Docket #: S24-459

Method and Apparatus for High-speed, High-resolution Optical System for Large-field-of-view Live Tissue Functional Imaging

Stanford scientists have developed an optical imaging system that enables simultaneous monitoring of multiple neural signals across large brain regions with high temporal and spatial resolution. This mesoscope system can transform neuroscience research by allowing researchers to study the relationships between diverse neural processes across behaviorally relevant brain areas in real time.

Modern neuroscience increasingly requires simultaneous observation of multiple neural signaling modalities across large brain areas. However, traditional microscopy systems face fundamental trade-offs between field of view, resolution, and imaging speed that prevent them from meeting these demands. Current systems struggle to manage the complex synchronization required between multiple excitation sources and detectors, leading to compromised signal quality and cross-talk between channels. These constraints have prevented researchers from simultaneously monitoring multiple aspects of neural function across behaviorally relevant brain areas.

The mesoscope system overcomes these limitations by combining a large 8mm field of view with high numerical aperture (0.47 NA) and approximately 85% light transmission efficiency. The system achieves temporal resolution up to 300Hz while preserving spatial precision of approximately 6?m, allowing researchers to simultaneously capture fast voltage dynamics alongside slower calcium or neuromodulator signals without cross-talk. This combination of features enables experimental paradigms previously not possible, such as studying the relationship between voltage dynamics and neurotransmitter release across entire cortical

regions during complex behaviors.

Stage of Development:
Preclinical
Continued research: Further improving the engineering aspects of the system and applying its utilization to different modalities and drug testing

Applications

- Multi-modal neural imaging for neuroscience research
- Voltage and calcium imaging platforms for cellular studies
- Drug screening and pharmaceutical testing systems
- Clinical tissue imaging devices
- Integration with microfluidics imaging systems

Advantages

- Simultaneous monitoring of multiple neural signals without cross-talk
- Large field of view (8mm) combined with high numerical aperture (0.47 NA)
- High temporal resolution (up to 300Hz) while maintaining spatial precision (approximately 6?m)
- Exceptional light collection efficiency (approximately 85% transmission)
- Compatible with spectrally diverse fluorophores and indicators

Publications

- Haziza, S., Chrapkiewicz, R., Zhang, Y., Kruzhilin, V., Li, J., Li, J., ... & Schnitzer, M. J. (2025). Imaging high-frequency voltage dynamics in multiple neuron classes of behaving mammals. Cell, 188(16), 4401-4423.

Patents

- Published Application: 20250164771

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