

Beyond Surface Area: Microfabrication-Compatible Electrode Nanostructuring for High-Performance Miniaturized Electrochemical and Bioelectrical Sensors

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Abstract:

The progressive miniaturization of electro(chemical) sensors improves spatial resolution and integration capabilities but leads to reduced electroactive area and increased electrode impedance, limiting sensitivity and signal quality. These constraints apply broadly to both electrochemical detection and bioelectrical measurements. Conventional approaches relying on ex situ nanomaterial integration are often hindered by poor reproducibility, cleanroom incompatibility, binder-related artefacts, and limited mechanical stability.

This talk will present a microfabrication-enabled paradigm based on direct electrode modifications, delivering binder-free, scalable, and stable nano–microarchitectures. The resulting electrodes provide increased effective surface area, improved charge-transfer properties, and reduced interfacial impedance, enhancing performance across sensing modalities.

The approach will be illustrated through two applications: (i) non-enzymatic glucose sensing in chloride-rich physiological media, where electrode engineering, combined with *ad hoc* electroanalytical operation, enables transient catalytic activity and (ii) nanostructured silicon microneedle arrays for wearable EEG, showing improved signal-to-noise ratios.

These results demonstrate that electrode architecture, beyond simple surface area scaling, governs performance, and establish nanostructuring as a reproducible pathway toward high-performance miniaturized sensing systems.

Keywords:

electrode nanostructuring, microfabrication-compatible sensors, electrochemical and bioelectrical sensing, non-enzymatic glucose monitoring, EEG monitoring, wearable microneedle electrodes

References:

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