Specifications subject to change.
Available second half 2022

NEUROPIXELS 2.0

Fully-integrated CMOS digital neural probe for small animal recording

Important Information

THE NEUROPIXELS PROBES ARE ONLY INTENDED FOR RESEARCH USE ONLY ("RUO") IN NON-HUMAN SUBJECTS SUCH AS SMALL ANIMALS. * THESE NEUROPIXELS PROBES SHOULD NOT BE USED IN HUMANS AND ARE NOT MANUFACTURED OR APPROVED FOR HUMAN USE. THEY HAVE NO PROVEN HUMAN EFFICACY AND ARE NOT INDICATED FOR HUMAN USE OR ANY FORM OF CLINICAL USE.

Description

The Neuropixels 2.0 neural probe is a CMOS digital integrated microsystems platform. A miniaturized package (compared to the Neuropixels 1.0 probes) and the option of a single shank or multiple shanks will allow for even higher density chronic recording in small animal models.

The probe features 1280 low-impedance TiN[1] recording sites densely tiled along one thin, 10 mm-long, straight shank, or 5120 electrodes divided over 4 shanks. The 384 parallel, configurable, low-noise recording channels integrated in the base enable simultaneous full band recording of hundreds of neurons.

On-chip circuitry for signal conditioning and digitization results in a small and light-weight package allowing the implantation and simultaneous use of multiple probes in close apposition.

Neuropixels probes enable long-term monitoring and dense sampling of single cell activity as well as larger neuron populations in awake and anaesthetized animals.

The probes connect to the custom-made recording system via a miniature and light-weight head stage, which is an essential interface board for reliable power supply, probe configuration, data streaming and system/probe diagnostics. Each head stage can connect two probes simultaneously.

Key Features

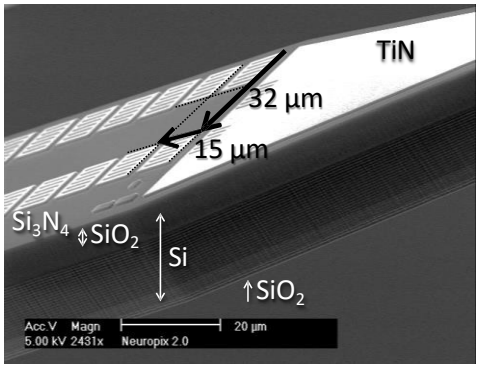
- 1280 or 5120 reliable, low-impedance TiN[1] electrodes
- Dense 2 row linear electrode layout along one 10-mm long single shank or four 10-mm long shanks
- 70 × 24 µm shank cross-section
- Minimal shank bending (≤100 µm)
- 384 parallel, full-band (AP, LFP), low-noise recording channels
- On-chip signal conditioning and digitization
- Channel-independent configuration and reference selection (internal or external)
- Small, flexible and light-weight package (0.12 g)
- Strict process and quality control ensure low performance variability
- Fully characterized and qualified
- Compatible with SpikeGLX and OpenEphys software
- Compatible with the Neuropixels 1.0 cabling and PXIe system

Key Applications

- High-density *in vivo* recording of neural activity in small animal models.
- Recording of large neuron populations from several brain regions in freely moving animals at high spatiotemporal resolution and large volume coverage.

Specifications

Figure 1: SEM image of the shank tip. Indicated are the electrode pitch and exposed materials.



ELECTRODES	
NUMBER	1280 (single shank version) or 5120 (multi shank version)
PATTERN	linear, two rows
PITCH	15 µm (column), 32 µm (row) (see Figure 1)
MATERIAL	Porous TiN[1] (Figure 2)
SIZE	12 × 12 µm
IMPEDANCE	~150 kΩ (at 1 kHz in PBS[2])
SELECTIVITY	Local switch under each electrode

SHANK PROPERTIES AND MATERIALS	
NUMBER	1 (single shank version) or 4 (multi shank version)
SHANK PITCH	250 µm
WIDTH	70 µm
LENGTH	10 mm
THICKNESS	24 µm
BENDING	≤100 µm (base to tip)
TIP LENGTH	175 µm
TIP SHAPE	Chisel
TIP ANGLE	~20°
FRONTSIDE MATERIAL	Silicon nitride (Si_3N_4) (Figure 1)
BACKSIDE MATERIAL	Silicon dioxide (SiO_2)
SIDEWALL MATERIALS	Silicon (Si), silicon dioxide (SiO_2)

