

From Materials to Systems: Passive, Low-Energy Sensors Based on Organic Mixed Ionic–Electronic Conductors

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Abstract:

Organic mixed ionic–electronic conductors (OMIECs) are promising materials for bioelectronics and electrochemical sensing due to their ability to couple ionic and electronic charge transport at low operating voltages. Realizing fully passive and battery-free sensor systems based on OMIECs, however, requires understanding the fundamental limits of signal propagation and energy dissipation in these materials.

Here, we first investigate dissipative charge transport in OMIEC channels using electrical phase velocity measurements and modulated electrochemical atomic force microscopy.[1] Interpreting the results within a transmission line framework reveals that energy dissipation is governed by the ratio between electronic mobility and volumetric capacitance, establishing a key figure of merit for OMIEC materials beyond transistor amplification.

Building on this understanding, we demonstrate a fully passive oxygen sensor based on an organic electrochemical transistor (OECT).[2] By combining optimized device geometries with near-field communication (NFC) power harvesting, the system enables wireless and battery-free oxygen sensing in air and water. The interrogating NFC field is sufficient to power the electronics, acquire the sensor signal, and transmit the data wirelessly.

These results connect microscopic transport physics with the development of sustainable, ultra-low-power sensing systems based on OMIEC materials.

Keywords:

Organic mixed ionic–electronic conductors, Organic electrochemical transistors, Passive wireless sensing, Low-power bioelectronics, Near-field communication sensors

References:

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