INVESTIGATING THE USE OF GRAPHENE ELECTRODES FOR POLY(3,4-ETHYLENEDIOXYTHIOPHENE) POLYSTYRENE SULFONATE ORGANIC ELECTROCHEMICAL TRANSISTORS

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Introduction

Research in to the use of poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) as a channel material in organic electrochemical transistors has grown rapidly in the last few years, especially for applications in neural interfacing[1] and neuromorphic computing[2]. High signal-to-noise ratio (SNR) detection of single neurons has been demonstrated with PEDOT:PSS-channel organic electrochemical transistors (OECTs)[1], however one of the remaining challenges for a fully transparent, flexible, and biocompatible OECT is finding a contact material that also possesses these properties. Graphene produced via chemical vapor deposition has been shown to exhibit the required electrical properties, while also being scalable, flexible, and transparent.[3] This work investigates the use of graphene for use as source/drain-electrodes with PEDOT:PSS a channel for a fully transparent and flexible OECT with high SNR.

Motivation

The applications of OECTs are broad as they have been used to detect ions, metabolites, hormones, DNA, as well as interface with electrically active cells and tissues.[4] OECTs have recently been shown to have the largest transconductance among electrolyte-gated transistors, which is of particular interest for neural interfacing.[5]

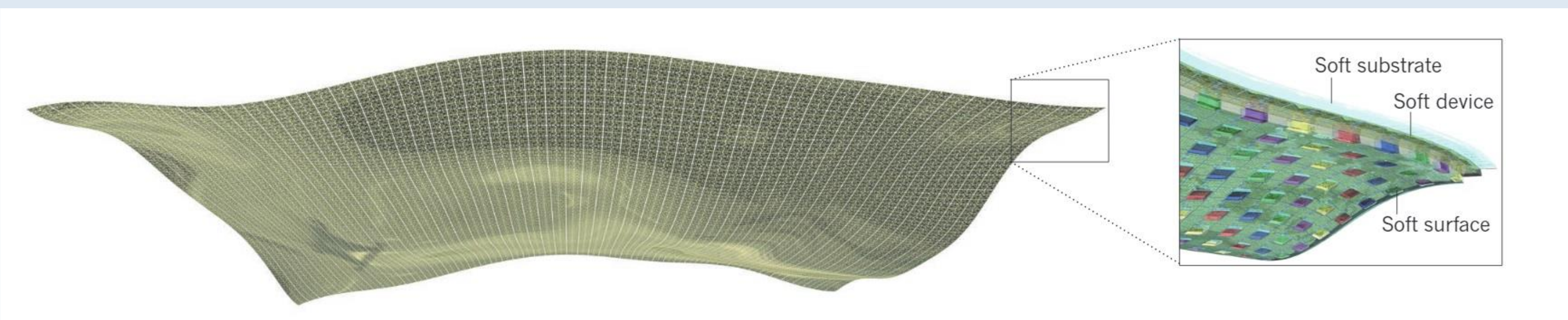

Figure 1: Example of a fully flexible sensor array for bio-applications. Reproduced from [4].

OECTs for neural interfacing are still largely designed on silicon or glass substrate, rather than on flexible substrates required for in-vivo applications. A remaining challenge for making fully flexible OECT arrays for use in in-vivo applications are highly flexible, biocompatible, and highly conductive source/drain-electrode material. Graphene is an ideal candidate for this application due to it's remarkable mechanical and electrical properties. Furthermore, the added benefit of using graphene comes from it's optical transparency, enabling the use of such devices for optogenetic recordings.

Design

We fabricated an OECT consisting a PEDOT:PSS channel, graphene source and drain electrodes, and gold contacts.

