



## NEUROPIXELS 2.0

High resolution fully integrated silicon neural probe for small animal recording

### Key Features

- 1280 or 5120 reliable, low-impedance TiN<sup>1</sup> electrodes
- Dense 2 row linear electrode layout along one 10-mm long single shank or four 10-mm long shanks
- 70 x 24 μm shank cross-section
- Maximal shank bending ≤200 μm
- 384 parallel, full-band (AP<sup>2</sup>, LFP<sup>3</sup>), low-noise recording channels
- On-chip amplification, signal conditioning and digitization
- Channel-independent reference selection (internal or external)
- Small, flexible and light-weight package (0.16-0.18 g)
- Systematic quality control process to ensure low variability in performance
- Fully characterized and qualified
- Compatible with SpikeGLX and Open Ephys software
- Compatible with the Neuropixels 1.0 cabling and PXIe system or OneBox

<sup>1</sup> Titanium Nitride Electrode, US9384990 B2

<sup>2</sup> Action potentials

<sup>3</sup> Local field potentials

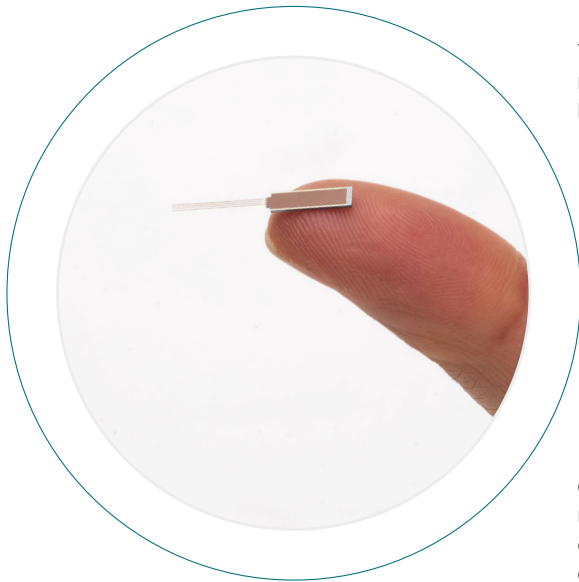
#### Important Information

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 delivered for use only under the imec general terms and conditions of sale of Neuropixels probes ("GTC"). [The GTC is available for download on [www.neuropixels.org](http://www.neuropixels.org)]

## Description

The Neuropixels<sup>4</sup> 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 recording sites densely tiled along one thin, 10 mm-long, straight shank, or 5120 electrodes divided over 4 shanks. The 384 parallel 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 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. The probes connect to the 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. Each headstage can connect two probes simultaneously. The probes are compatible with the Neuropixels 1.0 cables, PXIe based Card and Control System and OneBox, and are supported by the SpikeGLX and Open Ephys software.



## 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.

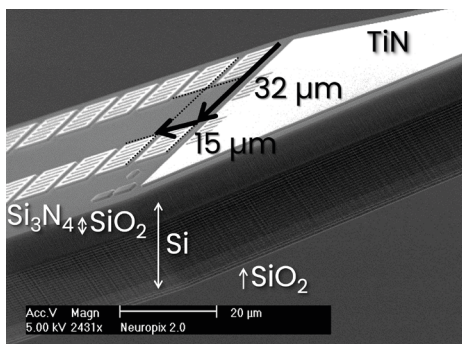


Figure 1: SEM image of the shank tip. Indicated are the electrode pitch and exposed materials.

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

## Ordering information



| ORDER CODE    | DESCRIPTION   |
|---------------|---|
| NP2013        | Box of 5 Neuropixels 2.0 multishank probes                  |
| NP2014        | Box of 5 Neuropixels 2.0 multishank probes with cap         |
| DNP2013       | Box of 6 Neuropixels 2.0 dummy multishank probes            |
| DNP2014       | Box of 6 Neuropixels 2.0 dummy multishank probes with cap   |
| NP2003        | Box of 5 Neuropixels 2.0 single shank probes                |
| NP2004        | Box of 5 Neuropixels 2.0 single shank probes with cap       |
| DNP2003       | Box of 6 Neuropixels 2.0 dummy single shank probes          |
| DNP2004       | Box of 6 Neuropixels 2.0 dummy single shank probes with cap |
| HS_2010       | Neuropixels 2.0 headstage                                   |
| HOLDER_2000_C | Neuropixels 2.0 metal cap probe holder pair                 |

