A feasibility study of knitting a capacitive sensor using electroconductive yarn

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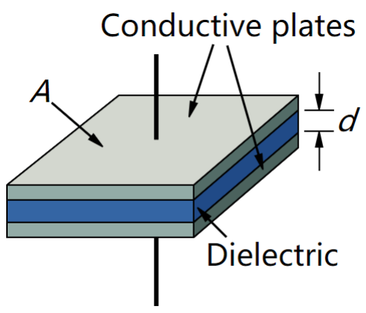
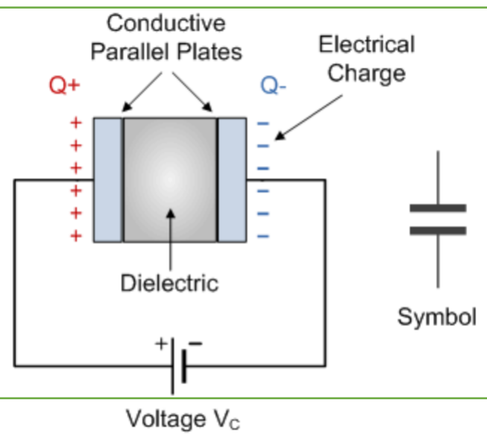
Introduction

A Knitted capacitive sensor is a type of wearable sensing product, produced as a 3D fabric structure that consists of two electroconductive fabric layers that acts as electrodes of a parallel plate capacitor separated by spacer yarn, produced during the knitting process. The principle of the sensor is described by the compression test where, the distance (d) between two outer layers will decrease due to compression, resulting in an increase in capacitance values. The knitted capacitor is capable of transforming mechanical signals into measurable electrical signals, so that it can be used in many wearable sensing applications like health monitoring and sensor integrated wearable sports products.

Capacitive sensor theory

- Capacitance= $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$
- Gauge factor= $GF = \frac{\Delta C/C_0}{\varepsilon}$





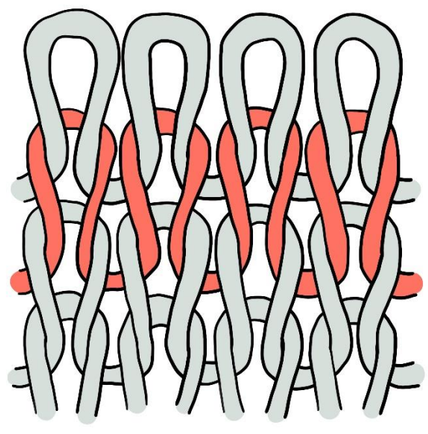
- Where ε_0 is the permittivity of free space (8.85×10^{-12} F/m), ε_r is the relative permittivity, A is the area of the capacitor plates and d is the displacement of the plates.
- where ΔC is the change in capacitance value, C_0 is the initial capacitance value, and ε is the strain value.

Methodology

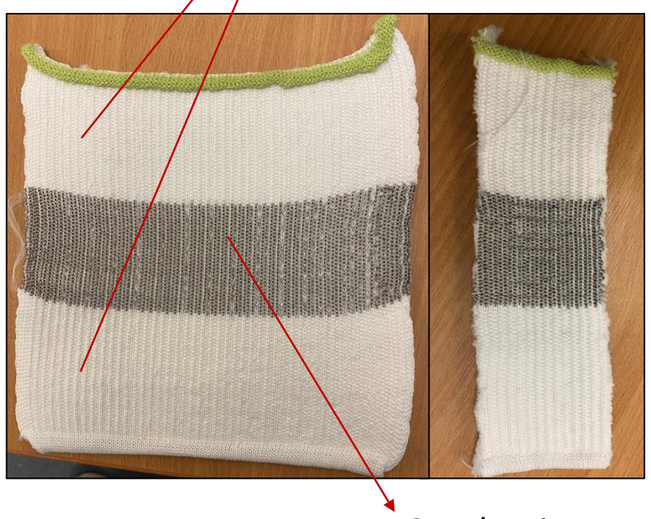
- Sample fabrication

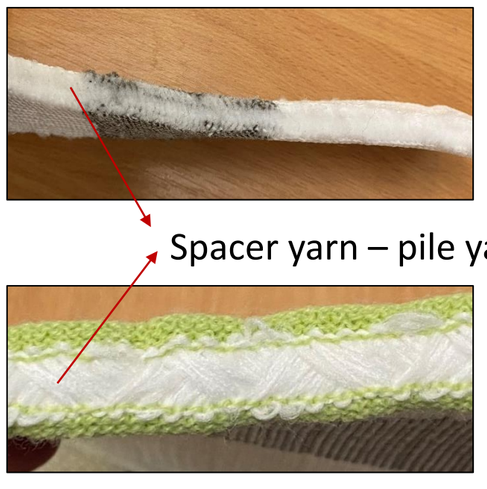
Unit cell structure: **Plain knitted structure**

The samples are manufactured by a SHIMA SEIKI computerised flat bed knitting machine.



