NanoEDGE

NANO-BASED WEARABLE ELECTRONICS FOR MENTAL DISORDER DIAGNOSIS AND FUNCTIONAL RESTORATION: PRODUCTION TECHNOLOGIES AND DEVICES

Skin electrodes for biopotential monitoring. ©Tel Aviv University

Bioimpedance and biopotential amplifier BIOPOT for wireless biopotential and bioimpedance monitoring (device behind the ear). ©Sensomedical Labs LTD

WEARABLE ELECTRONICS AND PRINTED ELECTRODES FOR EEG AND EMG RECORDINGS

Starting situation

Electrodes are the core element of monitoring systems like EEG and EMG. Besides the demand for electrical conductivity and direct contact to the skin, electrodes have to fulfil further requirements like biocompatibility, low contact resistance and high ability to adopt to the contour of the skin. These requirements can be fulfilled by printed electrodes made of graphene nanomaterials. However, hardly any graphene inks suitable for inkjet printing are available on the market and thus, industrial scale printing processes for these inks are also lacking.

Our approach

We will converge production techniques for functionalized electrodes with expertise in nanomaterial fabrication and characterization, state of the art engineering, and neuroscience to pave the way for the production of multi-level sensors that can rigorously enhance the performance of established monitoring methods like electroencephalography (EEG) and electromyography (EMG). Further, we will develop resource-efficient production technologies and scalable processes for small scale and high throughput electrode manufacturing and functionalization. To this end, laboratory scale processes for fabrication and functionalization of carbon nanomaterial-based electrodes available within the consortium will be combined with the expertise in development of inkjet printers and inkjet printing technology. This combination of expertise will lead to new production processes and process chains.
State of the art skin electronics for EMG and EEG will be improved by combining the printed electrodes with advanced electronics design of wearable electronics and wireless signal transmission. All technology will be developed with a focus on simple transfer to large-scale production, simple usability and cost.

Skin electrodes

The skin electrode fabrication consists of conducting ink printing on soft material followed by blade cutting and lamination process of an adhesive passivation layer. The thickness of each of the components (conducting ink, soft support and passivation layers) determines the electrode coupling with the skin and therefore the signal to noise ratio that can be achieved. For EEG applications, further optimization of these layers, if needed, can be achieved by reducing thickness and rigidity.

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Graphene ink & printing process

The development of a graphene-based ink is based on a commercial graphene ink. Ink modification was necessary to make it printable. Ethanol is added to avoid bubbles and to decrease the surface tension of the ink. Carbon nanoparticles are added to improve abrasion resistance of printed structures. A surfactant is added to improve printability and to increase the conductivity and surface smoothness of printed structures.
The printing process is a two-step process: Firstly, tracks and contact pads are printed by using a silver ink. Secondly, electrodes are printed by using the modified graphene ink. An inkjet printer with a 16-nozzles-printhead was used for optimisation of the printing parameters. Further, suited pre- and post-processing processes and parameters were developed. In a second step, the printing process will be transferred to an inkjet system suited for mass fabrication.

Wearable electronics

The wearable electronics is based on the BIOPOT of SensoMedical Labs LTD. The BIOPOT is a wireless bioimpedance and biopotential amplifier with a data transmission and data acquisition device that is used as a platform for product development in neurotechnology. It is a small size and low-profile wearable with customizable form factor and allows for days of activity monitoring. It uses latest Bluetooth low-energy 5.0 technology for data transmission and has on-board data buffer. It is also designed as a patch device for data acquisition. It is available in 8 or 19 channels options and can be configured for either EEG, EMG or other biopotential readings.

Application Example

The sensors developed within NanoEDGE can be used for the sophisticated detection of signals that are indicative for mental state, like neural, physiological and muscle signals. This will allow for a more comprehensive portraying of mental processes, thus considerably improving mental disorder diagnosis and functional restoration. Specifically, we will target the testing of the novel and low-cost skin electronics technology for EEG based neuro-feedback systems towards implementation in mental disorder diagnosis and mental function restoration. As such, we target some of the most pressing economic and societal challenges of both Germany and Israel – the reduction of costs for treatment of mental disorders.

Consortium

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