For **Neuro** and **Cardiac** Electrophysiology Study

High-Speed Wide-Field Optical Mapping

Application & Product List

- Voltage-Sensitive Dye Imaging
- Calcium Imaging
- GCaMP / GEVI Imaging
- Intrinsic Signal Imaging
- Wide-Field Imaging
- Multi-Wavelength Imaging
- Electrophysiology
- Optogenetics

Brainvision

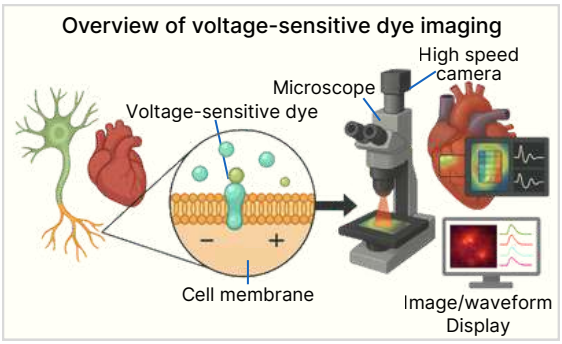
Brainvision Inc.

Voltage-Sensitive Dye Imaging

MiCAM03 N256 | BV Workbench | THT Mesoscope | LEX9

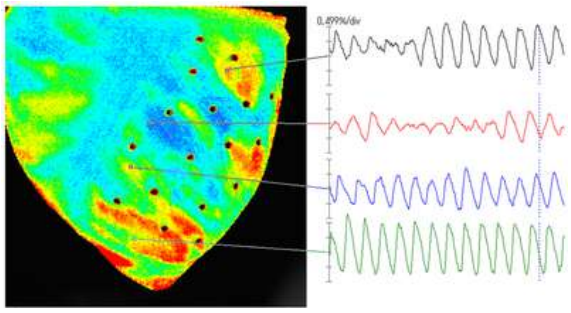
Voltage-sensitive dye imaging (VSDI) is a technique that uses voltage-sensitive dyes to visualize changes in the membrane potential of neuronal and cardiac cells. These dyes bind to and embed within the cell membrane, causing their fluorescence intensity and wavelength to shift in response to potential changes.

This method allows for the real-time recording of neuronal action potentials and cardiac excitation conduction from many cells simultaneously using a high-speed imaging device, all without the need for recording electrodes.

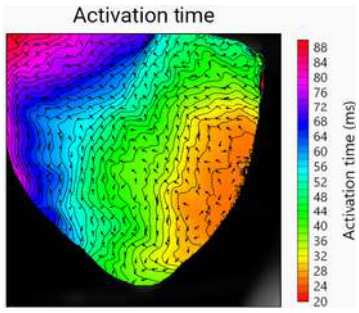


Imaging examples using heart and cardiomyocytes

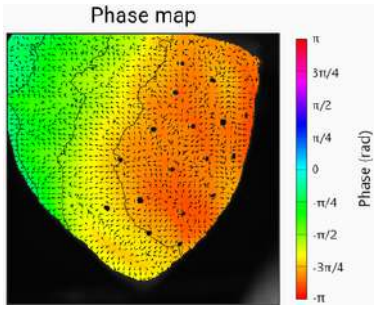
Isolated heart / Langendorff-perfused heart



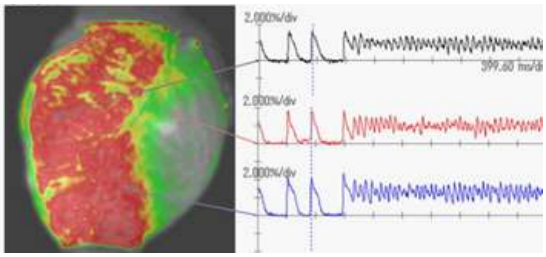
Ventricular fibrillation in an isolated pig heart. Action potential propagation was recorded at 1,818 fps



