Chitosan-based piezoelectric flexible and wearable patch for sensing physiological strain

G. de Marzo[a,b,*], D. Desmaële [a,*], L. Algieri[a], L. Natta[a], F. Guido[a], V. Mastronardi[a], M. Mariello[a,b], M. T. Todaro[c], F. Rizzi[a], M. De Vittorio[a,b]

[a] Istituto Italiano di Tecnologia, Center for Biomolecular Nanotechnologies, Lecce, Italy

[b] Dipartimento di Ingegneria dell'Innovazione, Università del Salento, Lecce, Italy

[c] Istituto di Nanotecnologia Consiglio Nazionale delle Ricerche, Lecce, 73100, Italy

* The authors contributed equally to the presented work

Special session: Organic Sensors and Systems

Keywords: Chitosan, Organic, Piezoelectric, Film, Sensor, Patch, Flexible

Innovative biocompatible organic materials with piezoelectric properties have a great potential for the development of wearable sensors for monitoring physiological parameters [1,2]. Among them, Chitosan (CS) is a natural, biodegradable, antibacterial and low cost biopolymer that shows an interesting piezoelectric behaviour [3]. In this context, this work reports on a protocol where plain chitosan films (CS-F) are exploited to easily create a piezoelectric flexible wearable patch.

By adapting a simple drop casting method reported in [4], we here demonstrate that a 70 µm thick CS-F can exhibit good piezoelectric properties. The structure of CS-F was analysed thanks to XRD technique: the spectrum (*Fig.1*) reveals peaks of partially crystalline chitosan film [5], indicating presence of organized polymeric chains. Piezoresponse Force Microscopy scans confirmed the presence of domains with opposite polarization directions (*Fig.2a-b*) with an extrapolated value of piezoelectric coefficient d_{33} of 2.54 pC/N.

A microfabrication process for patch realization has been set up. The top electrode was created by simple thermal evaporation of gold directly onto the free-standing CS-F. This bilayer was then precisely cutted using a cutting plotter (*Fig.3a-b*) and assembled on the copper bottom electrode. The complete patch can be conformally applied on the skin (*Fig.4a-b*).

The ability of the device to sense physiological movements was validated by an *ad hoc* measurement set up (*Fig.5a*) generating strain pulses; open circuit voltage peaks up to 20 mV were detected (*Fig.5b*).

This sensor represents an important step towards totally biocompatible and biodegradable wearable devices.

Words count: 243

[1] M. T. Chorsi *et al.*, "Piezoelectric Biomaterials for Sensors and Actuators," vol. 1802084, pp. 1–15, 2019.

[2] D. Bajer, H. Kaczmarek, B. Kro, E. Klimiec, and M. Chylin, "Advances in the study of piezoelectric polymers Advances in the study of piezoelectric polymers," 2019.

[3] E. Praveen, S. Murugan, and K. Jayakumar, "RSC Advances property of a bio-polymer – chitosan and its," *RSC Adv.*, vol. 7, pp. 35490–35495, 2017.

[4] A. Hänninen, E. Sarlin, I. Lyyra, T. Salpavaara, and M. Kellomäki, "Nanocellulose and chitosan based fi lms as low cost , green piezoelectric materials," *Carbohydr. Polym.*, vol. 202, no. September, pp. 418–424, 2018.

[5] F. Feng, Y. Liu, B. Zhao, and K. Hu, "Procedia Engineering Characterization of half N-acetylated chitosan powders and films," vol. 00, no. 2011, 2012.

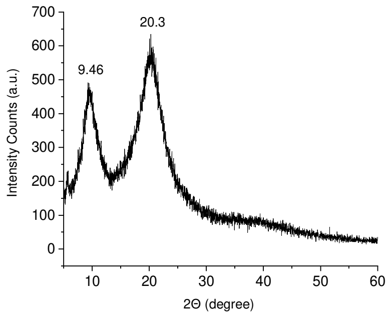

Fig. 1: XRD spectrum of the chitosan piezoelectric film. The peaks around 9.46 and 20.3 are related to the crystalline structure of the film

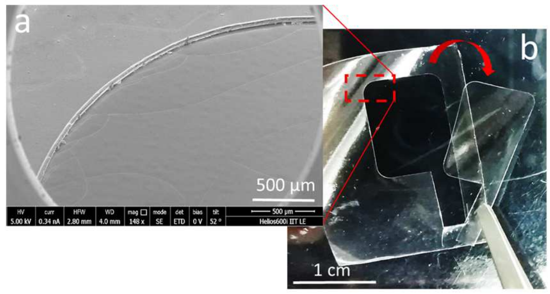

Fig. 3: Chitosan film processed with cutting plotter. a) SEM image of the cutted edge. b) Example of chitosan film shaped by cutting plotter.

