Massively scalable 3D electrophysiology and two-photon imaging in freely-moving animals

Scalable 3D nanoelectrode + 2-photon platform enabling high-resolution electrophysiology in freely moving animals.

From understanding the physiological basis for behavioral patterns to investigating possible treatments for neurological diseases like Alzheimer's, analyzing and disentangling the intricacies of brain function is essential. To do this, researchers must be able to monitor the dynamic fluctuating activity of neural circuits via the flow of electrical signals from one point to another, which generally takes place over milliseconds. Currently, most research into brain activity must be performed on subjects, such as mice, with fixed heads. Holding the head in place is the only thing that allows current methods, such as high-density electrophysiology and two-photon imaging, to capture accurate readings. However, this method significantly limits researchers' ability to analyze brain patterns that underly movement and real-world sensory processing.

Researchers at Purdue University have developed a novel device to accurately measure brain activity in mice under more normal conditions. Their technology, NET-2P (NanoElectrode Technology Integrated 2-Photon Platform) includes a flexible, minimally invasive probe with a miniature head-mounted microscope, allowing subjects a relatively normal range of motion. With NET-2P, researchers can monitor brain activity without needing to fix the subject's head, allowing them to move about, interact with each other and their environment, and even sleep. NET-2P also doesn't compromise on accuracy, capable of capturing intricate physiological structures with high temporal resolution, which is essential for monitoring the millisecond-long interactions that occur in brain electrophysiology. With the insight provided by NET-2P, researchers will be able to break new ground on pressing concerns like sleep research, neurological diseases, and neurodevelopmental disorders.

Technology Validation:

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Category
Materials Science & Nanotechnology/Nanomaterial Characterization & Imaging Tools
Biotechnology & Life Sciences/Analytical & Diagnostic Instrumentation

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The device is realized using novel 3D nanoscale metal printing based on a CERES printer for ultra-high-aspect-ratio nanoelectrodes on a flexible transparent substrate. As preliminary evidence, they have demonstrated 3D-metal printing for robust and flexible proof-of-concept probes capable of transmitting single unit activity and LFP with high SNR. Combined with CMOS IC amplifier array and an open-source mini2P (miniature microscope) for complete prototype.

Advantages:

-Allows for accurate readings of neural activity in freely moving subjects

-Eliminates the need for head-fixing, allowing researchers to more directly observe movement-based neural processing

-Provides accurate readings of brain activity during normal behavior, including sleep, social interaction, and sensory processing.

Applications:

-Research into brain patterns related to movement, sensory processing, and sleep

-Possible implications for sleep disorders

-Research into neurological disorders like Parkinson's and Alzheimer's

-Research into neurodevelopmental disorders such as autism

TRL: 4

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