Electronic Supplementary Material (ESI) for Analyst.
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Supporting information

A Troubleshooting Guide for Laser Pulling Platinum Nanoelectrodes

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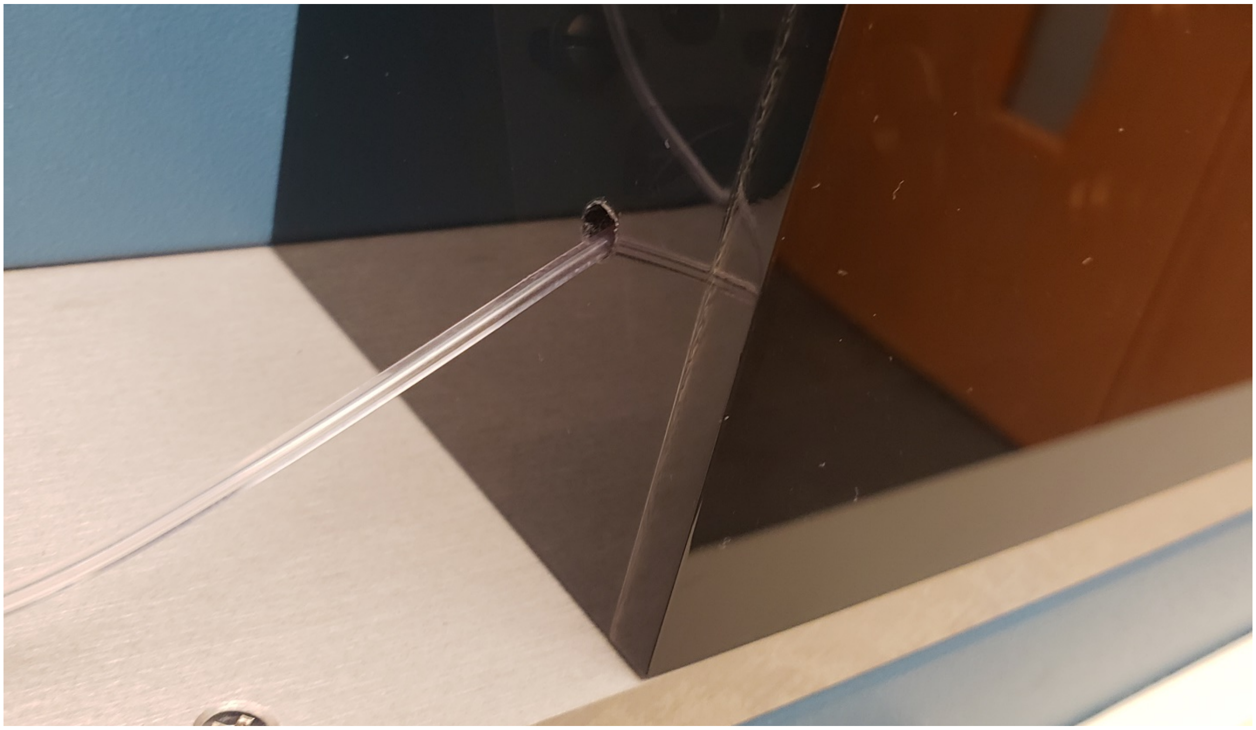


Figure S1. A representative photo of the hole drilled on the side of the laser puller cover

A small hole slightly bigger than the diameter of the vacuum tube was drilled on the side of the laser puller cover to bring the vacuum tubes in. This vacuum tube is later connected to the Pt wire loaded quartz capillary for the sealing process.

