Neuro-Swarm3: System-On-A-Nanoparticle For Wireless Recording Of Brain Activity

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BACKGROUND

A fundamental limitation for the implantable brain-machine interfaces (BMI) is the wiring requirements for power transfer and signal transmission. Microelectrode arrays (MEAs), the workhorse technology in neuroscience, offer multiplexed electrophysiological recordings with high temporal resolution. However, their use is inherently limited to a few hundred electrodes as direct electronic measurements suffer from complex wiring requirements and inherent bandwidth (spatial multiplexing) limitations due to electron-electron interactions within conductors. Moreover, electrode arrays can only record from small sections of the brain and require invasive cranial surgical operations.

The recent discovery of genetically encoded voltage sensitive fluorescence indicators (GEVI) has created tremendous excitement as light offers unparalleled multiplexing and information carrying capabilities. However, GEVI cannot be used in humans as it requires expression of voltage sensitive molecules by neurons and therefore genetic manipulation. In addition, attenuation of visible light in biological tissue renders much of the brain inaccessable to fluorescence based techniques.

TECHNOLOGY DESCRIPTION

Neuro-SWARM^3 is a system-on-a-nanoparticle probe, that enables non-invasive measurement of in vivo electro-physiological activity using near-infrared light. Neuro-SWARM^3 converts electrophysiological activity to an optically detectable signal that can be picked up from outside the brain using near-infrared (NIR-II, 1000-1700 nm) light. Neuro-SWARM^3 provides a bioelectrical signal detection capability in a single nanoparticle device that packs wireless powering, electrophysiological signal detection and data broadcasting capabilities at nanoscale dimensions.

Neuro-SWARM^3 uses optical excitation power transfer and signal readout primarily useful as a contrast agent for sensing the electrical field produced by neurons.

Neuro-SWARM^3 enables direct measurement of local electric field dynamics through near infrared light via localized surface plasmon enhanced scattering and electro-optic sensitivity to local electric-field dynamics, primarily through electrochromic loading of PEDOT:PSS.

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OTHER INFORMATION

KEYWORDS

Nanoparticle, Noninvasive electrophysiological measurement, Neuroscience, Near-infrared, Optically detectable