RECORDING CHANNELS AND DIGITAL INTERFACE	
NUMBER	384 (full-band)
BANDWIDTH	0.5 Hz-10 kHz
AP INPUT-REFERRED NOISE	8.2 μV_{rms} (typical[3])
LFP INPUT-REFERRED NOISE	10.6 μV_{rms} (typical)
SAMPLING FREQUENCY	30 kHz
GAIN	82.9 +/- 0.7
CROSSTALK	0.35% (single shank) or 1.51% (multi shank) (at 1 kHz; typical)
INPUT VOLTAGE RANGE	12.5 mV_{pp}
ADC RESOLUTION	14 bits
DATA RATE	161.28 Mb/s
POWER CONSUMPTION	~37.5 mW (in recording mode; typical)
SHANK HEATING	<1°C (in the brain)

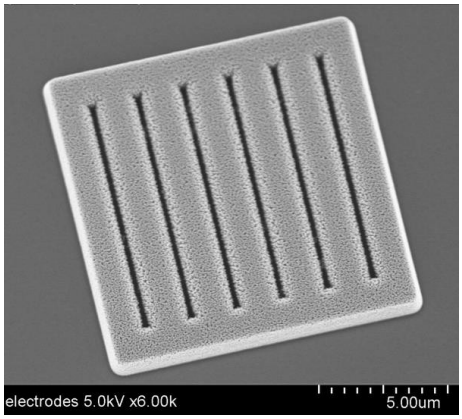


Figure 2: SEM image of a 12 × 12 µm TiN electrode.

[1] Titanium Nitride Electrode, US9384990 B2

[2] Phosphate buffered saline

[3] Process corner

REFERENCE SELECTION

INPUTS	Four internal recording electrodes per shank
	Large tip electrode on each shank (see Figure 1)
	External input on the probe package (see Figure 3)

PACKAGE DESCRIPTION

WIDTH AT PROBE BASE (W1)	3.5 mm
WIDTH AT SMD[4] BASE (W2)	6.9 mm
WIDTH OF SILICON SPACER (W3)	2.0 mm
WIDTH OF FLEX (W4)	4.0 mm
LENGTH OF PROBE BASE (L1)	8.6 mm
LENGTH OF SMD BASE (L2)	7.5 mm
LENGTH OF SILICON SPACER (L3)	7.8 mm
LENGTH OF FLEX (L4)	43.5 mm
THICKNESS AT PROBE BASE	~1.2mm (w/ Sispacer)
THICKNESS OF FLEX	80 µm
EXTERNAL REFERENCE INPUT	REF (multiple pads along flex)
GROUND INPUT	GND (multiple pads along flex)
BLACK EPOXY	EPO-TEK / H70E
CONFORMAL COATING OF SMD	ELPEGUARD / SL1307FLZ-T
WEIGHT	192 mg