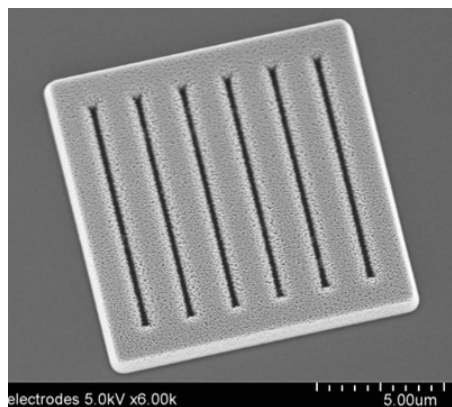


Figure 2: SEM image of a 12 x 12 μm TiN electrode.

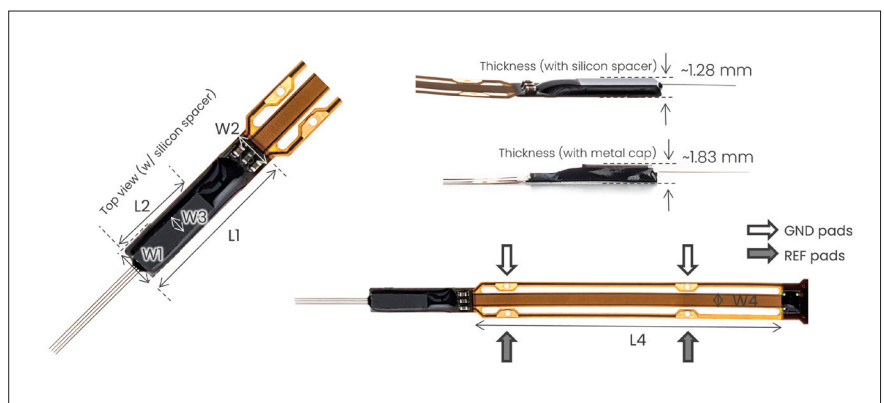


Figure 3: Dimensions of the different probe packages and locations of REF/GND input pads.

## ELECTRODES

|             |  |
|-------------|--|
| NUMBER      | 1280 (single shank version) or 5120 (multi shank version)    |
| PATTERN     | linear, two rows   |
| PITCH       | 15 $\mu\text{m}$ (column), 32 $\mu\text{m}$ (row) (Figure 1) |
| MATERIAL    | Porous TiN <sup>5</sup> (Figure 2)                           |
| SIZE        | 12 x 12 $\mu\text{m}$  |
| IMPEDANCE   | ~150 k $\Omega$ (at 1 kHz in PBS <sup>5</sup> )              |
| SELECTIVITY | Local switch under each electrode                            |

## SHANK PROPERTIES AND MATERIALS

|                    |  |
|--------------------|--|
| NUMBER             | 1 (single shank version) or 4 (multi shank version)    |
| SHANK PITCH        | 250 $\mu\text{m}$                                      |
| WIDTH              | 70 $\mu\text{m}$                                       |
| LENGTH             | 10 mm  |
| THICKNESS          | 24 $\mu\text{m}$                                       |
| BENDING            | $\leq 200 \mu\text{m}$ (base to tip)                   |
| TIP LENGTH         | 175 $\mu\text{m}$                                      |
| TIP SHAPE          | Chisel   |
| TIP ANGLE          | ~20°   |
| FRONTSIDE MATERIAL | Silicon nitride ( $\text{Si}_3\text{N}_4$ ) (Figure 1) |
| BACKSIDE MATERIAL  | Silicon dioxide ( $\text{SiO}_2$ )                     |
| SIDEWALL MATERIALS | Silicon (Si), silicon dioxide ( $\text{SiO}_2$ )       |