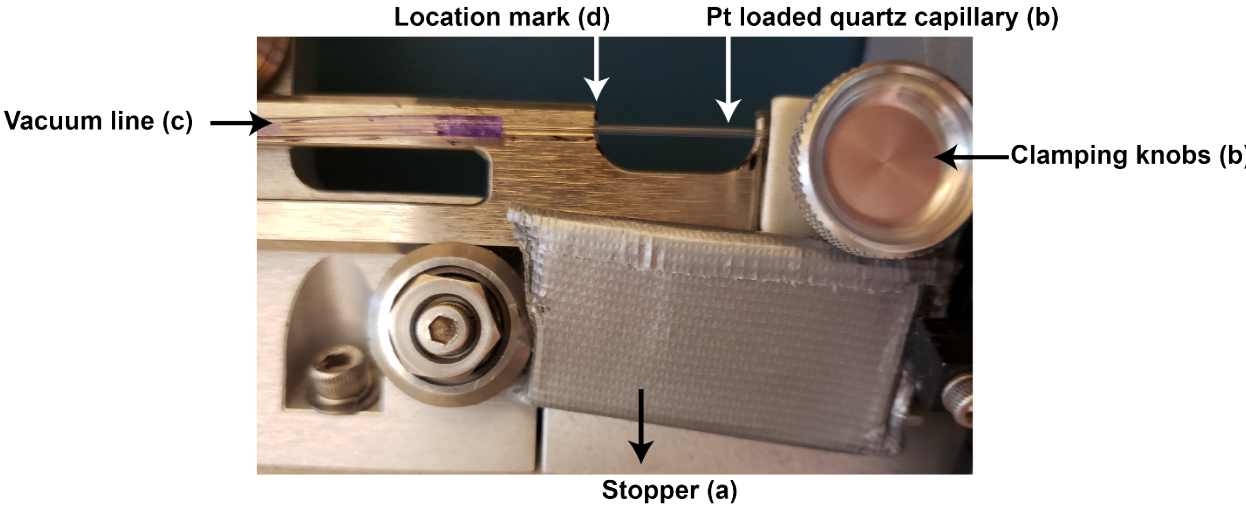


Figure S2. A representative photo of the laser puller set up

The puller bar was pulled forward towards the retro mirror assembly and was held in a place with self-made stoppers (a). Pt loaded-quartz capillary was held into the groove place, clamped down with the clamping knobs (b). Then, the vacuum line (c) connected to a vacuum machine was carefully connected to the loaded quartz capillary. Finally, a mark was made with a Sharpie marker on the quartz capillary (d) to make sure the quartz capillary could be placed at the same position every time.

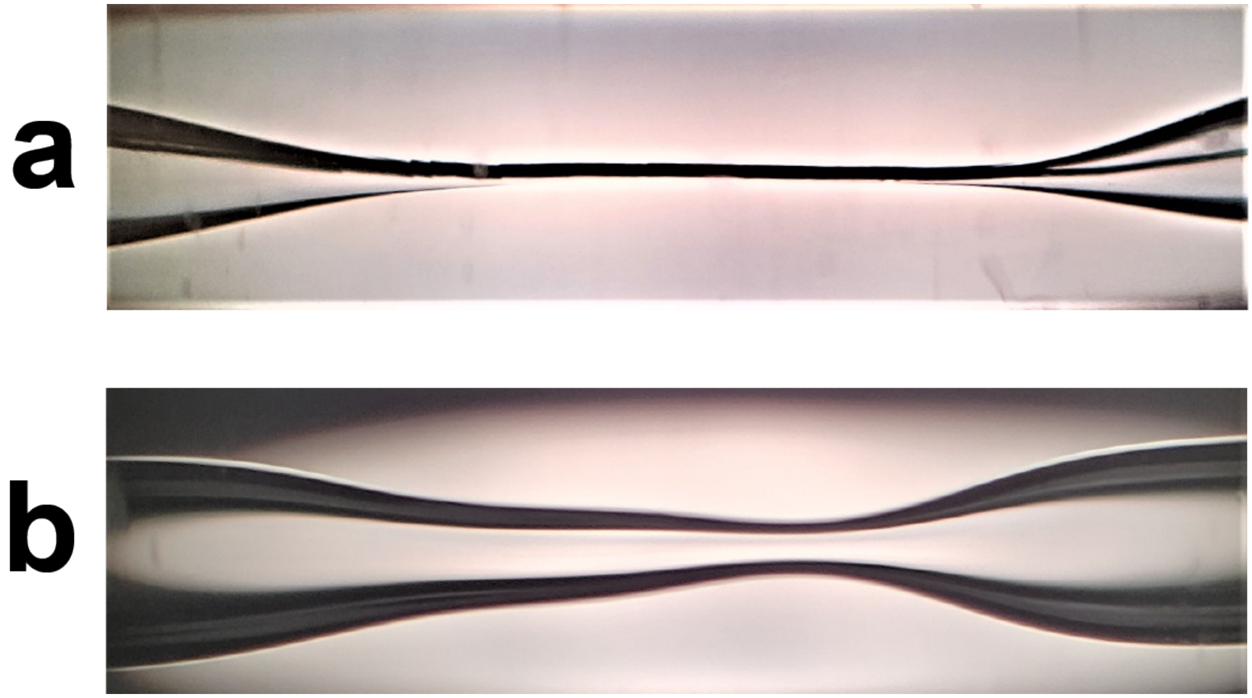
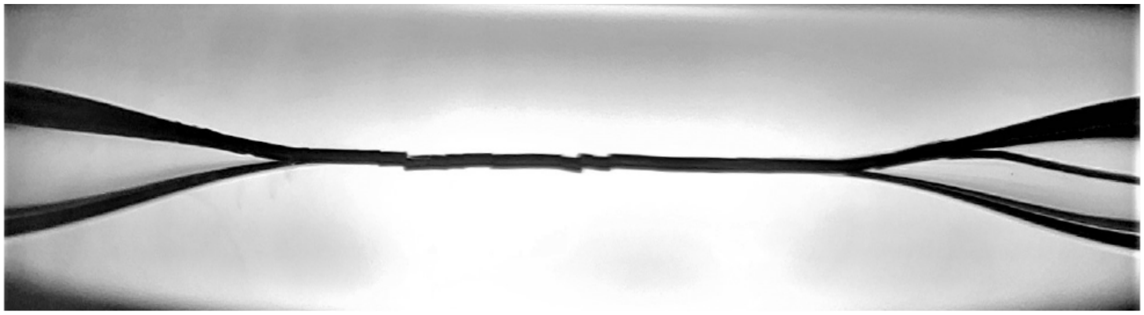


