Knitted fully textile triboelectric electroactive sensors for motion monitoring

J.Blūms[1], A.Kataševs[2], E.Mileika[3], I.Gorņevs[1], V.Jurķāns[1], I.Balgale[3], I.Baltiņa[3], A.Okss[3]

Riga Technical University, 6A Kipsalas str., Riga, LV1658, Latvia,

[1] *Institute of Technical Physics* Juris.Blums@rtu.lv
[2] *Institute of Biomedical Engineering and Nanotechnologies*
[3] Institute of Architecture and Design

Abstract: Industry of textiles with integrated electronic devices (e-textiles) develops rapidly during last two decades [1]. These textiles have the characteristics of softness, lightweight, and breathability and, thus, the potential for realizing comfort in wearable electronics. Accordingly, intensive endeavors have been devoted to developing fully textile sensors as well as corresponding energy harvesting devices, known as triboelectric nanogenerators (TENGs). Textile-based TENGs (t-TENGs) are most suitable for application in smart garments because they can be naturally integrated into apparel and do not have negative influence on its consumer properties and comfort [2]. So far, a relatively small number of studies have been devoted to t-TENGs development regarding of different materials, structures or fabrication methods [3].

The present study is devoted to the development of a new fully knitted electroactive motion sensor based on the triboelectric effect using only commercially available yarns for knitting. Due to its special design, this sensor can be seamlessly integrated into knitwear as a design element without compromising comfort and can be made during the knitwear manufacturing process.

The sensor structure is knitted on a hand-driven flat knitting machine in plain jersey using 4-ply polyester (220 tex), 2-ply polyamide (200 tex) and double wound 4-ply silver-coated polyamide yarn (130 tex). The stitch density is 6x4 per square centimeter.

The sensor structure, as illustrated in Figure 1, includes dielectric (A, B) and conductive (E) stripes sequentially knitted in a specific order (A-E-B-E-A). Dielectrics A and B must have opposite charge affinities according to the triboelectric series, and dielectric C must have a neutral charge affinity. Material selection ensures that when dielectric C is in contact with A, it becomes positively or negatively charged, and when in contact with B, it acquires an opposite charge. Coming into contact with the conductive stripes E, charged C induces the displacement of the charge through the load resistance *R*, which is detected by the voltmeter *V*. The total amount of moving charge is calculated as an integral of *V/R*.

Such structures show sensitivity to the peculiarities of movement of dielectric *C* (pressure between materials, speed of movement, geometry of stripes, etc.), which allows it to be used as the electroactive sensor of movement, which is an integral part of clothing and does not require special maintenance and further utilization. As an example, Figure 2, (a) shows the dependence of the generated voltage pulse on the pressure between the moving part *C* and the knitted strip structure, as well as the dependence of the induced charge on the speed of the part C motion for different widths of the electrodes E (*Fig.2, b*).

Keywords: *smart garment, self-powered structures, triboelectric effect.*

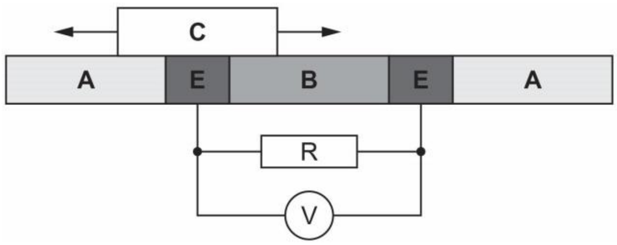

Figure 1 Principial scheme of the electroactive knitted sensor and measurement of induced voltage pulses

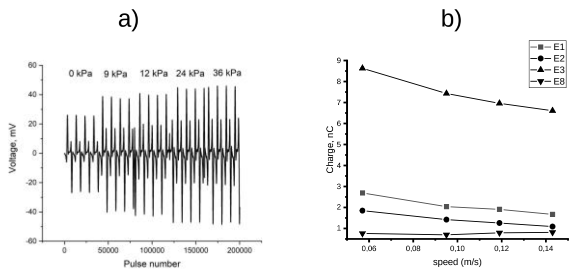

Figure 2 Induced voltage pulses as a function of pressure between knitted fabrics (a) and the amount of the induced charge as a function of the speed of relative motion of part C (b) for different width of electrode: E1 – 2.5mm; E2 – 4.0 mm; E3 – 6.0 mm; E8 – 17.0 mm.

REFERENCES

[1] Angelucci, A.; Cavicchioli, M.; Cintorrino, I.A.; Lauricella, G.; Rossi, C.; Strati, S.; Aliverti, A.: *Smart Textiles and Sensorized Garments for Physiological Monitoring: A Review of Available Solutions and Techniques.* Sensors, 2021, 814.

[2] W. Paosangthong, R. Torah, S. Beeby: *Recent progress on textile-based triboelectric nanogenerators*. Nano Energy 55, 2019, 401–423.

[3] Z. Lin, J. Yang, X. Li, Y. Wu, W. Wei, J. Liu, J. Chen, J. Yang: *Large-scale and washable smart textiles based on triboelectric nanogenerator arrays for self-powered sleeping monitoring*. Advanced Functional Materials 28, 2018.