NEUROPIXELS 1.0

Fully-integrated CMOS digital neural probe

Important Information
The Neuropixels probes are 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. The Neuropixels probes are provided and deliverded for use only under the imec general terms and conditions of sale of Neuropixels 1.0 probes ("GTC"). [The GTC is available for download on www.neuropixels.org]

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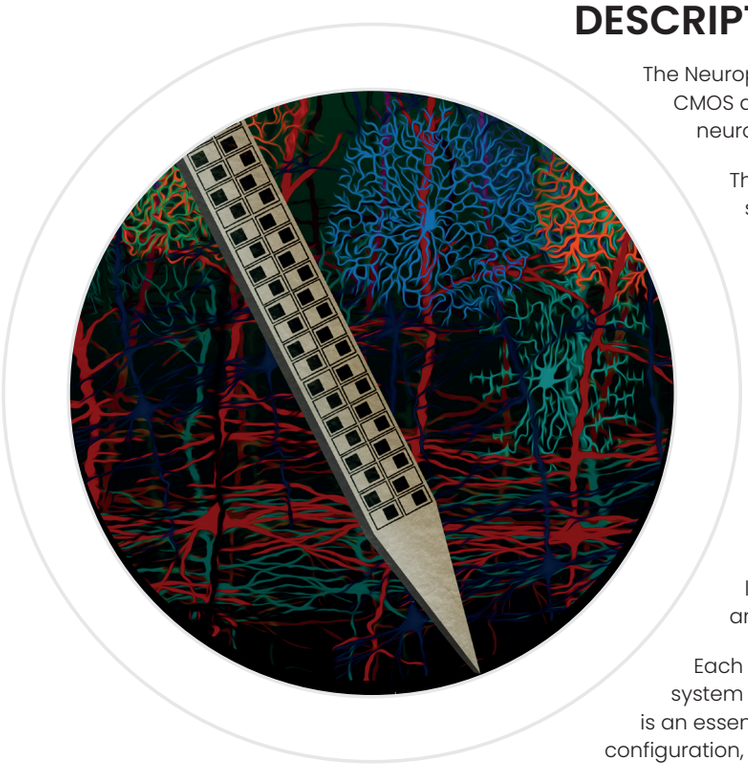
DESCRIPTION



The Neuropixels[1] 1.0 neural probe is the most advanced silicon CMOS digital integrated microsystem and tool for *in vivo* neuroscience research in small animals*.

The probes feature 960 low-impedance TiN recording sites densely tiled along a thin, 10 mm-long, straight shank. The 384 parallel, configurable, low-noise recording channels integrated in the base enable simultaneous, dual-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.

Each probe connects to a 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.

KEY FEATURES

- 960 reliable, low-impedance TiN electrodes
- Dense checkerboard electrode layout along a 10-mm long shank
- Small 70 x 24 µm shank cross-section
- Minimal shank bending (≤100 µm)
- 384 parallel, dual-band (AP[2], LFP[3]), 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 (0.4 g)
- Strict process and quality control ensure low performance variability
- Fully characterized and qualified
- Compatible with SpikeGLX and OpenEphys software
- Small and lightweight head stage (0.9 g)

1 JJ Jun et al., Nature 2017, 551, 232–236
2 Action potentials
3 Local field potentials

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KEY APPLICATIONS

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

KEY SPECIFICATIONS

ELECTRODES

NUMBER	960
PATTERN	Checkerboard
PITCH	16 µm (column), 20 µm (row) (see Figure 1)
MATERIAL	Porous TiN[4] (Figure 2)
SIZE	12 x 12 µm
IMPEDANCE	~150 kΩ (at 1 kHz in PBS[5])
SELECTIVITY	Local switch under each electrode

SHANK PROPERTIES AND MATERIALS

NUMBER	1
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 (dual-band)
AP BANDWIDTH	0.3-10 kHz
LFP BANDWIDTH	0.5-500 Hz
AP INPUT-REFERRED NOISE	5.9 μV_{rms} (typical[6])
LFP INPUT-REFERRED NOISE	9.2 μV_{rms} (typical)
AP SAMPLING FREQUENCY	30 kHz
LFP SAMPLING FREQUENCY	2.5 kHz
DIFFERENTIAL GAINS	50-3000 (8 values)
CROSSTALK	≤0.13% (at 1 kHz; typical)
INPUT VOLTAGE RANGE	±5 mV_{pp}
ADC RESOLUTION	10 bits
DATA RATE	163.8 Mb/s
POWER CONSUMPTION	~15 mW (in recording mode; typical)
SHANK HEATING	<1°C (in the brain)

REFERENCE SELECTION

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

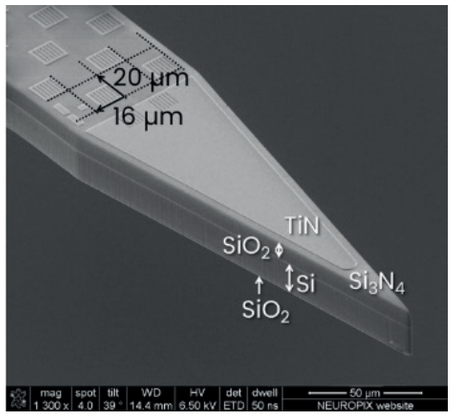

Figure 1: SEM image of the shank tip. Indicated are the electrode pitch and exposed materials.