Figure S3. The effect of vacuum strength on the complete seal.

The complete seal of the Pt wire inserted in a quartz tube (a) was obtained when the vacuum was sufficient with a standard protocol (Heat: 840, Filament: 5, 30 on/off, 4 cycles). However, the same parameters, with insufficient vacuum, were unable to seal even a blank capillary (b). The process of repeating the standard protocol for numerous rounds to force the seal resulted in the elongated and uneven condensing area of the quartz capillary. This highlights that even without the added factor of including a Pt wire, a blank capillary will not be readily sealed when there is insufficient vacuum.

a



b

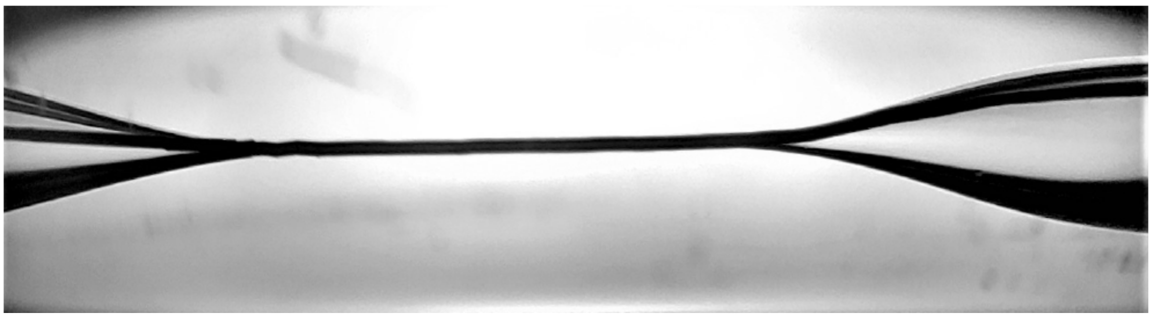


Figure S4. The loss of Pt wire integrity upon a complete seal
The integrity of the encased Pt wire was compromised (a), even when the sealing protocol remained the same (Heat: 840, Filament: 5, 30 on/off, 4 cycles). Numerous factors such as bending during the insertion of Pt wires and dirty Pt wires can contribute to the loss of Pt wire integrity upon a complete sealing.

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FILAMENT Range: 0 to 15. FILAMENT (FIL) specifies the scanning pattern of the laser beam that is used to supply HEAT to the glass. The P-2000 is preprogrammed with scanning pattern values (FILAMENTS), each of which defines the longitudinal length and the rate of the scan. The length of the region scanned is analogous to the width of the area heated by a conventional metal heating filament. Changing the laser power (heat) distribution within a heated region is analogous to changing the filament type in our conventional pullers. The following table lists the scan length and distribution for each FILAMENT value. FILAMENTS also define the distribution of heat within the scanning length

Table 3-1. FILAMENT scan pattern values.

