Implantation of Flexible Electrodes for Simultaneous *in-vivo* Extracellular Recording and Two-Photon Imaging

Alec Booth[1], Hammad Khan[2], Om Kolhe[2], Krishna Jayant[2,3]
[1]Indiana University School of Medicine, [2]Purdue University, Weldon School of Biomedical Engineering, [3]Purdue Institute for Integrative Neuroscience

Introduction:

Rigid silicon electrodes like Utah array grids and Neuropixel probes have been used in human and animal brain models to understand the dynamics of neural computation, treat neurodegenerative disorders, and act as brain-machine-interfaces. However, when implanted chronically, glial proliferation can rapidly disrupt the interaction between neurons and electrodes, drastically reducing recording fidelity. The development of flexible electrodes has the potential to minimize tissue damage and inflammation, which allows for long-term recordings over several months. In line with this objective, the Nano-neurotechnology Lab at Purdue University has developed a 6-μm thick, flexible, and biocompatible Parylene probe to facilitate chronic recordings in awake mice. However, flexible electrodes present a unique engineering challenge as the force required to insert into the brain causes the probe to buckle and fail during insertion.

Methods and Results:

Here, I designed a micropipette shuttle using a glass micropipette and custom insertion system which provided reproducible probe implantation into the cortex. The implantation device was designed in CAD software and 3D-printed for rapid prototyping. The procedure was developed on brain phantoms made of 0.6% agarose with a comparable Young's modulus to mouse brain tissue. Utilizing 3D-printed pieces and the surface tension of diluted poly-vinyl-acrylate adhesive to align the probe to a micropipette, insertion of the electrode and retraction of the shuttle was accomplished in awake mice.

Conclusion:

The implications of flexible recording electrodes are extensive. Long-term implantation opens the door for understanding behavioral and learning dynamics over time. Moreover, the flexibility of these probes allows for the combination of 2-photon optical microscopy, thus enabling multi-modal investigation of neuronal physiology. A low-cost, consistent procedure is the first step in the implementation of these flexible probes for further advancements in fundamental neuroscience research and its potential applications in human and animal studies.