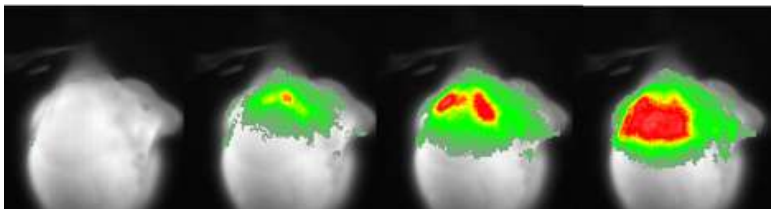
Activation map and conduction velocity



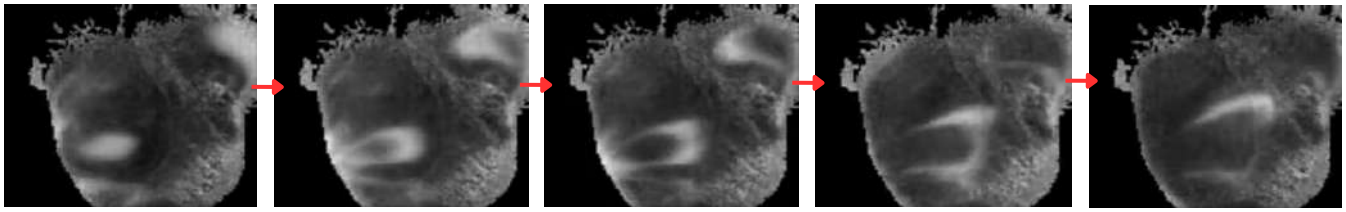
Phase map and conduction velocity



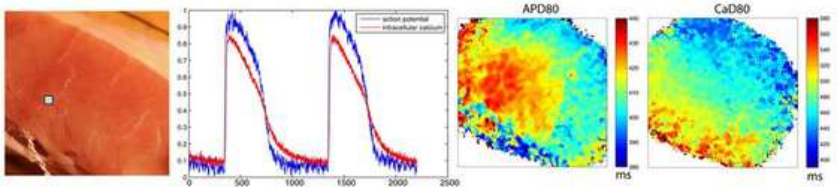
Ventricular fibrillation in isolated rat hearts



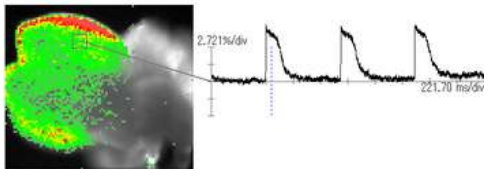
Signal propagation in rat atria



Propagation of an action potential (ventricular fibrillation) in a guinea pig heart, recorded at 10,000 fps. The wavefront was detected by calculating the first derivative of the action potential, as shown in this trace.

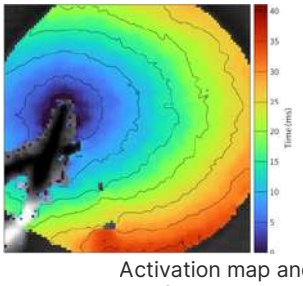
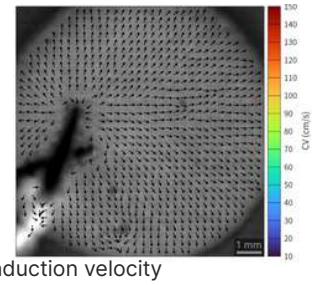


Simultaneous recording of membrane potential and calcium in isolated human heart

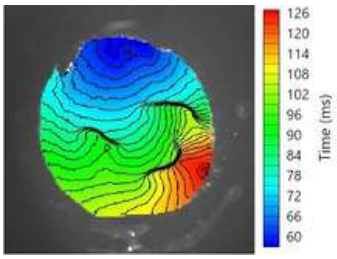


Spontaneous action potential changes in fetal mouse heart

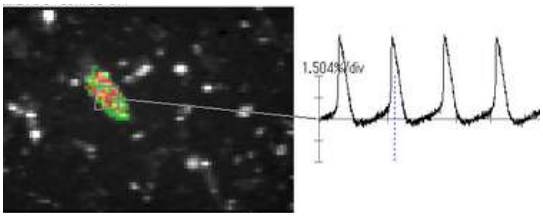
Cultured cardiomyocytes

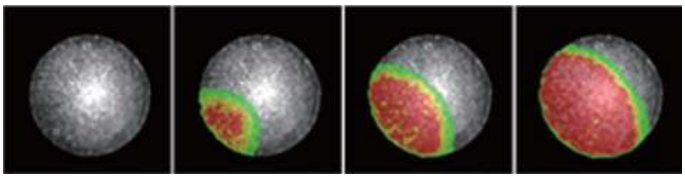
Activation map and conduction velocity of hiPSC-derived cardiomyocytes



Activation map of neonatal mouse ventricular myocytes



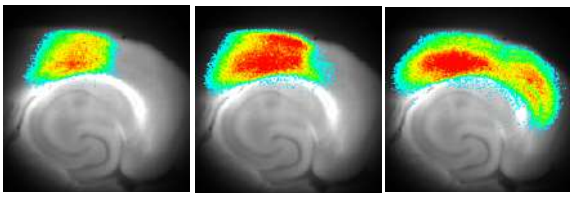
Spontaneous activity of hiPSC-derived cardiomyocytes



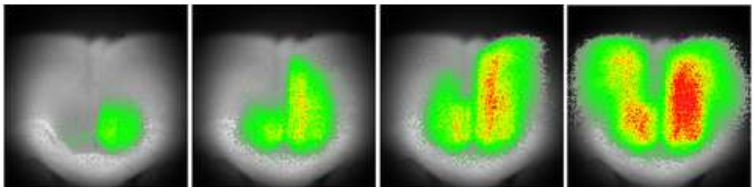
Action potential propagation in hiPSC-derived cardiomyocytes

Imaging examples using brain and neurons

Brain slices

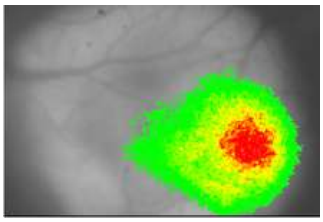


Membrane potential response of mouse brain slices (cortex) to electrical stimulation