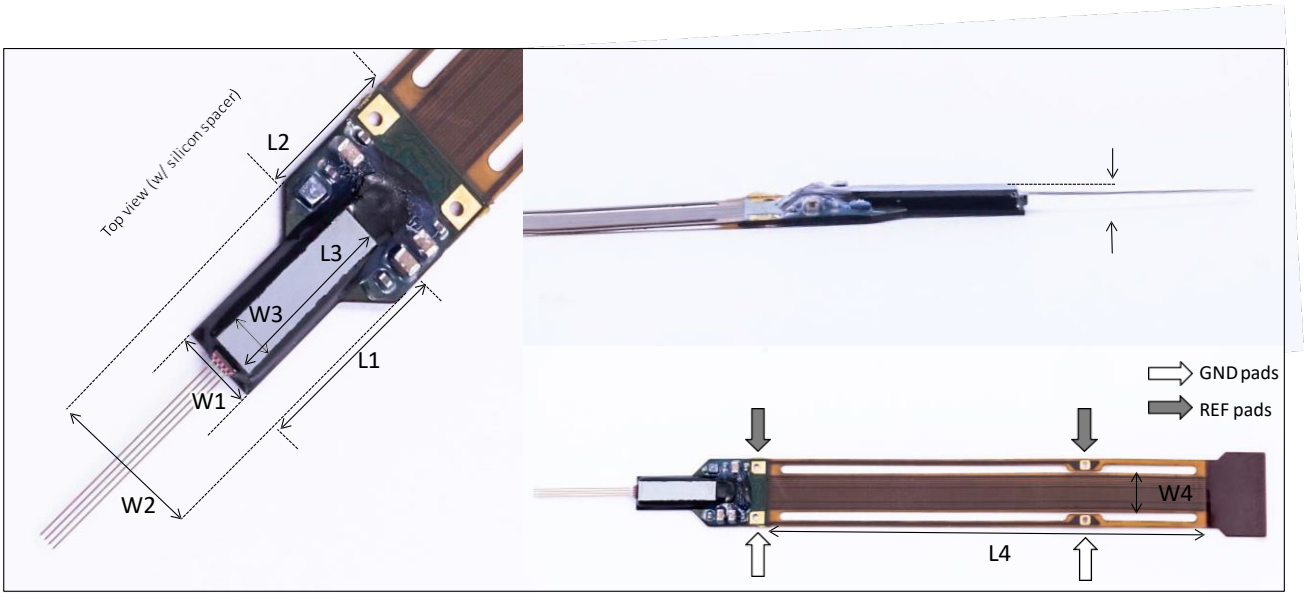


Figure 3: Dimensions of the different probe packages and locations of REF/GND input pads.

[4] Surface-mount devices: Biasing resistors, decoupling capacitors, EEPROM with probe ID, low-noise reference supply IC

HEAD STAGE

SIZE	10× 14.3 mm
WEIGHT	0.72 g (estimation)
ZIF CONNECTOR	2 x 27-pin
CABLE CONNECTOR	4-pin (Omnetics)
LED INDICATOR	One red LED
SOLDER PADS	LESION and GND
B2B CONNECTOR	BM23FR0.8-10DP-0.35V
EEPROM	Contains S/N and P/N

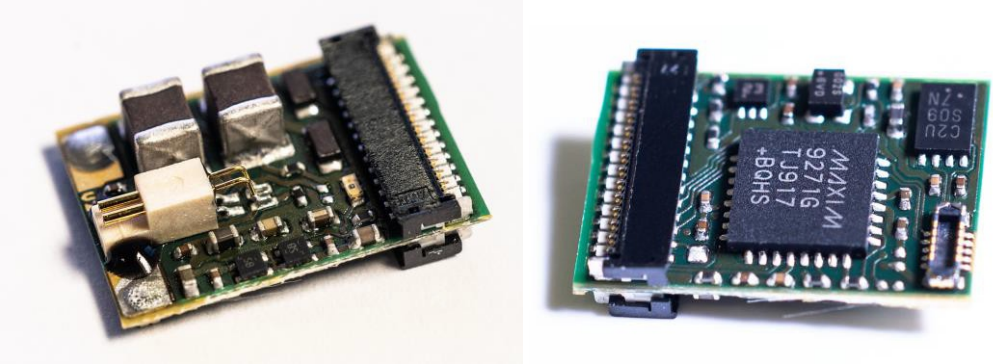


Figure 4: Head stage for Neuropixels 2.0 probes. One head stage can connect to 2 probes.

About Neuropixels

The Neuropixels 2.0 neural probe is an advanced silicon CMOS digital integrated microsystem and a tool for neuroscience research. It was developed through a collaboration funded by Howard Hughes Medical Institute (HHMI), University college London (UCL), The Flemish Institute for Biotechnology (VIB), the Catholic University of Leuven (KUL), The Norwegian University for Science and Technology (NTNU, and the Champalimaud Centre for the Unknown. Probes were designed, developed and fabricated at imec, Leuven, Belgium in collaboration with Howard Hughes Medical Institute (HHMI), University college London (UCL), The Flemish Institute for Biotechnology (VIB), the Catholic University of Leuven (KUL), The Norwegian University for Science and Technology (NTNU, and the Champalimaud Centre for the Unknown.

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*Small animals such as rodents and non-human primates