FILAMENT #	Scan Length	Equivalent FILAMENT #s	
0	1 mm		
1	1.5 mm	6	11
2	1.9 mm	7	12
3	4.5 mm	8	13
4	6.5 mm	9	14
5	8 mm	10	15

NOTE: Although there are 16 different FILAMENT values, the current version of the P-2000 firmware supports only six (0 through 5) unique scanning patterns. The range of values 6 through 10 duplicates the last five settings of the first range (1 through 5), as does the last range (11 through 15). E.g., Using a FILAMENT value of 6 or 11 is identical to 1; 7 or 12 is identical to 2, and so on (see Table 2).

Figure S5. A screencapture of Sutter Instrument manual available for P-2000 laser-puller. The filament parameters offer a range from 0-15, but the distribution pattern from 1-5 is repeated for 6-10 and 11-15.

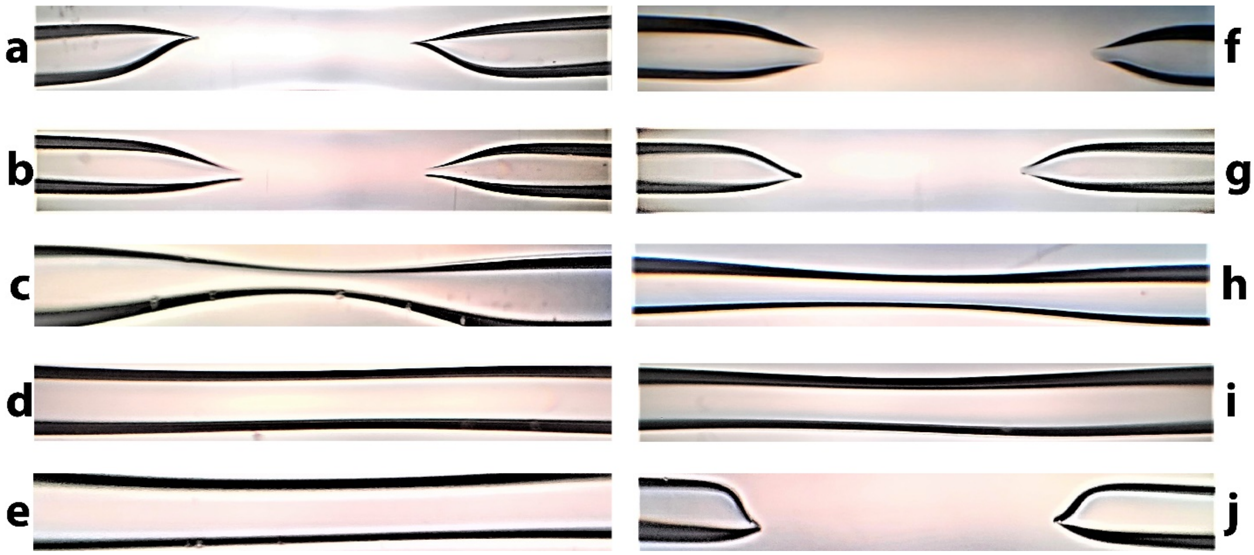

Figure S6. Representative microscopic images of quartz rods under different filament values. Starting from a filament of 7(a), the filament value was varied incrementally to 16(j). The distribution pattern observed for this particular laser puller is not as uniform as the stated patterns in the manual, but it follows a trend of repeating certain distributing pattern. Also, 16 is a valid input for the filament parameter.