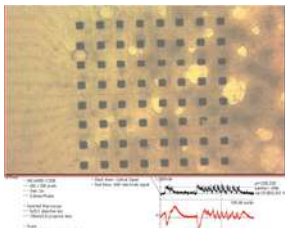
Membrane potential response of mouse brain slice (cingulate cortex) to electrical stimulation

In Vivo brain

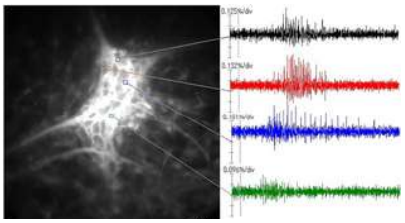


Membrane potential response of mouse in vivo brain to whisker stimulation

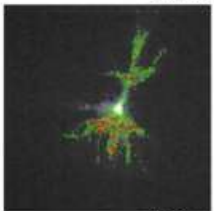
Cultured neurons / ganglion / single neuron



Spontaneous activity of cultured neurons



Response of rat enteric ganglia to nicotine administration



Single neuron

GEVI Imaging

MiCAM03 N256 | BV Workbench | THT Mesoscope | LEX9

GEVI (Genetically Encoded Voltage Indicator) imaging is a technology that captures changes in membrane potential as optical signals by using genetically encoded fluorescent proteins that are expressed on the cell membrane. A key advantage of this method is that it enables cell-type- or region-specific recording.

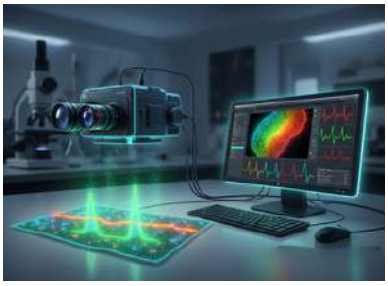
References：
Genetically expressed voltage sensor ArcLight for imaging large scale cortical activity in the anesthetized and awake mouse.
Neurophotonics. 2017 Jul; 4(3): 031212..

Adaptive behavior and the role of primary somatosensory cortex.
bioRxiv 2021.01.29.428886

Calcium Imaging

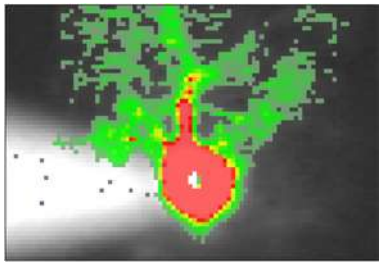
MiCAM03 N256 | BV Workbench | THT Mesoscope | LEX9

Calcium imaging is a method for visualizing changes in intracellular calcium ion concentrations using fluorescence. It uses a calcium-sensitive fluorescent indicator, which increases in fluorescence intensity or changes its fluorescence spectrum as the Ca^{2+} concentration increases. It is suitable for capturing the rough spatiotemporal distribution of which cells are activated and when.

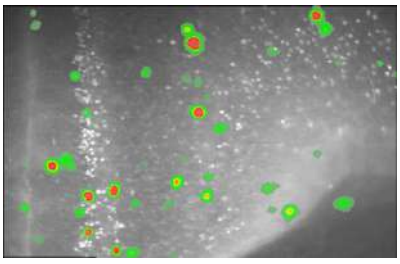


Imaging examples

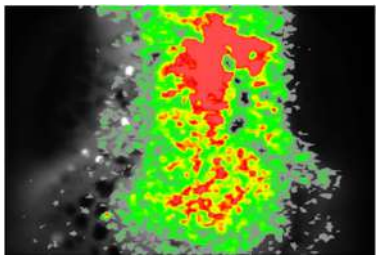
Neurons



Purkinje cells in the cerebellum

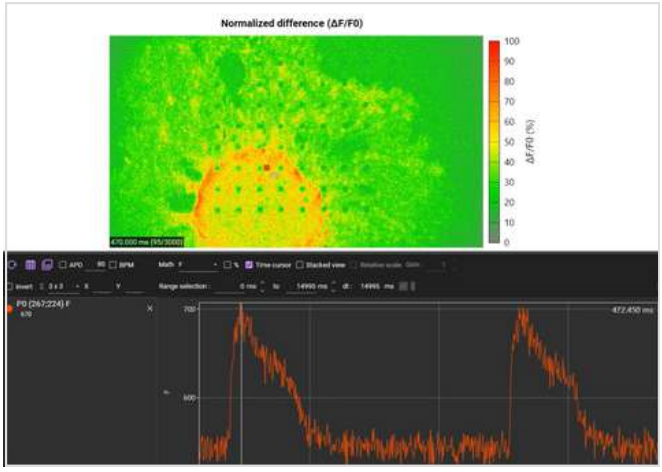


Brain slices (cortex)