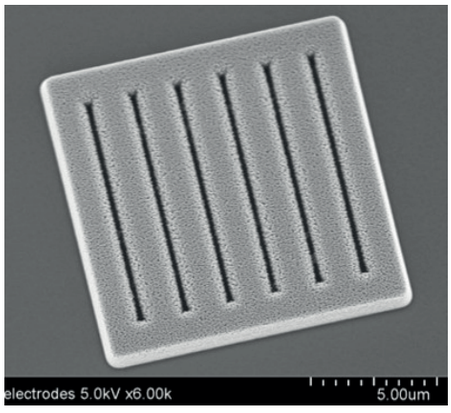

Figure 2: SEM image of a 12 x 12 µm TiN electrode.

4 Titanium Nitride Electrode, US9384990 B2
5 Phosphate buffered saline
6 Process corner

PACKAGE DESCRIPTION

WIDTH AT PROBE BASE (W1)	6.2 mm
WIDTH AT SMD[7] BASE (W2)	7.2 mm
WIDTH OF SILICON SPACER (W3)	3.9 mm
WIDTH OF METAL CAP (W3')	4.8 mm
WIDTH OF FLEX (W4)	4.3 mm
LENGTH OF PROBE BASE (L1)	10.7 mm
LENGTH OF SMD[7] BASE (L2)	12.2 mm
LENGTH OF SILICON SPACER (L3)	8.5 mm
LENGTH OF METAL CAP (L3')	7.3 mm
LENGTH OF FLEX (L4)	39.5 mm
THICKNESS AT PROBE BASE	~1.2 mm (w/ Si spacer) ~1.8 mm (w/ metal cap)
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[7]	ELPEGUARD / SL 1307 FLZ-T
WEIGHT	400 mg (w/ Si spacer) 440 mg (w/ metal cap)

HEADSTAGE

SIZE	15 x 16 mm
WEIGHT	0.9 g
ZIF CONNECTOR	45-pin
CABLE CONNECTOR	4-pin (Omnetics)
LED INDICATOR	One red LED
MECHANICAL FIXTURES	Two mounting holes of 1 mm Ø

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

ORDERING INFORMATION

PART NUMBER	DESCRIPTION
PRB_1_4_0480_1	Box of 5 Neuropixels 1.0 probes with silicon spacer
PRB_1_4_0480_1_C	Box of 5 Neuropixels 1.0 probes with metal cap
DPRB_1_4_0480_1	Box of 6 Neuropixels 1.0 dummy probes with silicon spacer
DPRB_1_4_0480_1_C	Box of 6 Neuropixels 1.0 dummy probes with metal cap
HS_1000	Head stage for Neuropixels 1.0 probes

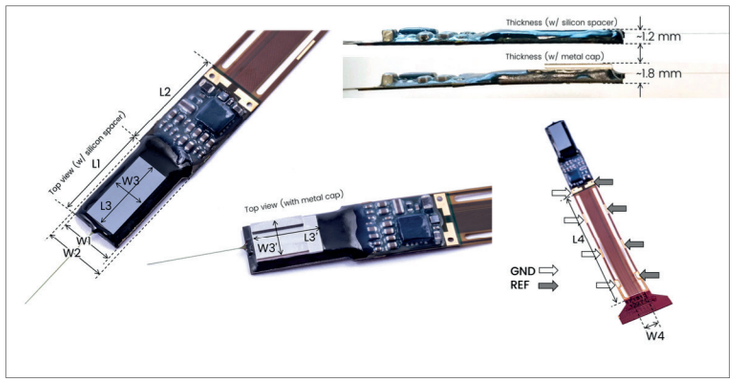

Figure 3: Dimensions of the different probe packages and locations of REF/GND input pads.

About Neuropixels
The Neuropixels 1.0 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), Wellcome Trust, Gatsby Charitable Foundation and Allen Institute for Brain Science. Probes were designed, developed and fabricated at imec, Leuven, Belgium in collaboration with HHMI Janelia Research Campus, Allen Institute for Brain Science and University College London.

* Small animals like rodents and non-human primates