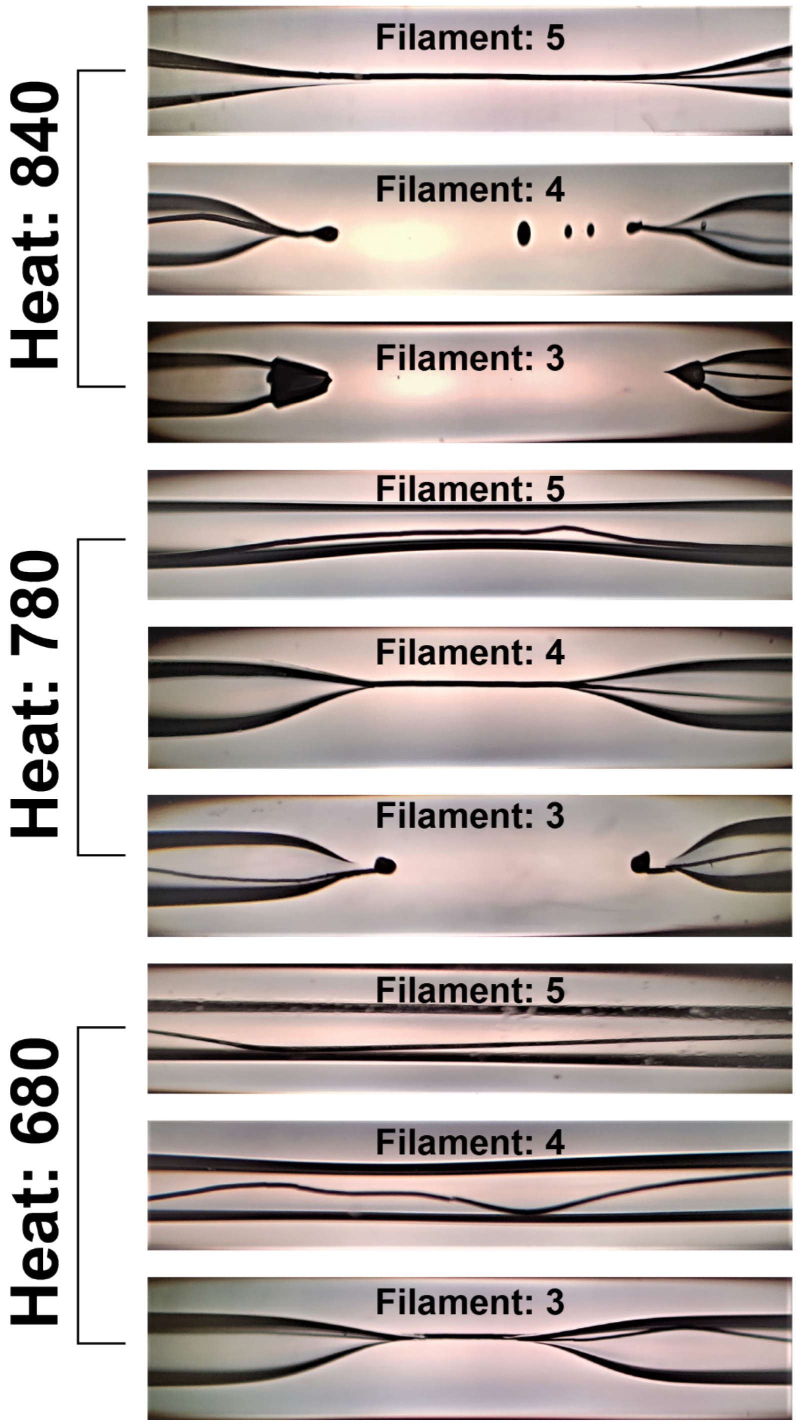

Figure S7. Representative images for the interdependent relationship between heat and filament

Each heat and filament settings was applied for 4 cycles of 30 seconds on/off. As the filament value increased, a higher value of heat was needed to complete the seal.

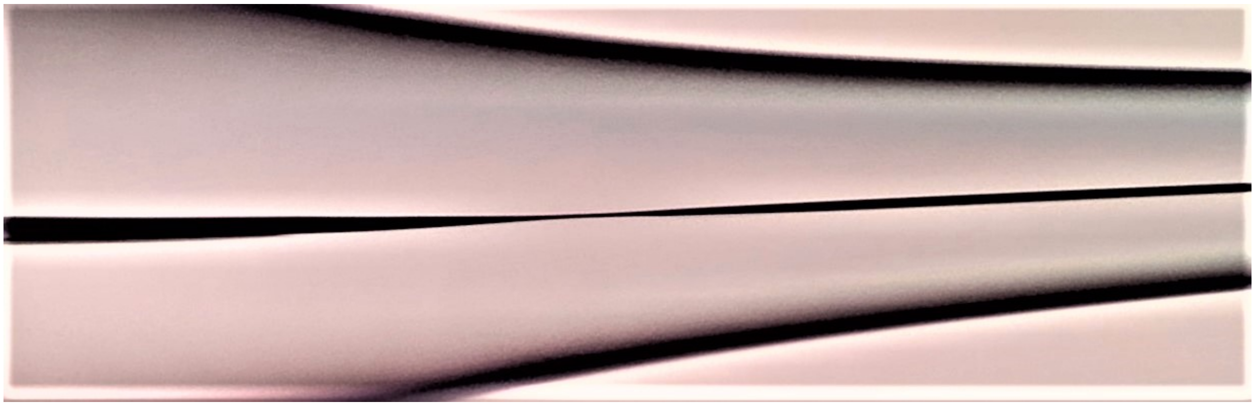

Figure S8. Representative microscopic images of pinched pt wire resulted from pulling. When using a higher filament such as 4 or 5, the pinched Pt wires are observed which provide resistive and capacitive electrode.

