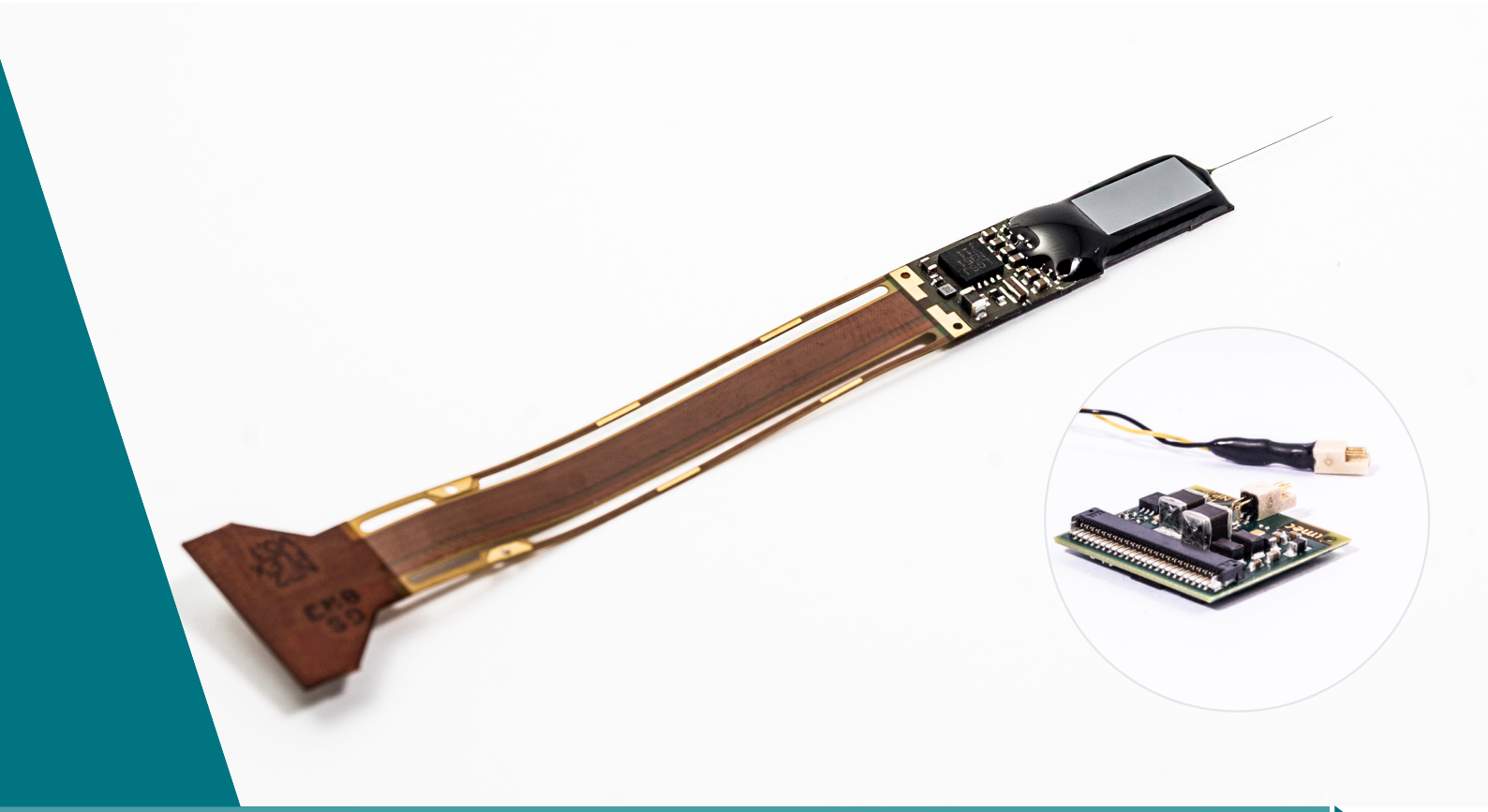
www.neuropixels.org



NEUROPIXELS 1.0
High resolution fully integrated silicon neural probe

Key Features

- 960 reliable, low-impedance TiN electrodes
- Dense staggered electrode layout along a 10-mm long shank
- Small 70 x 24 µm shank cross-section
- Maximal shank bending ≤100 µm
- 384 parallel, dual-band (AP[1], LFP[2]), low-noise recording channels
- On-chip amplification, signal conditioning and digitization
- Channel-independent configuration and reference selection (internal or external)
- Small, flexible and light-weight package (0.4 g)
- Systematic quality control process to ensure low variability in performance
- Fully characterized and qualified
- Compatible with SpikeGLX and Open Ephys software
- Small and lightweight headstage (0.9 g)

1 Action potentials
2 Local field potentials

Description

The Neuropixels[3] 1.0 neural probe is a 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 proximity. 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 headstage, which is an essential interface board for reliable power supply, probe configuration, data streaming and system/probe diagnostics.

