Electro-Plasmonic System and Methods

Tech ID: 34249 / UC Case 2026-579-0

BACKGROUND

Scaled neural sensing has been pursued for decades. Physical limitations associated with electrical (electrode-based) field recordings hinder advances in both field of view and spatial resolution. Electrochromic plasmonics (electro-plasmonics) has emerged as a rapidly advancing field combining traditional electrochromic materials with plasmonic nanostructures, including recent demonstrations of electrochromic-loaded plasmonic nanoantennas for optical voltage sensing. Existing optical electrophysiology techniques face critical limitations including poor signal-to-noise ratios due to low photon counts from genetically encoded voltage indicators, which have small cross-sections and low quantum yields. Fluorescent voltage indicators suffer from photobleaching, phototoxicity, and require genetic modifications that limit their clinical applicability. Current electrochromic devices also struggle with limited cycling stability, slow switching times, and restricted color options, and conventional plasmonic sensors exhibit inherently low electric field sensitivity due to high electron densities of metals like gold and silver. Current approaches to electro-plasmonics lack stable, high-contrast optical modulators that can operate at sub-millisecond speeds while maintaining human biocompatibility.

TECHNOLOGY DESCRIPTION

To help address these challenges for scaled neural sensing applications, researchers at UC Santa Cruz (UCSC) have developed electrochromic-loaded plasmonic nanoantennas that achieve thousands-fold enhanced electric field sensitivity compared to pristine plasmonic structures, enabling sub-millisecond response times and with exceptionally high signal-to-shot-noise ratios. The devices feature ultra-thin electrochromic loads that exploit the low electron density of conducting polymers versus metals to dramatically amplify field sensitivity, while achieving label-free, non-invasive optical detection of cellular electrical activity. Additionally, the research results present optical modulators with unprecedented contrast ratios and switching times by leveraging highly dispersive Fano resonances in extraordinary light transmission effects. UCSC's preliminary research results demonstrated scaled electrophysiological imaging of cardiomyocytes in vitro.

APPLICATIONS

- diagnostics – neuro
- therapeutics – neuro
- research tools – neuro

FEATURES/BENEFITS

- Uses bright-field configuration based on electro-plasmonic nanohole arrays for extremely sensitive transduction.
- Eliminates need for genetic modifications, fluorescent labels, or invasive procedures while providing biocompatible sensing with minimal phototoxicity and no photobleaching limitations.
- Allows for sub-millisecond temporal resolution without cross-talk to neighboring nanoelectrodes.
- Utilizes CMOS-compatible fabrication processes and standard electrochemical deposition techniques for scaled production.

INTELLECTUAL PROPERTY INFORMATION

Patent Pending

RELATED MATERIALS

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OTHER INFORMATION

KEYWORDS

neural, neural sensing, electrochromic, electrochromic plasmonics, electro-plasmonics, electrophysiology, brain-machine interface, BMI, brain, electrogenic, nanophotonic, nanoprobes, electro-optic switching

CATEGORIZED AS

- **Medical**
  - Disease: Central Nervous System
- **Nanotechnology**
  - NanoBio
- **Sensors & Instrumentation**
  - Biosensors
  - Medical
  - Scientific/Research

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