PRESS RELEASE

NanoEDGE: Wearable electronics and printed electrodes for EEG and EMG recordings

Nano-based wearable electronics for mental disorder diagnosis and functional restoration: Production technologies and devices

NanoEDGE is an interdisciplinary research project aiming at converging 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).

Electrodes are the core element of monitoring systems. Today's electrodes for detecting electrical muscle signals (EMG) or neuronal signals (EEG) are made of metal and provided with a gel layer. In long-term measurements, the gel dries and prevents reliable measurement on the patient. 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.

Graphene nanoparticle ink for inkjet printing

The NanoEDGE project aims at the development of an ink from graphene nanoparticles for inkjet printing and a scalable printing process as well as a resource-efficient process chain for the production of electrodes for direct skin contact. 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 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

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noise ratio that can be achieved. For EEG applications, further optimization of these layers, if needed, can be achieved by reducing thickness and rigidity. Such ultra-thin electrodes combined with low-cost skin electronics will form a new generation of wearable sensors. With these sensors, the sophisticated detection of biological signals that are indicative for mental state, like neural, physiological and muscle signals, will allow for a more comprehensive portraying of mental processes, thus considerably improving mental disorder diagnosis and functional restoration.

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 optimization 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.

Enhancing performance and processes

The interdisciplinary approach of the NanoEDGE research project aims to converge the production techniques for functionalized electrodes with expertise in nanomaterial fabrication and characterization, state-of-the-art engineering, and neuroscience. Thus will improve the production of multi-level sensors and enhance the performance of monitoring methods like EEG and EMG. State-of-the-art skin electronics will be enhanced by combining the printed electrodes with advanced electronics design of wearable electronics and wireless signal transmission. Further, NanoEDGE 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 project 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 and simplify usability and decrease costs.

Mental disorder diagnosis and functional restoration

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, the project will target the testing of the novel and low-cost skin electronics technology for EEG based neurofeedback systems towards implementation in mental disorder diagnosis and mental function restoration. As such, NanoEDGE target some of the most pressing economic and societal challenges – the reduction of costs for treatment of mental disorders.

Bilateral project

NanoEDGE is a joint R&D project comprising participants from Germany and Israel. With the promotion of joint German-Israeli research projects in applied nanotechnology, new impulses are to be set which contribute to the intensification and stabilization of bilateral relations.

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Consortium

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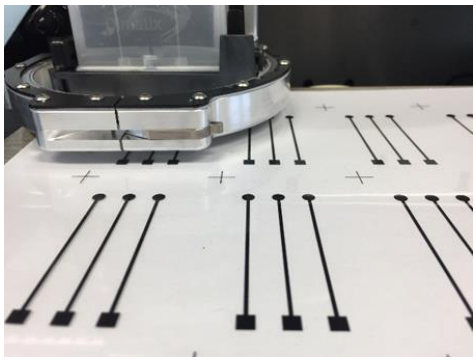

Printed test electrodes (© Fraunhofer IBMT).