Screen Printed Electrochemical Sensors for Real-Time Sodium Monitoring in Sweat

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One of the key technological challenges in sensor design is providing low-cost, minimally invasive devices for *in situ* and *real-time* monitoring of chemicals produced by the human body[1]. The ease of access to body fluids such as saliva and sweat makes interesting applications of wearable sensors suitable for use in health care[3] and sport science[4].

We report on the preparation of disposable potentiometric sensor strips for monitoring sodium in sweat. We also present their integration in a microfluidic chip used to harvest sweat in-situ during exercise. The sensor-chip is integrated with a miniaturized electronic platform able to transmit data wirelessly in real time during a stationary cycling session in a controlled environment.

Combination-electrodes are prepared by screen printing in order to reduce costs[5]. An appropriate solid contact material is interposed between the carbon layer and the drop-cast outer membranes of the ion-selective & reference electrodes. The selective response of the ion-selective membrane is due to the presence of an ionophore, while the reference membrane is insensitive to changes in the sample composition. By measuring the potential bias between the two electrodes, the concentration of the primary ion in solution can be inferred.

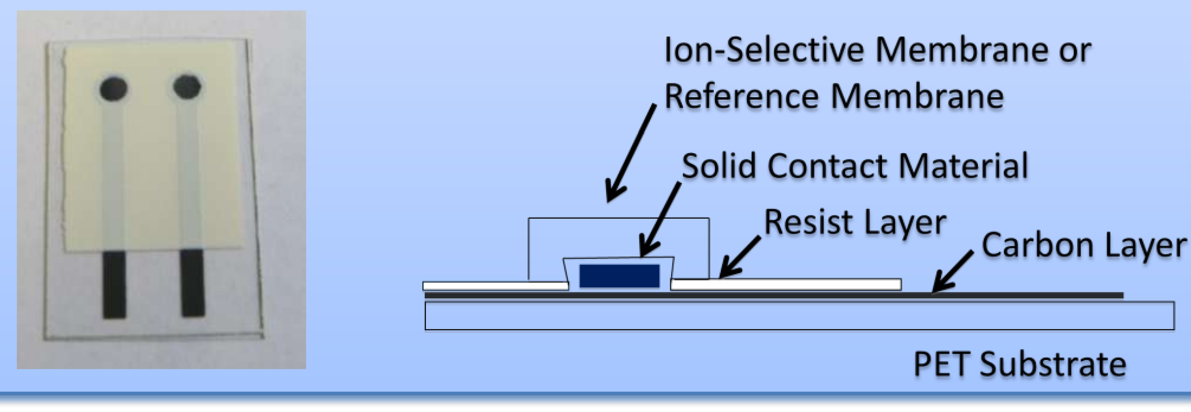

Figure 1 shows the average calibration of 3 Na-ISEs vs a standard double liquid junction Ag/AgCl reference electrode and a miniaturised solid contact reference electrode realised on a screen printed substrate. The concentration range of interest was 10^{-5}-10^{-1} M Na^+. Figure 2 displays an expanded view of the different layers used to realise the microfluidic chip that was mounted on top of the potentiometric strip. This configuration allows sweat to be collected through a Mega-Duct directly connected to the microfluidics, as shown in Figure 3.