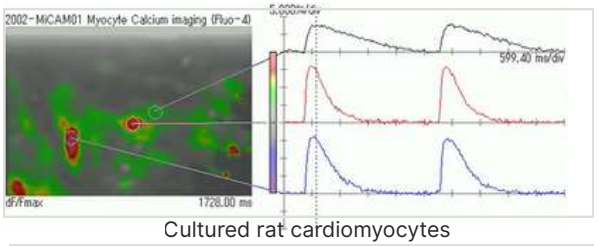


Fish brain

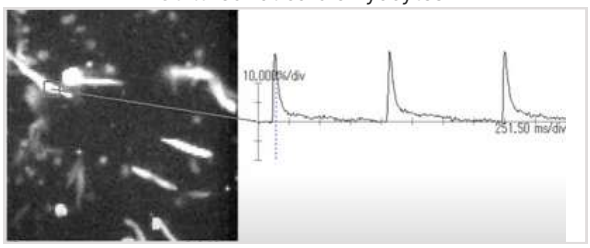
Cardiomyocytes



Cultured cardiomyocyte sheet



Cultured rat cardiomyocytes

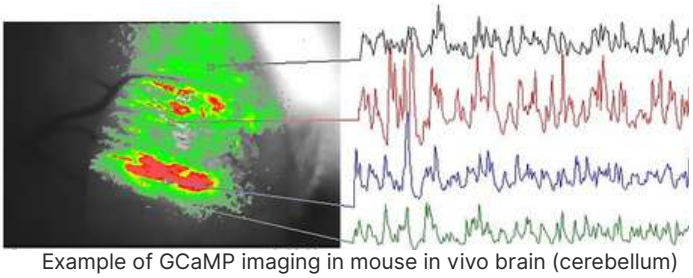


Isolated mouse atrial cardiomyocytes

GCaMP Imaging

MiCAM03 N256 | BV Workbench | THT Mesoscope | LEX9

GCaMP imaging is a technique that uses GCaMP, a type of genetically encoded calcium sensor (GECI), to fluorescently visualize changes in intracellular calcium ion (Ca^{2+}) concentrations .



Example of GCaMP imaging in mouse in vivo brain (cerebellum)

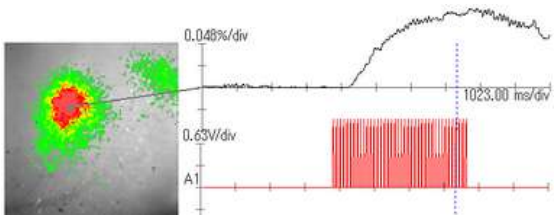
Reference：
Astrocytes modulate baroreflex sensitivity at the level of the nucleus of the solitary tract.
J Neurosci. 2020 Apr 8; 40(15): 3052-3062.

Intrinsic Signal Imaging

MiCAM03 N256 | BV Workbench | THT Mesoscope | LEX9

Intrinsic optical signal imaging (IOSI) is an optical technique that does not require fluorescent probes. It detects hemodynamic changes associated with neural activity, such as blood flow, blood oxygenation (i.e., levels of oxygenated and deoxygenated hemoglobin), and blood volume, through the reflection and absorption of light.

Reference：
In vivo imaging and analysis of cerebrovascular hemodynamic responses and tissue oxygenation in the mouse brain.
Nat Protoc. 2018 Jun;13(6):1377-1402.



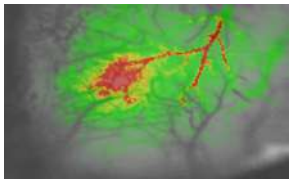
Intrinsic signal responses to whisker stimulation in the mouse in vivo brain

Flavoprotein Fluorescence Imaging

MiCAM03 N256 | BV Workbench | THT Mesoscope | LEX9

Flavoprotein fluorescence imaging is a technique for visualizing neural activity by detecting the autofluorescence emitted when intracellular flavoproteins are oxidized. Flavoproteins emit green autofluorescence when excited with blue light at approximately 450 nm.

Reference：
In vivo transcranial flavoprotein autofluorescence imaging of tonotopic map reorganization in the mouse auditory cortex with impaired auditory periphery.
Hear Res. 2019 Jun;377:208-223.

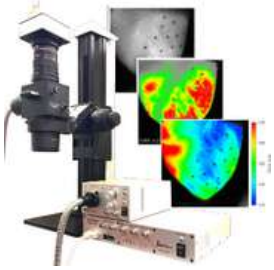

Example of flavoprotein fluorescence imaging

Wide-Field Imaging

THT Mesoscope | LEX9

This is a microscopy method that enables clear observations at relatively low magnification (approximately 0.19× to 6.3×). It is used to map membrane potential activity and calcium responses throughout the brain and heart.

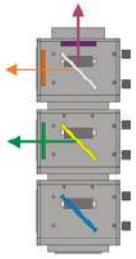
The THT Mesoscope's large-diameter lens and high numerical aperture design enable it to visualize low-intensity, wide-area responses that were previously overlooked, and also enable acquisition with a high signal-to-noise ratio.



