Aluminosilicate Glass Micropipettes for Fluorescence Guided Electrophysiology System

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Introduction and Background

An essential method of studying deep-brain neurological function is by recording specific cell types. The gold standard for high resolution recording is patch-clamp electrophysiology. Despite current efforts, limitations in identifying specific cell subtypes due to light-scattering in tissues in high-powered microscopy techniques such as confocal and multiphoton, degrading image resolution [1]. To address this, optical waveguides and wavefront shaping techniques assist in delivering light to select regions of the brain. The Smith lab's fluorescence-guided electrophysiology system enables neuron subtype detection at greater depths using an integrated fiber optic and micropipette assembly. However, micropipette geometry limits compatible optical fibers, thus restricting optical sensitivity and resolution. As a result, an expanded range of micropipette geometries is required. **I hypothesize that exploriung the parameters of aluminosilicate micropipette construction can improve the system's compatibility with advanced optical fibers, enhancing precision and resolution in deep-brain electrophysiological recordings.**

Experimental Methods

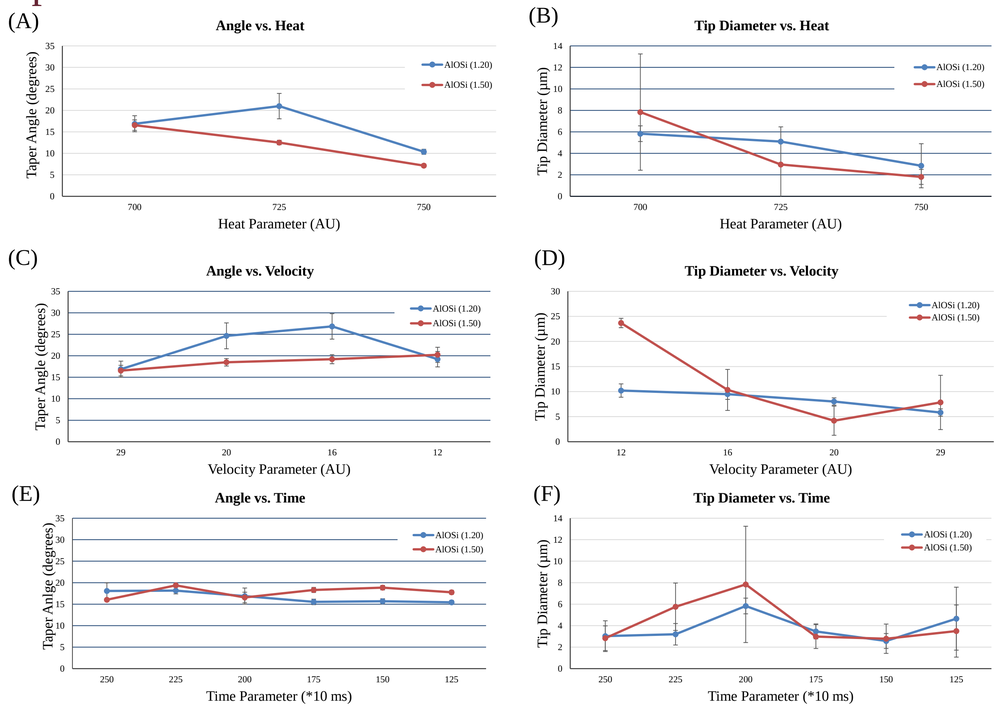

Fig 1: Results of parameter changes on micropipette, as defined using the Micropipette Cookbook [2]. Heat, velocity and time parameters were tested on P-87 Puller with both 1.2mm outer diameter (OD) / 0.87 inner diameter (ID) and 1.5 OD / 1.10 ID Aluminosilicate Glass Pipettes. Error bars are based on n=4. Shown is Angle vs. Heat (a), Tip Diameter vs. Heat (b), Angle vs. Velocity (c), Tip Diameter vs. Velocity (d), Angle vs. Time (e), and Tip Diameter vs. Time (f)

Results

Integrated Micropipette and Fiber

Fig 2: Shown are images of a standard 1.5 OD / 1.1 ID borosilicate micropipette, measured with a 17-degree angle tip, (a) and representative assembly with a 1.5µm aperture NSOM-style fiber (b). A 1.2 OD / 0.87 ID aluminosilicate micropipette (Heat = 700, Velocity = 20, Time = 200), measured with a 27-degree angle tip, (c) and representative assembly with an overlayed SolidWorks render of a focused fiber optic, as described in Future Work.

Conclusion

Presented is a range of geometries achievable from the pulling of aluminosilicate micropipettes. Overall, taper angles from 7-degrees to 30-degrees have been observed, with larger angles more readily-achievable with 1.2mm OD micropipettes. This is likely due to the greater ratio of wall-thickness to core-diameter of the 1.2mm to the 1.5mm, suggesting that greater angles may be feasible with thicker walled micropipettes.

Future Work

The next phase of this research involves integrating a focused fiber optic to leverage the broader range of micropipette geometries. Preliminary investigation suggests that the inclusion of a 45-degree focused fiber with a 5-µm radius of curvature, 10µm focus, and 1.5µm spot size yields a theoretical SNR increase of 1000 compared to current 1.5µm aperture NSOM-fiber. Furthermore, the suggested integration would also provide a peak distance-to-target detection at 23µm, providing a new ability for targeting within multiple-neuron clumps, not currently possible. Lastly, the inclusion of aluminosilicate and removal of tapered tips should mitigate breakage, facilitating faster fiber replacement and improving system suitability for translation.

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References

[1] Miranda, Christopher, et al. "Automated microscope-independent fluorescence-guided micropipette." Biomedical Optics Express 12.8 (2021): 4689-4699.

[2] Sutter Instruments. Micropipette: P-2000 Laser Based Micropipette Puller [Online].

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