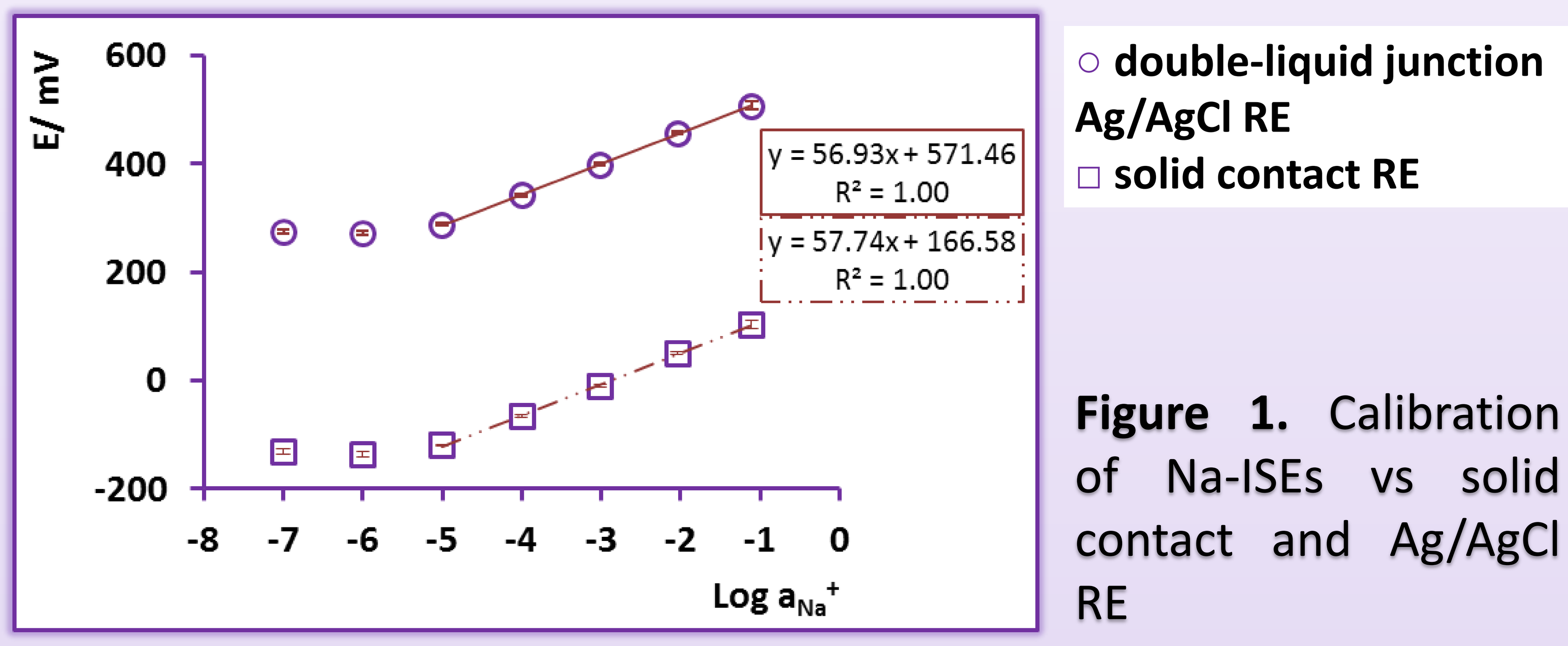

Figure 1. Calibration of Na-ISEs vs solid contact and Ag/AgCl RE

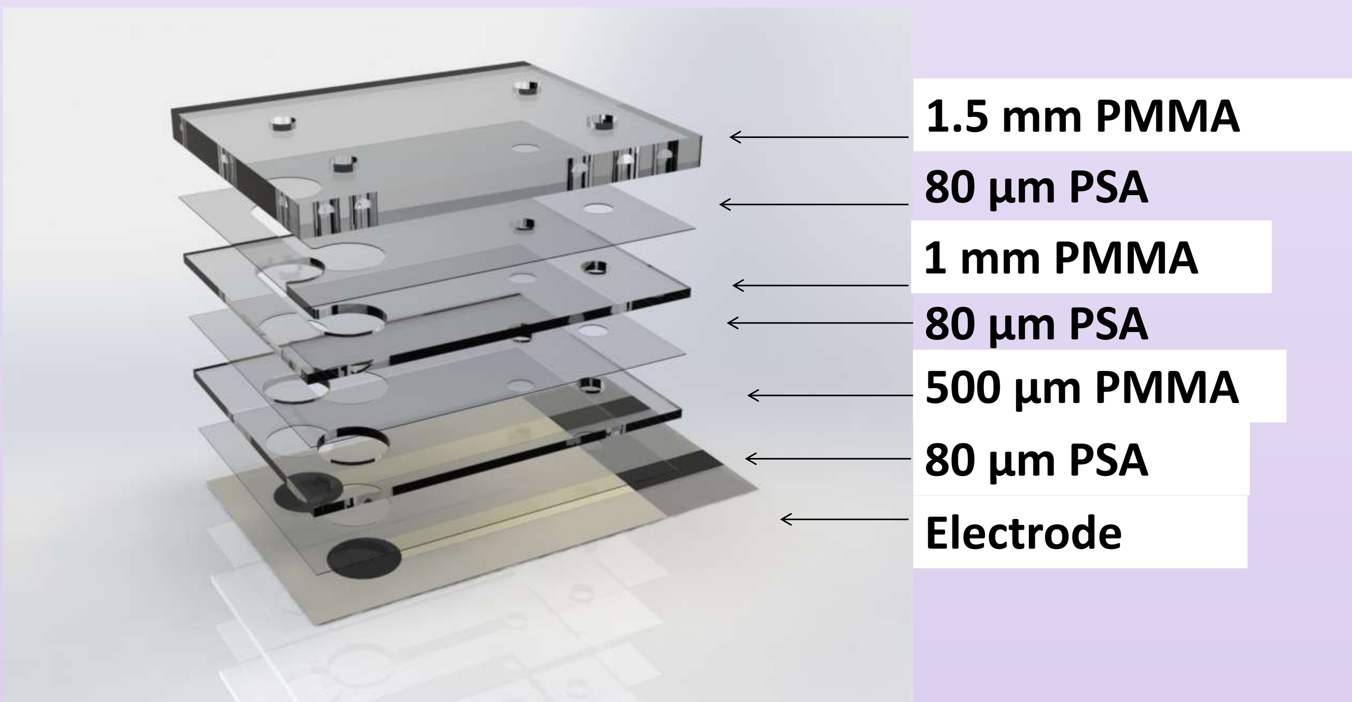

Figure 2. Microfluidic chip mounted on top of the screen printed potentiometric strip

Figure 3 Macro-Duct system used to harvest sweat

Real time tests were carried out with the microfluidic chip, positioned on top of the Na^+ selective potentiometric strip, which was connected to a miniatursed wireless electronic platform protected by a 3D-printed encasing (Figure 4). The signal shows a pronounced change after ~15 minutes (Figure 5), which corresponds to the delay in onset of sweat generation, coupled with the time required for the sweat to travel from the skin through the Macro-Duct and microfluidic module to the sensor strip.