Multi-wavelength imaging

THT Mesoscope | LEX9 | ESTM 10A

This is an optical method for simultaneously measuring multiple physiological parameters from a single field of view within the same area. Specifically, in cardiac tissue, membrane potential (V_m), intracellular calcium (Ca^{2+}) responses, and NADH autofluorescence, which serves as an indicator of metabolism, are captured simultaneously at three wavelengths to examine the electrical, calcium, and metabolic states.



Optogenetic Experiments

LEX9 | ESTM 10A

This is a technique where light-responsive proteins are expressed in living neurons or cardiomyocytes, and specific cells are then excited or inhibited by exposure to light of a defined wavelength. LEX9 are used for light stimulation.

Electrophysiology

ESTM 10A | BV ISO100

Our products can be used not only for optical mapping but also for electrophysiology experiments, such as patch-clamp recordings. When combined with the electrical stimulator ESTM10A and the stimulus isolator BVISO100, this setup can be applied to everything from student physiology training to academic research.

The World Standard System for Optical Mapping

High-speed CMOS mapping system

MiCAM03-N256

MiCAM03 N256

This optical mapping system can rapidly capture and visualize subtle changes in fluorescence intensity within biological samples stained with fluorescent probes, such as voltage-sensitive and calcium dyes.

Spatial resolution
256x256 - 32x32 pixels

Maximum frame rate
1,923fps in high resolution mode (256x256 pixels)
20,000fps in high-speed mode (32x32 pixels)

Number of cameras
2

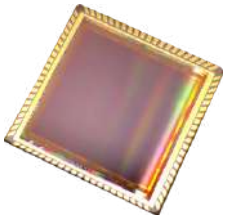
Image sensor size
17.6mm x 17.6mm

Signal/Noise Ratio
> 71dB

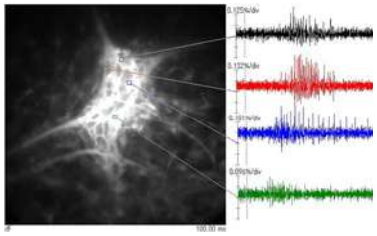
Features

Accelerating and streamlining research

High-speed, high signal-to-noise (S/N) data acquisition makes it possible to easily and clearly capture subtle biological signals and rapid biological phenomena that were previously difficult to detect. This eliminates experimental bottlenecks, thereby enabling more efficient research.



A CMOS image sensor developed to achieve high speed and a high S/N ratio



Membrane potential imaging data of enteric ganglia

Long-term data acquisition

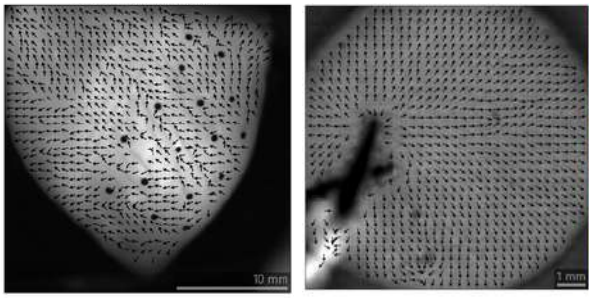
High-speed data transfer via USB 3.0 and direct writing to SSD enable extended continuous recording from tens of minutes to several hours, thereby contributing to the observation of biological phenomena over longer time scales.

Number of pixels	Frame rate	Recordable time
256x256	500 fps	228 min
	1,000 fps	114 min
	1,923 fps	62 min

Maximum recording time
when saving directly to a 1TB SSD

Support for a wide range of biological samples

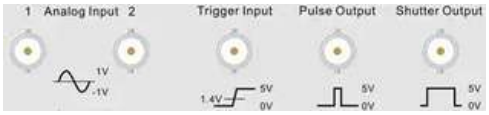
The well-depth switching function allows imaging a wide range of samples, from highly fluorescent tissues to small cultured cells, under optimal conditions.



Both the isolated heart (left) with high fluorescence intensity and cultured cardiomyocytes (right) with low fluorescence intensity can be imaged with a high S/N ratio, enabling the depiction of conduction velocity vectors.

Easy synchronization with external devices

The system can be easily synchronized with multiple peripheral devices (e.g., LED light sources, stimulators) with high synchronization accuracy, thereby supporting reliable experimental data acquisition.



Equipped with 2 channels for stimulus pulse output and light source control output

Fully synchronized imaging with two camera heads

It is also possible to perform simultaneous measurement of two fluorescence wavelengths and multi-angle imaging.