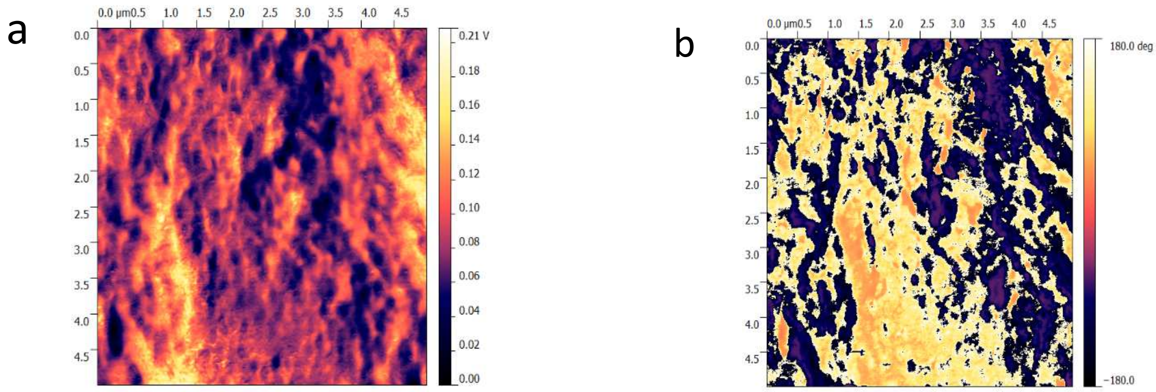

Fig. 2: PFM measurements on chitosan film. a) PFM amplitude image and b)PFM phase image of the inverse polarization domains.

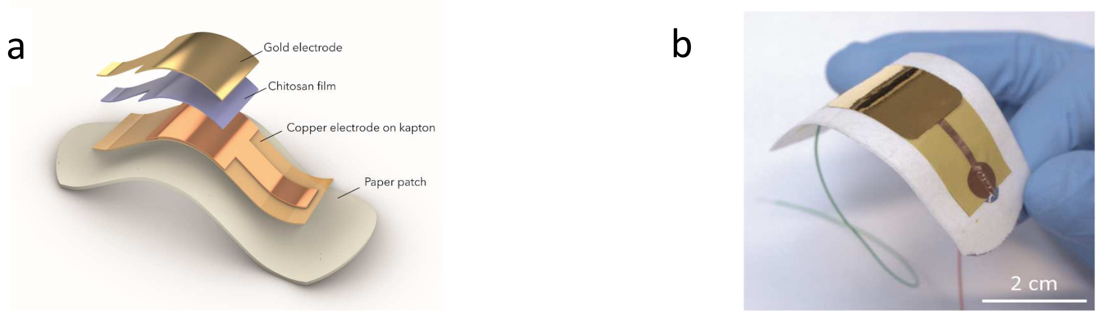

Fig. 4: Assembled patch. a) Exploded scheme of the device. b) Photo of the final assembled device.

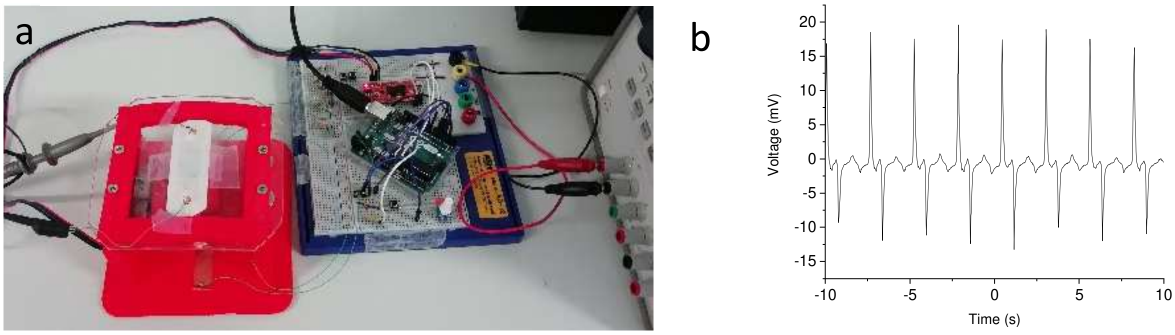

Fig. 5: Set up measurement. a) Physiological movements simulator (in red) has a membrane on the top to place the patch. The system is equipped with an actuator controlled by Arduino. b) Voltage signal recorded by the patch, peaks reach 20 mV without amplification system.