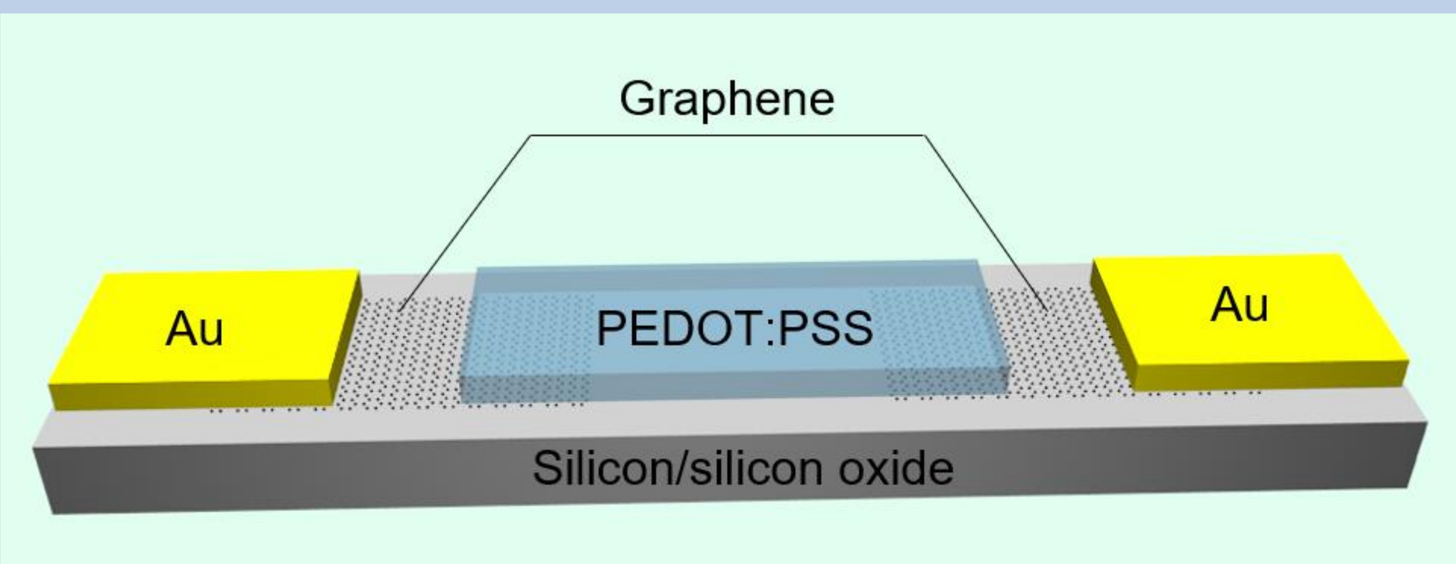

Figure 2: Design of PEDOT:PSS and graphene OECT

Methods

To maximise the SNR of the OECT, improve bandwidth, and potentially reduce power consumption, the total resistance of the transistor needs to be minimised.
Here we investigate the contact resistance between the PEDOT:PSS channel and graphene source/drain electrodes, as well as the resistance of the PEDOT:PSS channel, using a transmission line measurement technique. Sets of transistors are made, where channel length and graphene electrode lengths are changed, while maintaining a constant contact area between PEDOT:PSS and graphene. Making it possible to calculate the average contact resistance per unit area between PEDOT:PSS and graphene.

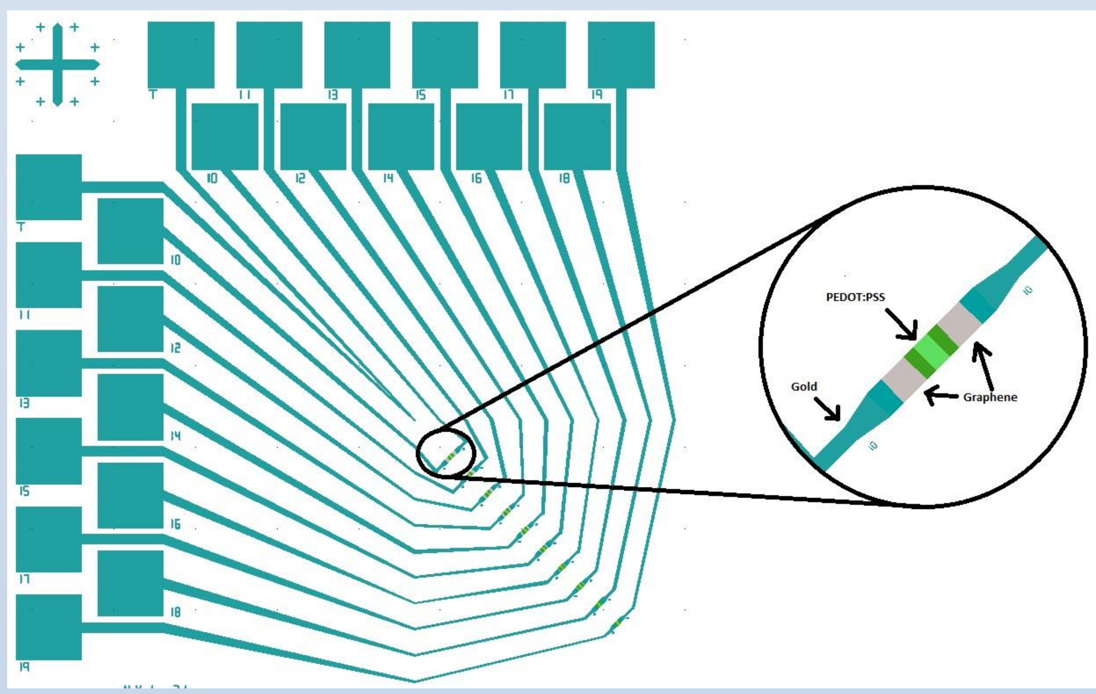

Figure 3: Device schematic showing an array of 10 OECT with changing graphene electrode length.

Future Work

The bandwidth of PEDOT:PSS OECTs is still potentially a limiting factor for its use in dense sensor arrays, as devices with high transduction were reported to have a bandwidth of approximately only 1kHz.[5] Future designs would need to investigate ways to overcome this bandwidth limit while retaining sufficient amplification. Due to PEDOT:PSS being a volumetric capacitor, a detailed study into how channel volume of PEDOT:PSS OECTs affect the On/Off current gain for very small channels still needs to be investigated.

References

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