Simply connect additional camera heads to the processor

Application

- Membrane potential (voltage sensitive dye) imaging
- Calcium imaging for in vivo brain/cardiomyocytes
- Imaging with FRET, GCaMP, GEVI
- Intrinsic optical signal imaging based on hemoglobin and flavoprotein autofluorescence
- Ratiometric fluorescence imaging with 2 camera heads
- Panoramic imaging with 2 camera heads
- Other high speed imaging

Main specifications

Name	High-Speed Optical Mapping System MiCAM03-N256
Model	MC03-N256
Image Sensor	Original CMOS
Active Pixels (H x V)	256 x 256
Active Image Area (H x V)	17.6mm x 17.6mm
Pixels Size (H x V)	69μm x 69μm
Shutter Mode	Global shutter
Maximum Frame Rate and Pixels (for 1 camera)	1,923fps (256x256px) 3,125fps (192x192px) 5,556fps (128x128px) 20,000fps (32x 32px)
Quantum Efficiency	55%@550nm / 50%@600nm
Well-Depth	3,000,000e- / 600,000e- (switching)
Dark Noise	500e- / 130e-
Lens mount	Original M42 mount (Option: C or F mount)
Standard System Configuration	Camera Head (1-2), Processor, PC, Monitor, Acquisition software, Analysis Software
Supported OS	Windows 10/11 64bit
Dimension (WxHxD)	80mm x 80mm x 50mm
Weight	474g

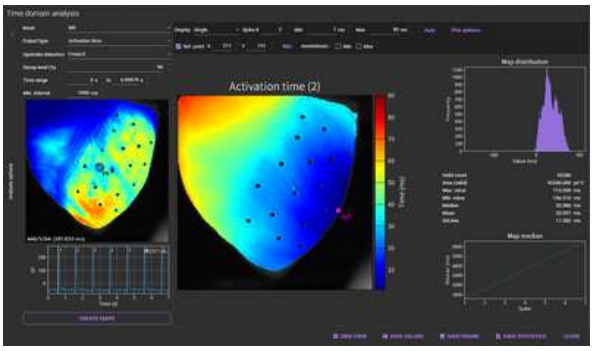
Quickly Create Various Maps for Scientific Papers

Analysis Software for Optical Mapping

BV Workbench

BV Workbench is the latest version of the data analysis software developed for optical mapping and calcium imaging of the brain and heart.

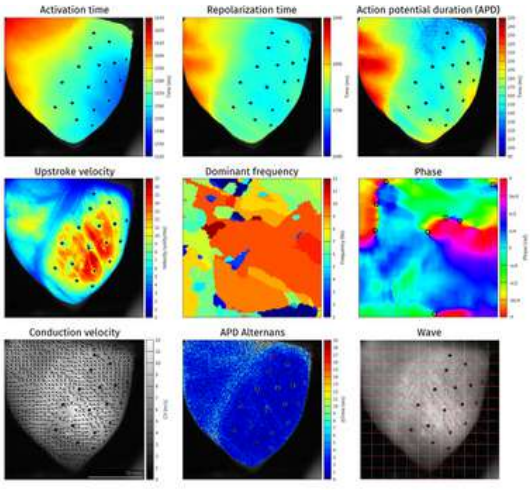
In addition to data files acquired with MiCAM03, the software also allows the import of 16-bit TIFF files obtained with third-party camera systems.



- **Easily create various map images**
- **Automatic peak detection and optimal value setting**
- **Intuitive and easy operation, reducing analysis time**
- **Export high-resolution images for scientific papers and presentations**
- **Can also import 16-bit TIFF files from other companies' systems**
- **Technical support via email**

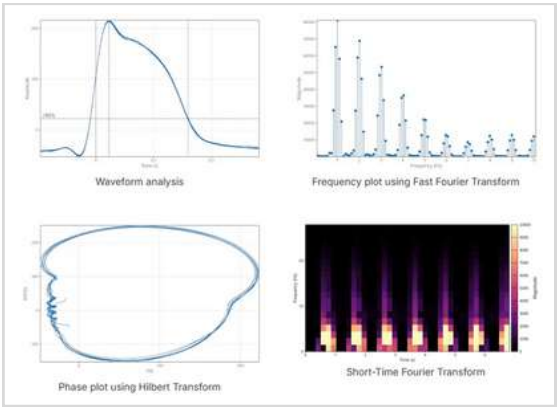
Map creation feature

- Activation (half rise) map
- Repolarization (half decay) map
- APD map / CaTD map
- Phase map / Phase singularity / PS trajectory
- Conduction velocity map
- Dominant frequency map
- Amplitude alternans map
- APD alternans map
- Maximum upstroke velocity map
- Diastolic interval map
- Decay τ (tau) map
- Rise time map
- Peak time map
- Peak amplitude map
- Peak to repolarization (half decay) time map
- Peak interval map



Waveform analysis function

- Peak amplitude
- Rise time
- Upstroke velocity
- xx% decay time
- Decay constant
- APDxx
- Diastolic interval
- Peak interval
- Alternans
- APDxx Alternans



Main specifications

Input data	RAW / TIFF / GSD
Output data	PNG / SVG / TIFF / CSV / AVI
Supported OS	Windows 10 / 11 (64 bit)
Recommended Hardware	- Any Intel or AMD x86-64 processor with four logical cores and AVX2 instruction set - support. - 32 GB of RAM - NVMe Solid-state drive - NVIDIA GPU

Detecting Low Light with a Wide Field of View

Fluorescence Mesoscope

THT Mesoscope

THT Mesoscope

This system was developed for detecting low-light fluorescence emitted from biological samples at low magnification.