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.

Ordering information

ORDER CODE	DESCRIPTION
PRB_1_4_0480_1_C	Box of 5 Neuropixels 1.0 probes with metal cap
PRB_1_4_0480_1	Box of 5 Neuropixels 1.0 probes with silicon spacer
DPRB_1_4_0480_1_C	Box of 6 Neuropixels 1.0 dummy probes with metal cap
DPRB_1_4_0480_1	Box of 6 Neuropixels 1.0 dummy probes with silicon spacer
HS_1000	Headstage for Neuropixels 1.0 probes
HOLDER_1000_C	Neuropixels 1.0 metal cap probe holder pair

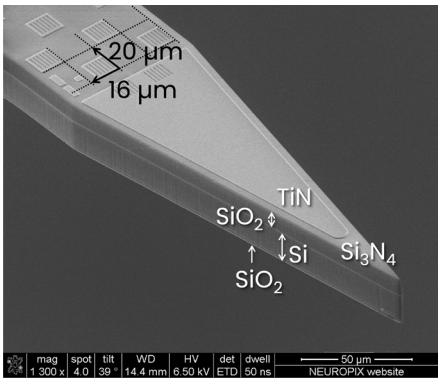


Figure 1: SEM image of the shank tip. Indicated are the electrode pitch and exposed materials.

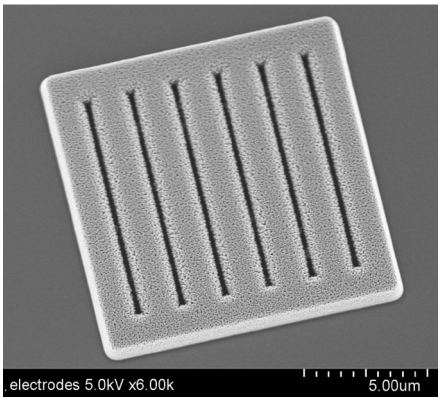


Figure 2: SEM image of a 12 x 12 µm TiN electrode.

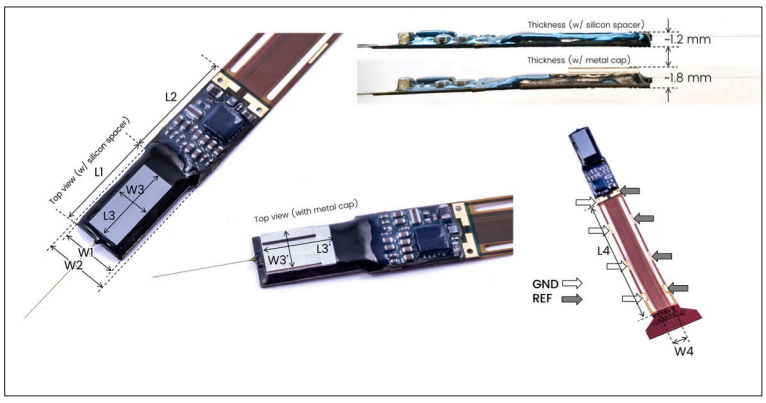


Figure 3: Dimensions of the different probe packages and locations of REF/GND input pads.

3 JJ Jun et al., Nature 2017, 551, 232–236

ELECTRODES

NUMBER	960
PATTERN	Staggered
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 (Figure 1)
	External input on the probe package (Figure 3)

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 (with Si spacer) ~1.8 mm (with 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 (with Si spacer) 440 mg (with 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
CONFORMAL COATING OF SMD[7]	ELPEGUARD / SL 1307 FLZ-T

METAL CAP HOLDER

LENGTH	17.8 cm
DIAMETER	6.25 mm
MATERIAL	Aluminium 6061

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

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