Organic bioelectronics interfaces for intraoperative high-resolution and transient electrophysiological sensing.

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Probing electrophysiological signals requires interfaces that combine mechanical compliance, low noise and stable coupling with living tissue. We introduce two device based on organic electrodes that implement these principles through flexible substrates and engineered conductive coatings.

First, we present transient PLA-based multi-electrode arrays for epicortical recording and spinal cord stimulation. Their Ti/Au–PEDOT:PSS architecture provides >90% impedance reduction at 1 kHz compared to bare gold electrodes and maintains stable performance over four weeks in vitro. Acute in vivo experiments show high-SNR somatosensory evoked potentials from cortical arrays and selective sensory–motor recruitment from spinal arrays, with geometry-dependent modulation consistent with spinal anatomy.

Using the same conductive coating, we introduce a flexible 64-channel µECoG array for intraoperative monitoring, fabricated through gold-standard microfabrication. Millimeter-scale resolution combined with PEDOT:PSS interfaces improve SNR and remain stable after ageing. Recordings and post processing of spontaneous activity from healthy, tumour and border regions identified via MRI reveal distinct patterns, and preliminary correlation analysis highlights spatially organized electrophysiological signatures emerging from these complex interfaces.

Together, these platforms show how organic electronics, transient substrates and nanostructured conductive polymers can engineer compliant, low-noise biointerfaces for stable, scalable and high-resolution electrophysiological sensing in vivo. This work was conducted within the Technologies for Healthy Living and Brain and Machines Flagships of IIT and funded by the EU Horizon Europe programme (grant No. 101098597, Piezo4Spine).