CATEGORIZED AS

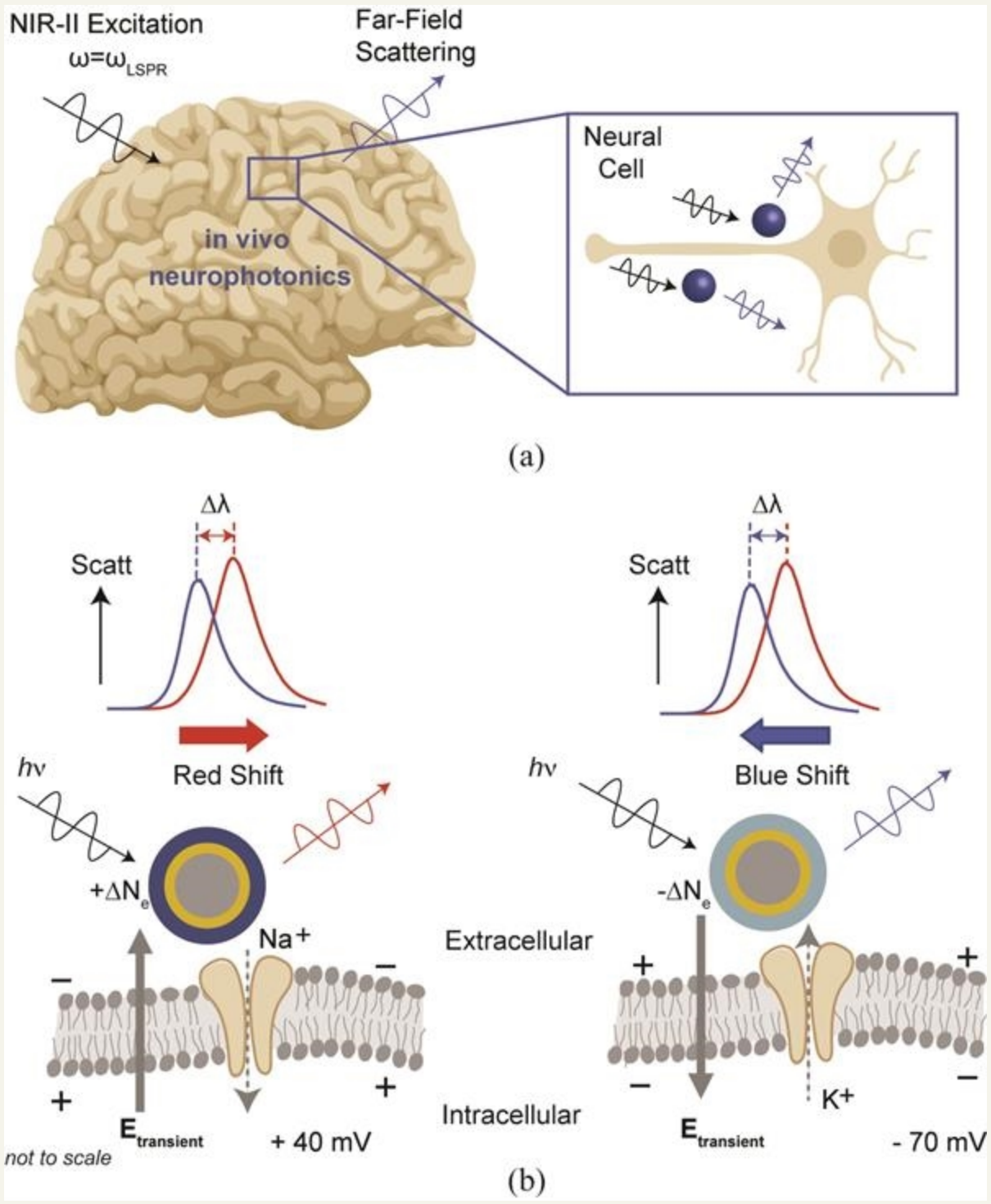
- **Sensors & Instrumentation**
  - Biosensors
  - Medical
  - Scientific/Research

RELATED CASES

2021-984-0

NeuroSWARM^3 can be made with a dielectric (silica, SiO_2) and magnetic (magnetite, Fe_3O_4) core, covered by a metallic (gold) shell, an electrochromic polymer (PEDOT) coat, and an optional surface functionalization with, for example, lipids or antibodies. This technology can also work with a semiconductor core, but methods to produce semiconductor nanoparticles which are uniform in shape and distribution remain elusive[1].

The layers of NeuroSWARM^3 can be altered to change the wavelength used for optical sensing, but it is originally designed for near infrared wavelengths with dimensions of silica-gold-PEDOT layers totaling less than 200 nanometers in diameter.



APPLICATIONS

Neurophysiology research

Diagnostics of brain diseases

Brain research

Diagnostic imaging

Biological electrochemical systems

ADVANTAGES

Neuro-SWARM offers five fundamental advancements simultaneously:

(1) it enables use of infrared light within the biologically transparent near infrared (NIR-II, 1000-1700 nm) window for direct read-out through the skull,

(2)it circumvents invasive surgical operations since no wiring or power supply is needed for the wireless electroplasmonic excitation and remote detection backscattering signal,

(3)due to its nanoscale dimensions (< 200 nm) comparable to viral particles, NeuroSWARM can be delivered to brain tissue through the blood or cerebrospinal fluid,

(4) as the electro-plasmonic signal conversion removes front-end signal processing requirements and enables optical read-out, it opens the door to large scale in vivo measurements that are not restricted by electrode dimensions, wiring, or electronic bandwidth limitations,

(5) by being much smaller than the critical dimensions that trigger glial cell response (~ 12 µm),it offers a long term operation capability.

INTELLECTUAL PROPERTY INFORMATION

Country	Type	Number	Dated	Case
United States Of America	Published Application	20240268746	08/15/2024	2021-984

RELATED MATERIALS

- Neuro-SWARM³: System-on-a-Nanoparticle for Wireless Recording of Brain Activity - 06/28/2021

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Plasmofluidic Microlenses for Label-Free Optical Sorting of Bioparticles

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