This mesoscope has a simple optical path consisting of two large-diameter objective lenses and a custom-made large fluorescent filter.

- **Wide-field imaging possible**
- **High N.A value with low magnification**
- **Simple structure specialized for imaging**
- **The optical axis can be tilted and rotated: no need to tilt the animal sample**
- **Multifunction: used as a fluorescence beam splitter**
- **Easy Removal of Fluorescent Filter**

Examples

Single wavelength imaging

Epi- and sile-illumination
Single wavelength imaging

Extension arm

Epi-illumination/
dual wavelength imaging

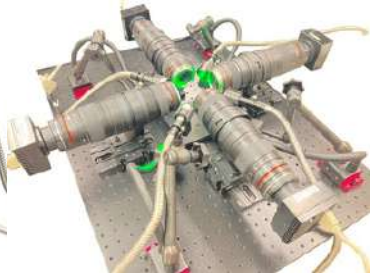
45 degree tilt

90 degree tilt

Evident BX51WI base
includes manual XY table from
Luigs&Neumann, Germany

Inverted

For langendorff-perfused heart
Horizontal view



For langendorff-perfused heart
Panoramic imaging (4 directions)

Main specifications

Optical system	Tandem lens optical system used for camera only
Objective lens	PLAN 0.3x / PLAN APO 0.63x / PLAN APO 1x / PLAN APO 1.6x / PLAN APO 2x / PLAN APO 5x
Projection lens	PLAN APO 0.63x / PLAN APO 1x / PLAN APO 1.6x / PLAN APO 2x / 135mm/2.0 lens / 85mm/1.4 lens 50mm/0.95 lens

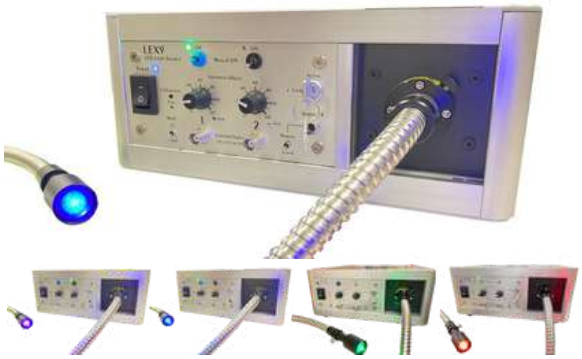
LED System for Clarifying Fast Biological Phenomena

Multi-LED Light System

LEX9

LEX9

Two different LED units can be installed inside the system. The system allows you to switch one or two wavelengths on or off manually, or to alternate two wavelengths in frame synchronization with a high-speed camera system. This makes it ideal as an excitation light source for high-speed fluorescence imaging.



Higher power
Improve S/N ratios

Dual wavelength excitation
Two wavelengths can be acquired with one camera

Highly stable
Minimize unnecessary noise when imaging biological signals

Fast switching
For high-speed imaging and pulsed light stimulation

Application

Excitation light source for fluorescence imaging

- GCaMP imaging
  (Hemodynamic correction using 405nm/460nm)
- Calcium imaging
- Voltage sensitive dye imaging
- Intrinsic optical signal (IOS) imaging

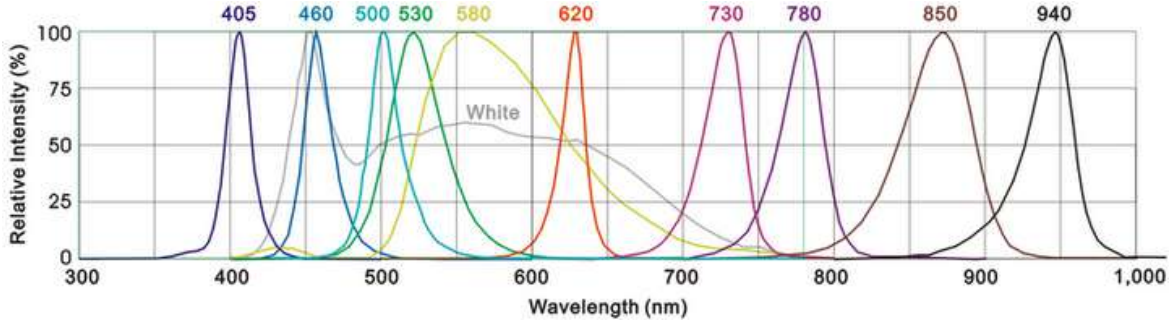
Light stimulation for Optogenetics

- Channelrhodopsin (ChR2)
- Halorhodopsin (NpHR)
- Arch and Chrimson, etc.