Figure 4. Device used to carry out real-time sodium tests

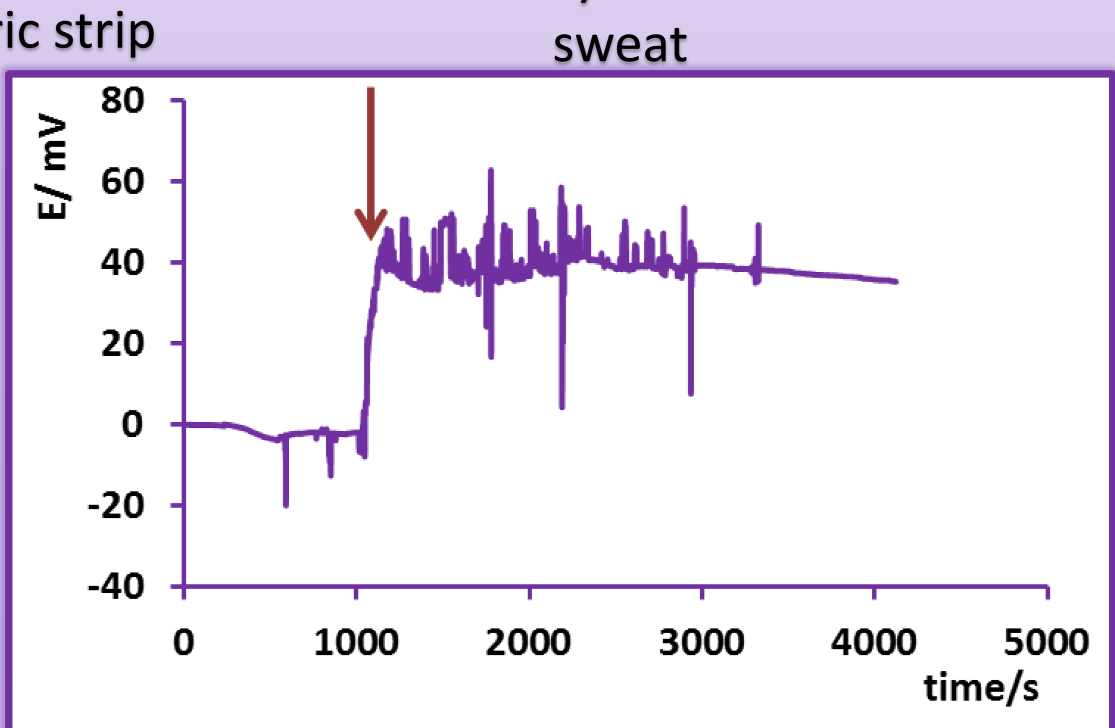

Figure 4. Real-time potential variation during a stationary cycling trial

After validation of the potentiometric system, we are planning to further reduce its dimensions. Current design efforts in our group are targeted towards the realisation of a **wearable watch-like device.**

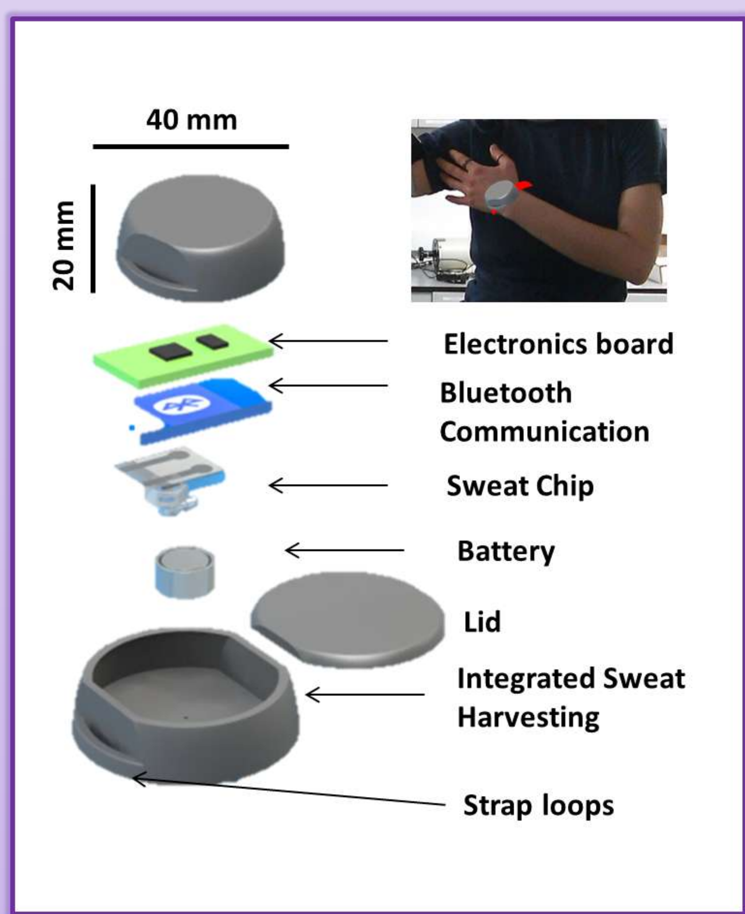

Figure 5. Watch like future design

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