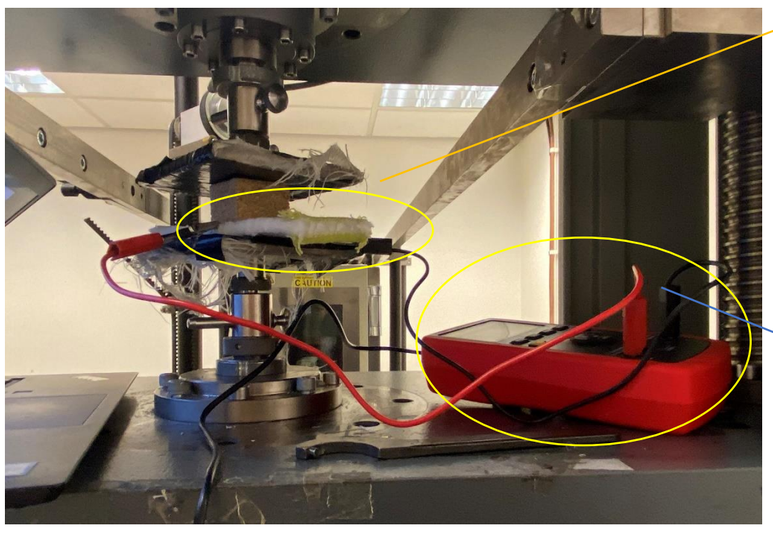
Planar view of the knitted capacitor





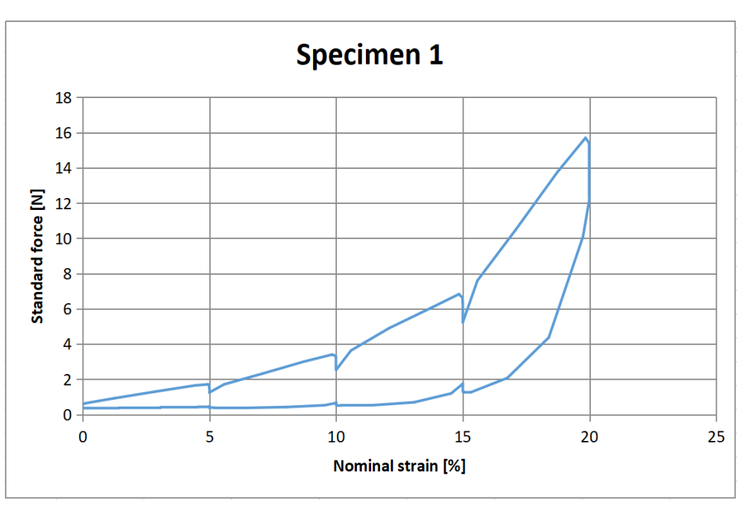
Cross sectional view of the knitted capacitor

- Testing procedure

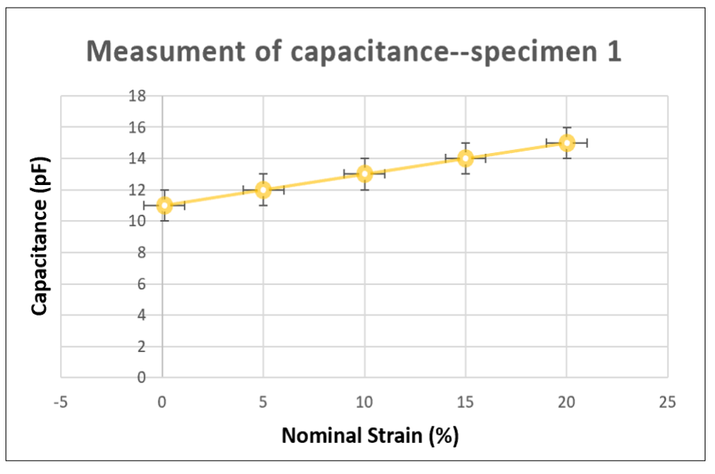


The samples were tested on a Zwick Roell Z50 tensile tester with Wheatstone bridge circuit.

Results



The most representative Compression stress – strain curve.



The measurement of capacitance values change with applying compression strain on the sensor during the test.

Applications

- Pressure/touch device
- Gas sensing
- Proximity sensing
- Fibre monitoring

The figure illustrates a garment incorporated with a capacitive touch sensor which responds to variable pressures (Uzun et al., 2019).

*Reference: Uzun, S. et al. (2019). Knittable and Washable Multifunctional MXene-Coated Cellulose Yarns. *Advanced functional materials*, 29(45).