Other fluorescence imaging

- Experiments requiring bright and stable light
- Experiments requiring wide area illumination

Wavelength characteristics of LED units



Options

Additional LED unit

Light guide + Condensing lens

Light guide holder

Main Specifications

Center wavelength	405nm / 460nm / 530nm / 580nm / 620nm (Option: 500nm / 730nm / 780nm / 875nm / 940nm)
LED intensity at 100% setting	405nm: 407mW/cm2 460nm: 1,833mW/cm2 530nm: 650mW/cm2 630nm: 1,057mW/cm2
Drift of light intensity	< 0.3% (5 sec) < 0.5% (10 min) < 1.0% (100 min)

All the Functions Necessary for Imaging/Electrophysiology

Multifunction Stimulator

ESTM10A

ESTM 10A

This is an all-in-one system with built-in functions often used in biological imaging and electrophysiology experiments, such as stimulus pulse output, acquisition timing control for the camera, LED lighting control, biological signal recording, and digital oscilloscope functionality.

- **Stimulus pulse output** (4ch)
- **Isolator output** (1ch)
- **Camera frame sync signal input/output** (1ch)
- **LED light source signal output** (3ch)
- **Signal recording** (Ana:2ch/Digi:2ch)
- **Digital oscilloscope**

Example of Use

1. As an **electrical isolated simulator**
2. As a **multi-device synchronizer** to perform biological imaging and bioelectrical signal recording in synchronization with camera, light sources, and electrophysiological amplifier
3. As a **timing synchronization device** for performing multi-wavelength excitation fluorescence imaging
4. As a **controller** that connects to a light source or external device driven by TTL signals and turns on/off at any timing.
5. As a **data logger**
6. As an **oscilloscope** to monitor biological signals
7. As a **window discriminator**
   (* Electrophysiology amplifier required separately)

Next-Generation Stimulus Isolator for Artifact Minimization

Stimulus Isolator

BVISO100

BV ISO100

This stimulus isolator offers basic functionality required for electrophysiology experiments, as well as unique features such as convenient automatic calibration and capacitance balancing.

It can be used in a wide range of electrophysiology experiments, including patch-clamp experiments, and in the electrical stimulation of brain slices and cardiac sample

- **Easy switching between voltage-current output**
- **Support for analog/ pulse input**
- **Capacitance balance adjustment to suppress artifacts**
- **Automatic calibration**
- **Real-time monitoring of output voltage/ current**
- **Software included**

Reference video

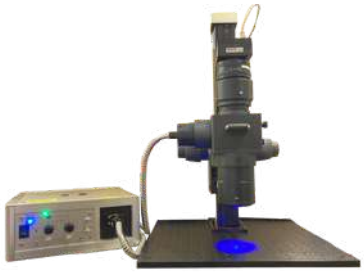
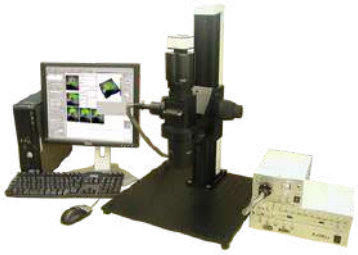
Below are two videos that explain the steps involved in the optical mapping experiment. They can be accessed by scanning the QR codes.

Optical Mapping of Action Potentials and Calcium Transients in the Mouse Heart
Di Lang, Matthew Sulkin, Qing Lou, Igor R. Efimov
J Vis Exp 2011 Sep 13:(55):3275.

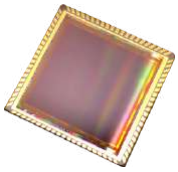
Wide-field Single-photon Optical Recording in Brain Slices Using Voltage-sensitive Dye
Yoko Tominaga, Makiko Taketoshi, Naoko Maeda, Takashi Tominaga
J Vis Exp. 2019 Jun 20:(148).

Solve your problems with a custom-made system

Based on the technical capabilities and development expertise gained from our extensive experience in developing our own products, we also offer special-order products not available on the market, as well as customization of standard products for a variety of purposes. Please feel free to contact us.

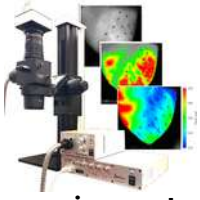




Our Advantages



Custom CMOS image sensors having high speeds, wide dynamic range, and low noise

Our cameras are used to detect both voltage sensitive dye signals and calcium signals at optimal S/N ratios.



Optical mapping system, optics, and software developed based on 27 years of experience

Turnkey systems are ready for immediate use. Custom-made products are also available upon customers requests.

952 scientific research papers have been published using our optical mapping systems

Our systems are used by customers in over 230 universities, research institutes, and companies. 430 units have been installed in the last 27 years.

About Brainvision/SciMedia

Brainvision and SciMedia are dedicated to helping scientists worldwide improve the quality of their research.

We specialize in high-speed imaging systems for biological research applications. Our systems are designed to detect voltage, calcium, and intrinsic signals by providing the optimal combination of high speed, high resolution, and high signal-to-noise ratios.

We have always been committed to providing excellent service worldwide, and we are constantly working to improve our hardware, software, and technical support to help our users.

Please contact us if you have any questions. We look forward to assisting you with your specific research applications.

** Specifications, appearance, and functions may change without notice. * All products featured in this brochure are research use only (RUO) devices and cannot be used for clinical testing or diagnosis. * All products featured in this brochure are made in Japan.