

Modulation of organic semiconductors for advanced neuromorphic applications

H. Xhepa^(1, 2), M. Duong-Tuan^(2, 3), N. Meyer^(1, 2), F. Santoro^(1, 2), V. Criscuolo^(1, 2)

⁽¹⁾ Faculty of Electrical Engineering and IT, RWTH Aachen, 52074, Germany,

⁽²⁾ Institute of Biological Information Processing – Bioelectronics, IBI-3, Forschungszentrum Jülich, 52428 Germany,

⁽³⁾ College of Engineering and Computer Science, VinUniversity, 12426 Vietnam

Neuromorphic computing seeks to replicate the brain's exceptional information processing capabilities by emulating neuronal and synaptic functions in electronic systems. A key feature of these functions is synaptic plasticity, defined as the activity-dependent modulation of synaptic strength over short- and long-term timescales, which underlies learning and memory [1]. To mimic these processes, neuromorphic devices must exhibit tunable conductance states and non-volatile memory behaviour. In this context, organic neuromorphic platforms based on Organic Mixed Ionic Electronic Conductors (OMIECs) have emerged as promising candidates due to their low power consumption, mechanical flexibility, and intrinsic biocompatibility [2].

Organic Electrochemical Transistors (OECTs) have been regarded as ideal candidates for neuromorphic devices due to their ability to support coupled ionic and electronic charge transport and have demonstrated non-volatile memory capabilities. Here, conductive polymers, particularly PEDOT:PSS films, are the most commonly used channel material [3]. Concerns regarding the acidity of the sulfonate groups [4] have encouraged the exploration of small anionic dopants such as hexafluorophosphate (PF_6^-), perchlorate (ClO_4^-) [5]. However, the potential ejection of dopant ions and the influence of electrolyte counterions have received limited attention, as most studies mainly focus on electrolyte cations [6]. In this work, we investigate ion-exchange processes between different electrochemically deposited PEDOT films and their surrounding electrolyte.

PEDOT films doped with mobile anions, including PF_6^- , ClO_4^- , and PSS^- , were electrodeposited onto commercially available interdigitated electrodes (IDEs) to fabricate OECT devices. The resulting films were characterized across multiple electrolyte compositions using Cyclic Voltammetry and Electrochemical Impedance Spectroscopy to probe ionic exchange and mass transport dynamics. Furthermore, steady-state and transient OECT measurements were performed to evaluate device performance and investigate the appearance of short- and long-term synaptic plasticity.

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