Flexible Artificial Chemosensory Neurons and Synapses for Wearable, Continuous, and Non-invasive Cognitive Health Tracking

AIHUB: Neuroperceptive Analytical Microsystems for (Bio)Chemical Sensing

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This training project is part of our research activities to develop intelligent patches for wearable, continuous, and non-invasive health tracking. The work aims to incorporate the latest advances in neuromorphic engineering, (bio)chemical sensing, printed organic electronics, capillarity microfluidics and sweat science in the integration of an organic artificial chemosensory neural network for delivering chemical perception of health status from biomarkers sensed in sweat. To this end, the student will pursue the fabrication of all-printed organic electrochemical transistors (OECTs) made of poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) channels, and their validation as building blocks of both neurons and synapses of the network in a flexible sweat-sensing patch. Diverse gate materials and bioreceptors at the solution interfaces will be employed for multi-analyte detection of ions and metabolites. Printed OECTs are gaining significant importance as integral parts for biosensing and neuromorphic computing thanks to their high signal amplification, sub-volt operation, high biocompatibility, ion-driven dynamics, and mechanical flexibility. Despite these properties, their use to analyze complex biofluids is hampered by the cross-sensitivity and limited stability of the transistors. We will apply neuro-inspired processing techniques akin to those recently demonstrated by the two tutors of the project to boost accuracy and augment chemical information in real time from the plural electrochemical biomonitoring to be incorporated in the targeted smart wearable.

During the duration of the JAE-Intro, the grantee will have the opportunity to collaborate with a multidisciplinary team with expertise in machine learning, analytical chemistry and electronics. Training activities will include fabrication of OECT arrays on flexible substrates via inkjet printing methods; functionalization by use of ion-selective membranes and enzymes; simulation of the biosensors dynamical response in solutions by means of finite element methods; electrochemical characterization; and familiarization with the advanced scientific equipment available at the printed electronics, chemical transducers and microsystems characterization laboratories of the IMB-CNM-CSIC. The student will also be expected to follow the scientific seminars regularly taught by lead researchers at the institute.

Keywords printed electronics · artificial chemoperception · organic electronics · neuromorphic computing · sweat science · flexible electronics · smart wearables