## RECORDING CHANNELS AND DIGITAL INTERFACE

|                          |   |
|--------------------------|---|
| NUMBER                   | 384 (full-band)   |
| BANDWIDTH                | 0.5 Hz – 10 kHz   |
| AP INPUT-REFERRED NOISE  | ~6.8 $\mu\text{V}_{\text{rms}}$ (typical <sup>6</sup> )         |
| LFP INPUT-REFERRED NOISE | ~5 $\mu\text{V}_{\text{rms}}$ (typical)                         |
| SAMPLING FREQUENCY       | 30 kHz  |
| GAIN                     | 100   |
| CROSSTALK                | 0.35% (single shank) or 1.51% (multi shank) (at 1 kHz; typical) |
| INPUT VOLTAGE RANGE      | 10 mVpp   |
| ADC RESOLUTION           | 12 bits   |
| DATA RATE                | 144 Mb/s  |
| POWER CONSUMPTION        | ~22 mW (in recording mode; typical)                             |
| SHANK HEATING            | <1°C (in the brain)   |

## REFERENCE SELECTION

|        |  |
|--------|--|
| INPUTS | Large tip electrode on each shank (Figure 1)<br>External reference input on the probe package (Figure 3) |
|--------|--|

<sup>5</sup> Phosphate buffered saline  
<sup>6</sup> Process corner

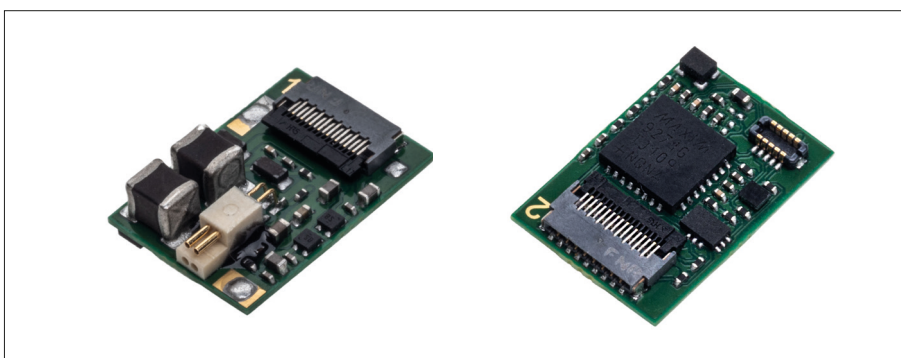


Figure 4: Headstage for Neuropixels 2.0 probe. One headstage can connect to 2 probes.

## PACKAGE DESCRIPTION

|  |  |
|--|--|
| WIDTH AT PROBE BASE (W1)                     | 3.5 mm   |
| WIDTH AT SMD <sup>7</sup> BASE (W2)          | 3.5 mm   |
| WIDTH OF SILICON SPACER (W3)                 | 2.0 mm   |
| WIDTH OF METAL CAP (W3')                     | 1.8 mm   |
| WIDTH OF FLEX (W4)                           | 2.0 mm   |
| LENGTH OF PROBE + BASE SMD <sup>7</sup> (L1) | 14 mm  |
| LENGTH OF SILICON SPACER (L3)                | 7.8 mm   |
| LENGTH OF METAL CAP (L3')                    | 8.0 mm   |
| LENGTH OF FLEX (L4)                          | 42 mm  |
| THICKNESS AT PROBE BASE                      | ~1.28 mm (with Si spacer)<br>~1.83 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 <sup>7</sup>        | ELPEGUARD / SL 1307 FLZ-T                              |
| WEIGHT                                       | ~163 mg (with Si spacer)<br>~183 mg (with metal cap)   |

## HEADSTAGE

|                                       |                           |
|---------------------------------------|---------------------------|
| SIZE                                  | 10 mm x 14 mm x 3.7 mm    |
| WEIGHT                                | 600 mg                    |
| ZIF CONNECTOR                         | 2 x 17-pin                |
| SOLDER PADS                           | GND (ELEC_TIP, CAL_SIG)   |
| CABLE CONNECTOR                       | 4-pin (Omnetics)          |
| CONFORMAL COATING OF SMD <sup>7</sup> | ELPEGUARD / SL 1307 FLZ-T |

## METAL CAP HOLDER

|          |                |
|----------|----------------|
| LENGTH   | 7.5 cm         |
| DIAMETER | 4 mm           |
| MATERIAL | Aluminium 6061 |

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

### 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 like rodents and non-human primates