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In-Vitro Evaluation of the Long-Term Stability of PEDOT:PSS Coated Microelectrodes for Chronic Recording and Electrical Stimulation

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Abstract : For the chronic application of neural prostheses and other brain-computer interfaces, long-term stable microelectrodes for electrical stimulation are essential. In recent years many developments were done to investigate different appropriate materials for these electrodes. One of these materials is the electrical conductive polymer poly(3,4-ethylenedioxythiophene) (PEDOT), which has lower impedance and higher charge injection capacity compared to noble metals like gold and platinum. However the long-term stability of this polymer is still unclear. Thus this paper reports on the in-vitro evaluation of the long-term stability of PEDOT coated gold microelectrodes. For this purpose a highly flexible electrocorticography (ECoG) electrode array, based on the polymer polyimide, is used. This array consists of circular gold electrodes with a diameter of 560 µm (0.25 mm2). In total 25 electrodes of this array were coated simultaneously with the polymer PEDOT:PSS in a cleanroom environment using a galvanostatic electropolymerization process. After the coating the array is additionally sterilized using a steam sterilization process (121°C, 1 bar, 20.5 min) to simulate autoclaving prior to the implantation of such an electrode array. The long-term measurements were performed in phosphate-buffered saline solution (PBS, pH 7.4) at the constant body temperature of 37°C. For the in-vitro electrical stimulation a one channel bipolar current stimulator is used. The stimulation protocol consists of a bipolar current amplitude of 5 mA (cathodal phase first), a pulse duration of 100 µs per phase, a pulse pause of 50 µs and a frequency of 1 kHz. A PEDOT:PSS coated gold electrode with an area of 1 cm2 serves as the counter electrode. The electrical stimulation is performed continuously with a total amount of 86.4 million bipolar current pulses per day. The condition of the PEDOT coated electrodes is monitored in between with electrical impedance spectroscopy measurements. The results of this study demonstrate that the PEDOT coated electrodes are stable for more than 3.6 billion bipolar current pulses. Also the unstimulated electrodes show currently no degradation after the time period of 5 months. These results indicate an appropriate long-term stability of this electrode coating for chronic recording and electrical stimulation. The long-term measurements are still continuing to investigate the life limit of this electrode coating.

Keywords : chronic recording, electrical stimulation, long-term stability, microelectrodes, PEDOT
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