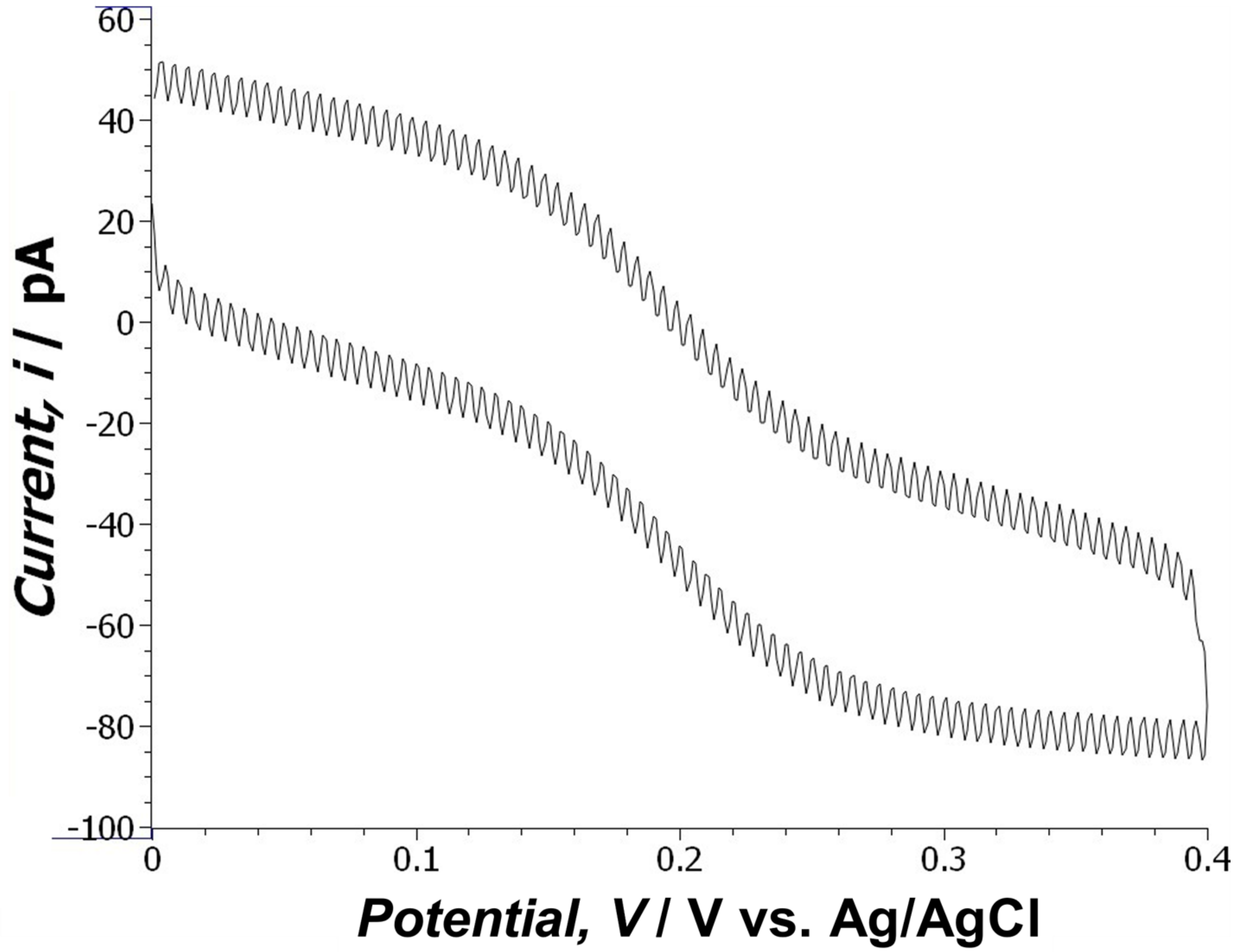

Figure S9. Representative cyclic voltammogram of electrodes made with delay less than 128

When delay was set below 128 (i.e., the laser was turned off after the pull occurred), the resulting electrode showed consistent electrical noise despite any cleaning procedures taken. The CV was taken from 0 V to 0.4 V at 50 mv s^{-1} using 1 mM Ferrocene methanol in pH 7.5 100 mM MOPS. A CHI potentiostat was used, and the graph is plotted in a mixed convention, with negative current being the anodic current.

