HIGH-DENSITY NEURAL RECORDINGS WITH NEUROPIXEL PROBES

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Figure 1. Recording from >3000 electrode sites simultaneously with 8 neuropixel probes in awake mice (courtesy of Dr. Nick Steinmetz).

Introduction

- Ideal experiment to study neuronal processing in the brain would involve recording brain-wide neural activity with single cell and sub-millisecond resolution.
- Practical approaches towards this aim have been centered around the extracellular recording techniques, where continuous development has enabled scaling the yield from few (single channel metal microelectrodes) to few tens (wire tetrodes) and to few hundreds (silicon probes) of simultaneously recorded neurons[1].
- This application note is focused on the Neuropixel probes[2], which represent an impressive recent advancement providing order of magnitude increase in the yield to allow recording simultaneously from thousands of neurons (Fig. 1).

Neuropixel probes

- CMOS technology based probes were developed in a large concortium project managed by Dr. Tim Harris (Janelia, USA) in partnership with IMEC
- Integrated design with on-board amplification, multiplexing and digitization
- 1.0 probes are tailored for the rodent experiments and offer simulatenous recording of any combination of 384 recording sites out of 960 sites per shank (Fig. 2)
- Electrode size is 12×12 µm with noise level of 5.1 ± 0.6 µV (mean ± s.d.; 0.3-10 kHz)
- Probes, head-stages and data acquisition systems are available from IMEC
- SpikeGLX and Open Ephys are currently the main data acquisition software pacakges
- 2.0 probes are under development with increased channel counts and improved form factor (incl. multi-shank probes); estimated general availability in 2021

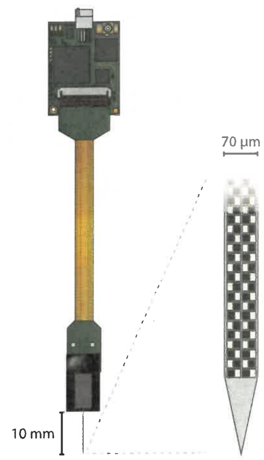

Figure 2. Neuropixel 1.0 probe[2]

USEFUL LINKS

Neuropixel probe website: https://www.neuropixels.org/

Neuropixel Slack channel: https://neuropixelsgroup.slack.com/

Svovoda lab Neuropixel setup: https://www.janelia.org/open-science/manipulator-system-for-multiple-neuropixels-probe-recordings

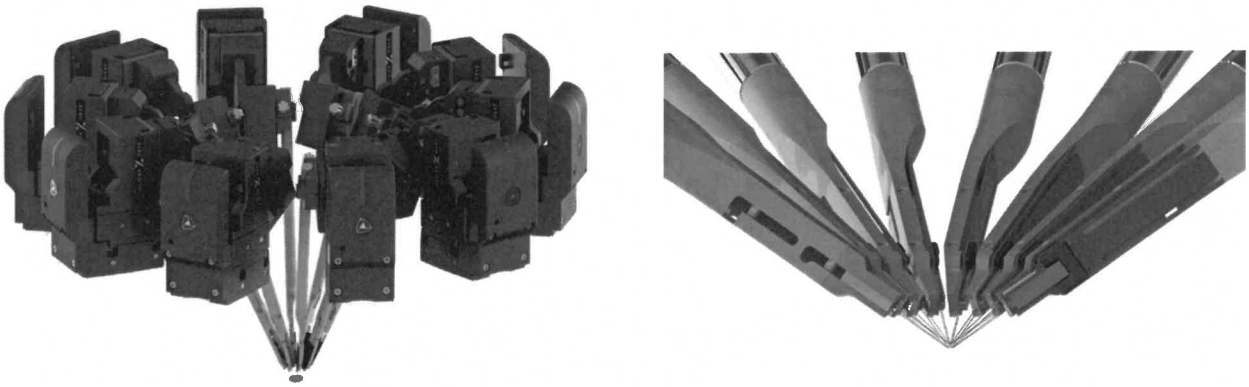

Figure 3. 10 Neuropixel 2.0 probes installated using Sensapex uMp-NPH-2 adapters (20 degrees probe spacing).

Practical implementation tips

- Unreliable electrical connections are common source of problems: always ensure that the ground wire is properly soldered to the reference pad and that flex cable is plugged straigth and firmly to the headstage connector
- There are ready-made designs available for attaching the probes to the micromanipulator. Sensapex designs are available for both 1.0 and 2.0 probe versions and designed to be slim but stable (probes themselves become limiting factor for multi-probe experiments)
- To minimize tissue damage and maximize recording yield:
  (1) Insert the probe with fine resolution and in a stable manner; using manual micromaniputor may lead to troubles
  (2) Insert very slowly: best results are often achieved with one to few µm/s insertion speeds (see also[3])
- Join the Neuropixel slack channel for nearly real-time support by top notch experts!

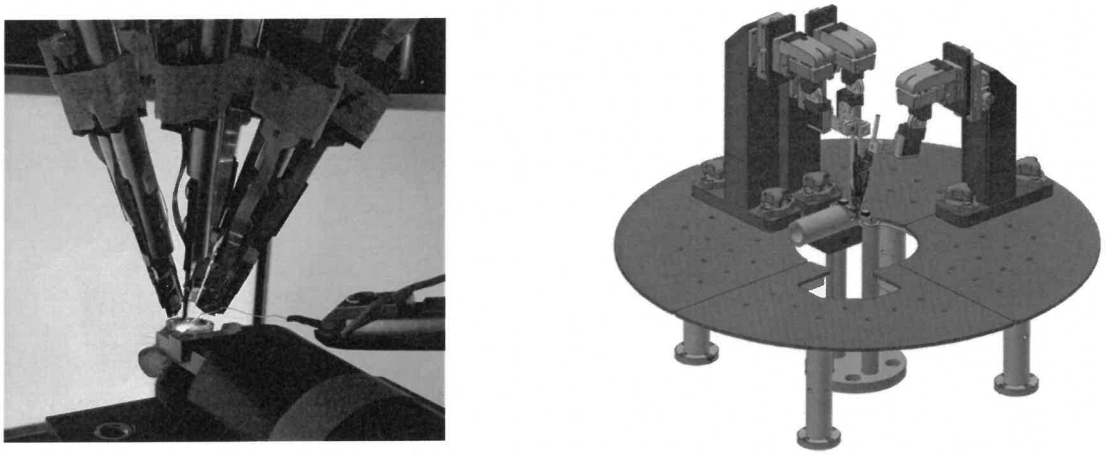

Figure 4. Left, 8 probe setup close-up (courtesy of Dr. Nick Steinmetz); right, Svoboda lab Neuropixel setup (courtesy of Dr. Karel Svoboda)

Sensapex has worked with Neuropixel probe users since the very beginning. Our controllers have dedicated features for setting relative coordinates and for automated probe insertion.

Learn more at: www.sensapex.com/products/ump-micromanipulators/

REFERENCES

1. Steinmetz, N.A. et al. (2018). Challenges and opportunities for large-scale electrophysiology with Neuropixels probes. Curr. Opin. Neurobiol. 50, 92–100.
2. Jun, J.J. et al. (2017). Fully Integrated Silicon Probes for High-Density Recording of Neural Activity. Nature 551, 232–236.
3. Fiáth R et al. (2019). Slow Insertion of Silicon Probes Improves the Quality of Acute Neuronal Recordings. Sci Rep. 14; 9(1):111.