain Sensors

Piezoresistive Strain sensor

Tensile strain
Gauge factor (GF) = (ΔR / R0) / ε, that is, the fractional change in the resistance, with ε being the strain



Compressive strain
Sensitivity = (ΔE / E0) / ΔP. where ΔE represents the change in the electrical signals

Active material - CNT, graphene, carbon black, polymers, metal nanowires

Advantages - simple structure, low cost, high linearity and excellent sensing performance

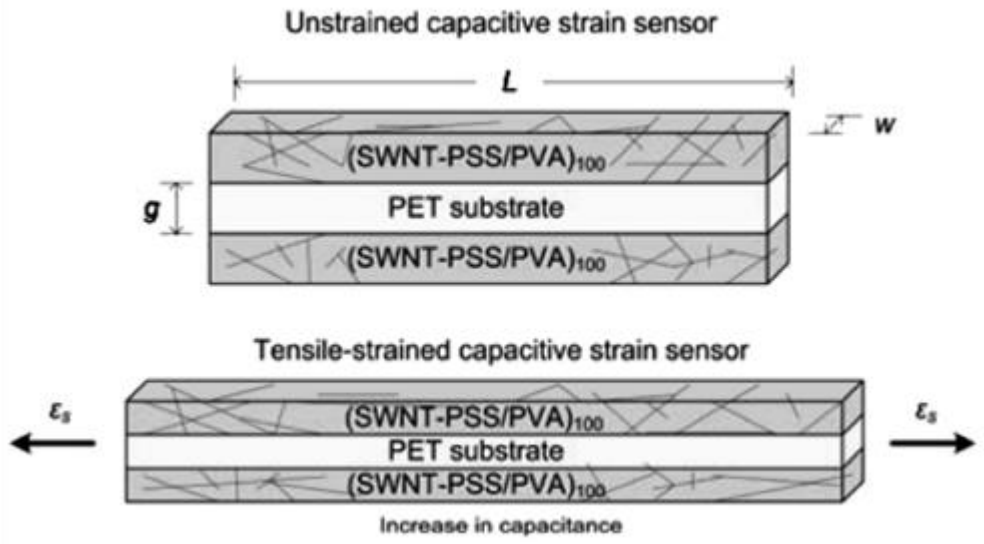
Strain Sensors

Capacitive Strain sensor

Gauge factor, GF = (ΔC / C0) / ε

Active material - dielectric material - elastomers, ionic liquid/gels, thinned inorganic material

Advantages - Low input energy,
High dynamic response and
Low noise impact



Strain Sensors

Piezoelectric Strain sensor

These can be used as a generator as well as the biosensor.

Evaluated in either of the two working modes -
open circuit voltage (V_{oc})
Short circuit current (I_{sc})

Active material - ZnO, PZT nanoribbons, BaTiO3, and organic polymer like PVDF

Thank You