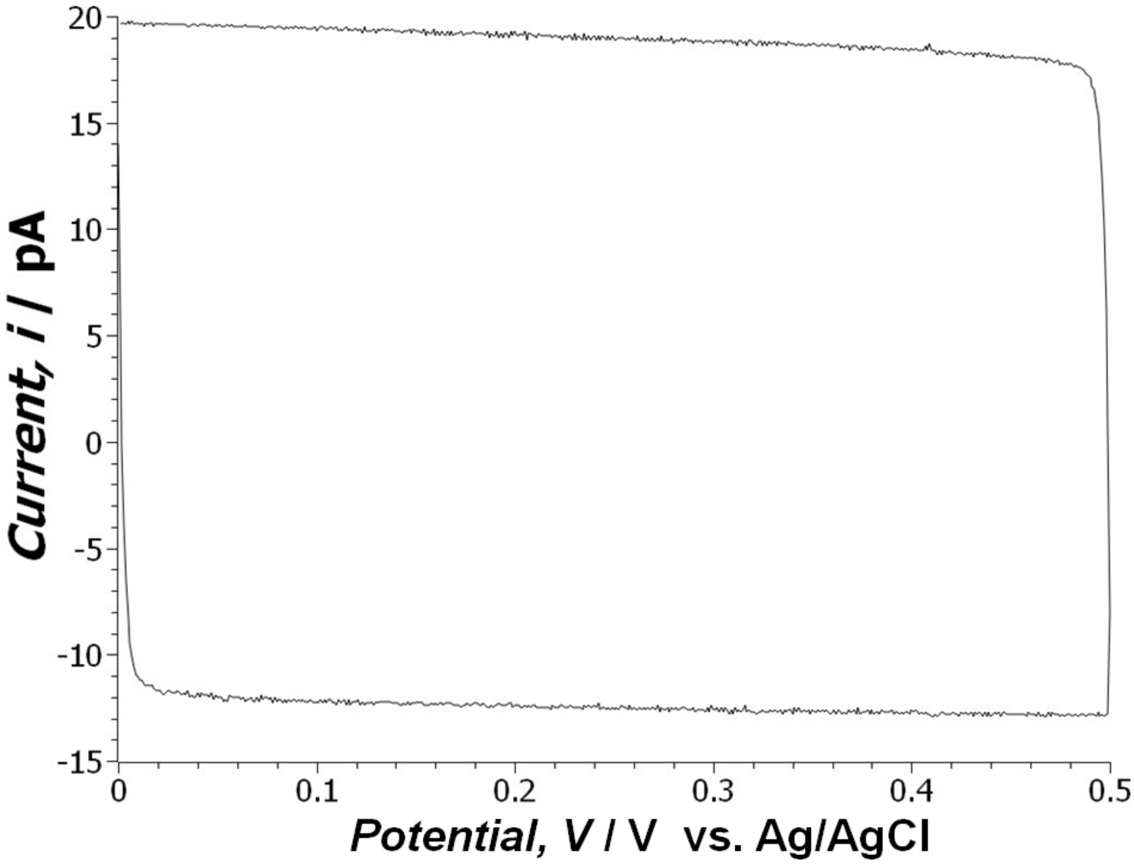

Figure S10. Representative cyclic voltammogram of electrodes without exposed tip
When the fabricated electrode has a reliable electric communication with the potentiostat but its tip is not exposed to the surrounding environment, there is a big capacitive current without any redox peak. The CV was taken on a CHI potentiostat from 0 V to 0.5 V at 50 mv s^{-1} using 1 mM Ferrocene methanol in pH 7.5 100 mM MOPS.

