Flexible implantable neural electrodes with enhanced wrinkle microstructures and PEDOT:PSS coating for neuromodulation in vivo

Bowen Ji, Zhejun Guo, Longchun Wang, Wen Hong, Chunpeng Jiang, Jingquan Liu

National Key Laboratory of Science and Technology on Micro/Nano Fabrication, Department of Micro/Nano Electronics, Shanghai Jiao Tong University, Shanghai, 200240, China
(jibowen2015@sjtu.edu.cn; gzj98762@sjtu.edu.cn; LongchunWang@sjtu.edu.cn; nikkihong@sjtu.edu.cn; jiangchunpeng@sjtu.edu.cn; jqliu@sjtu.edu.cn)

Abstract

Limited electrode size with high electrochemical performance and reliability of modified materials are two of the main concerns for flexible neural electrodes in recent years. Here, an effective fabrication method of enhanced micro-scale wrinkles based on oil-pretreated hyperelastic substrates (PDMS and Ecoflex) is proposed for the application of implantable neural electrodes. The uniform PEDOT:PSS coating is obtained on the wrinkled surface. Cyclic voltammetry (CV) scanning for 2500 times is performed to investigate adhesion and stability of modified PEDOT:PSS. Flexible wrinkled microelectrodes are further verified by in-vivo ECoG recordings combined with optogenetics in mice. These results highlight the importance of micro-structure in neural electrode and tremendous application potentials in flexible electronics.

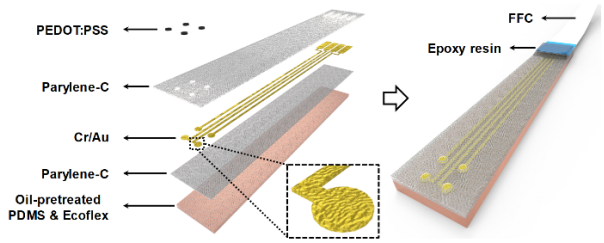

Figure 1: Schematic illustration of the enhanced wrinkled microelectrodes.

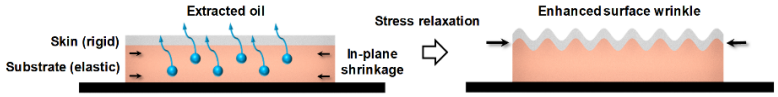

Figure **2**: Basic formation principle of the enhanced microsale wrinkles.

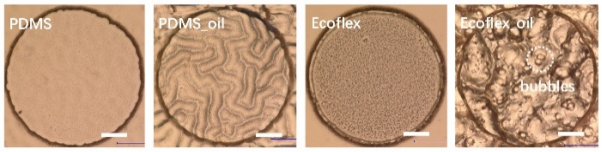

Figure **3**: Comparison of surface morphologies with and without oil pretreatment.

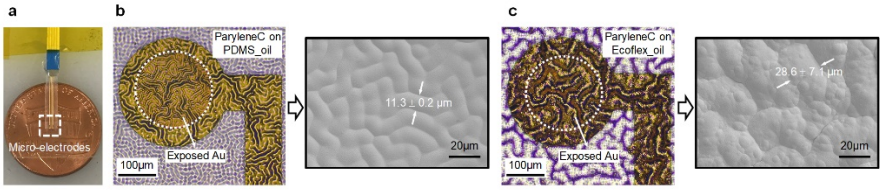

Figure **4**: (a) Microelectrode device; Micro-wrinkle structures on PDMS_oil substrate(b) and Ecoflex_oil substrate(c).

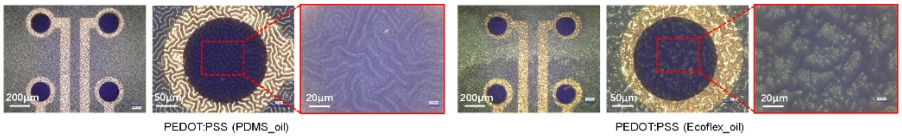

Figure **5**: PEDOT:PSS modification on PDMS_oil and Ecoflex_oil microelectrodes.