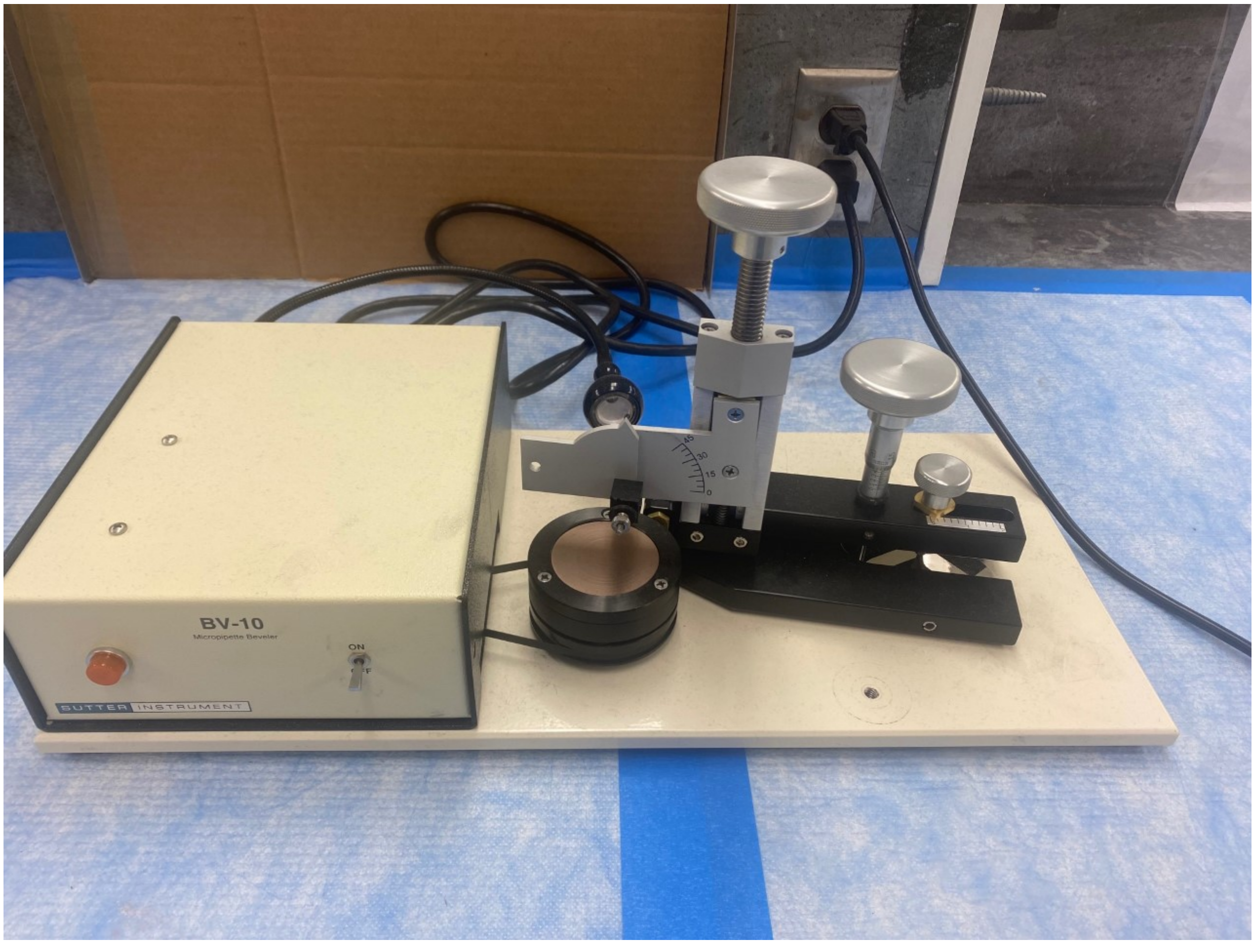

Figure S11: Micropipette Beveler from Sutter Instruments

This beveler provides a pad with extremely fine grit for the polishing of submicron and nanoelectrodes.

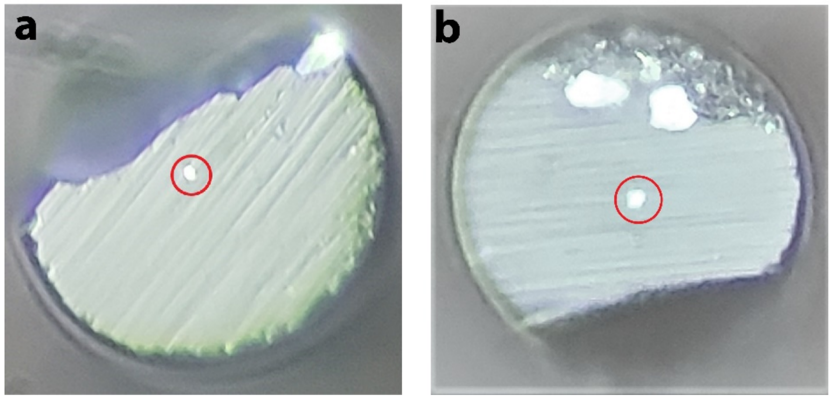

Figure S12. Representative microscopic images of electrode surface during a series of beveling.
The chipped glass that does not physically damage the electrode surface (a) indicated with a red circle still works well as an electrode. The dirty pad used for the beveling leads to a compilation of glass fragments (b) from the previous beveling.