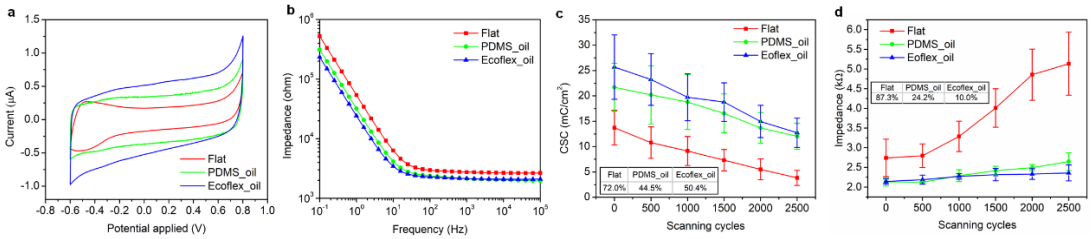

Figure **6**: (a) CV and (b) EIS of PEDOT:PSS microelectrodes on the flat, PDMS_oil and Ecoflex_oil substrates; (c) CSC and (d) impedance variation with 2500 CV scanning cycles.

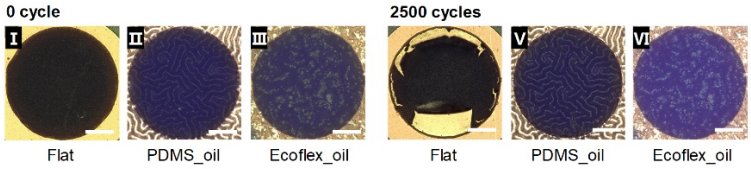

Figure **7**: Stability of PEDOT:PSS coating on three substrates with 2500 CV scanning cycles.

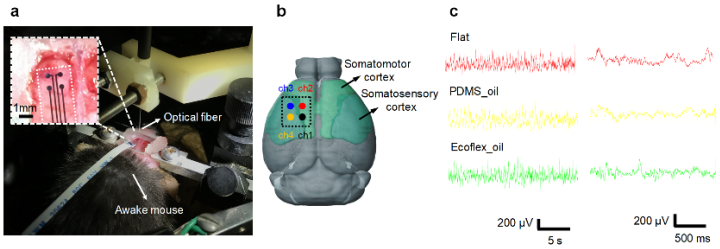

Figure **8**: (a) Picture and (b) scheme of wrinkled microelectrodes on the cortex of mouse brain; (c) Comparison of ECoG signals from PEDOT:PSS microelectrodes based on three substrates.

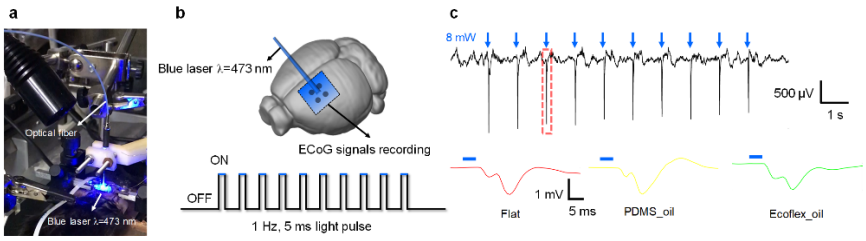

Figure **9**: (a) Image and (b) scheme of a sequence of 473 nm light pulse above the device implanted in a ChR2 mouse; (c) Representative light-induced ECoG signal and the single excited potential from PEDOT:PSS microelectrodes based on three substrates.

References

[1] Oh, J.Y.; Kim, J.Y.: Spontaneously Formed Wrinkled Substrates For Stretchable Electronics Using Intrinsically Rigid Materials. IEEE Electron Device Letters, Vol. 37, No. 5, pp. 588-590, 2016.

[2] Yang, L.; Zhao, Y.: Highly Crumpled All-Carbon Transistors For Brain Activity Recording. Nano Letters, Vol. 17, No. 1, pp. 71-77, 2016.

[3] Egunov, A. I. ; Korvink, J. G.: Polydimethylsiloxane Bilayer Films With An Embedded Spontaneous Curvature. Soft Matter, Vol. 12, No. 1, pp. 45-52, 2016.