
# Neuralynx Plating Solutions and Protocols
# User Manual

Plating Techniques and Protocols


105 Commercial Drive, Bozeman, MT 59715
Phone 406.585.4542 • Fax 866.585.1743
www.Neuralynx.com
support@Neuralynx.com

Revision 2.0
4/10/2013

# Table of Contents



# List of Figures and Tables

# 1 Document Overview

This manual covers the recommended setup and procedure for plating electrodes. References are included for in depth discussion on various protocols.

# 2 Neuralynx Plating Solutions Overview

Neuralynx provides two options for plating: platinum black for platinum iridium electrodes and gold for nichrome electrodes. This document reviews the advantages of plating and has detailed pictures showing the necessary equipment and setup. The plating section takes the user through the plating process with the recommended protocol for both solutions. Sections specific to platinum iridium/platinum black and nichrome/gold are designated with [***Pt***] or [***Au***] respectively.

The manual assumes the user will be using the nanoZ$^{(T)}$ and is familiar with its operation. Optionally, the user can use the Neuralynx Plating application rather than the nanoZ interface. Please refer to the appropriate manual for instructions on nanoZ and Neuralynx Plating application operation.

It is not the intent of this manual to review various plating protocols and recipes. A recommended protocol is provided as a starting point.

In the context of this document tetrodes, stereotrodes and probes denote a set of electrodes and are thus equivalent.

# 3 Glossary

| | |
|---|---|
| ***Charge capacity*** | The ability of an electrode to store charge. |
| ***DVM*** | Digital volt meter. |
| ***Impedance*** | Form of electrical resistance that includes both resistive and reactive components. |
| ***Matlab*** | Mathematical software package. |
| ***NanoZ*** | Device to measure impedance and plate electrodes. |
| ***NiCr*** | Nichrome alloy used for electrodes. |
| ***NZPlating*** | Neuralynx Plating and Lesioning application. |
| ***PBS*** | Phosphate Buffer Solution |
| ***PEG*** | Polyethylene Glycol 8000 mw |
| ***PtIr*** | Platinum/Iridium alloy used for electrodes. |
| ***RPC*** | Reverse Polar Current. A type of plating that is biphasic. |
| ***SDK*** | Software Development Kit for nanoZ |
| ***Site activation*** | Development of iridium oxide layer on electrode to increase charge capacity. |
| ***Stereotrode*** | Probe made of two wires twisted together. |
| ***Tetrode*** | Probe made of four wires twisted together. |

# 4 BACKGROUND

The reason to plate is to control the impedance of the electrode. Impedance is tied to the total area of the electrode. Plating can significantly increase the area by creating a three dimensional surface at the electrode tip, thereby lowering the electrode impedance. This improves the signal by lowering thermal noise. Occasionally, a protocol may call for a higher impedance to limit the data collection radius. This will however increase the noise floor of the signal. Finally, for multiple electrode recording, it is advantageous to match the impedances across the electrode set. This makes the recorded signals more consistent and facilitates interpretation.

Optionally, you may want to apply a biphasic wave to the electrode. This creates a layer of platinum oxide which increases the electrode's *charge capacity*, [1][2]. Charge capacity is the amount of charge that the electrode can store on its surface. This technique of increasing charge capacity is called *site activation.* Although separate from plating, activation uses much of the same equipment. Charge capacity is typically used in context of stimulation.

# 5 SETUP

Neuralynx provides and supports a variety of tools to ensure your electrodes are consistent and reliable. Available are the Neuralynx Tetrode Assembly Station, nanoZ, and a nanoZ application that allows additional user control.

The Tetrode Assembly Station is a complete system to quickly make *tetrodes* or *stereotrodes.* It consists of a stereotaxic apparatus and the Neuralynx tetrode spinner. The spinner greatly reduces the effort to create consistent tetrodes. It allows computer control via a USB interface, native routines, and manual operation.

Neuralynx also sells the *nanoZ*(T). This manual assumes the use of the nanoZ for plating. The nanoZ allows direct electrode impedance or *spectroscopy* measurements with respect to a reference. Additionally, the nanoZ is used for plating and site activation. The Software Development Kit, *SDK*, is provided with the nanoZ. It allows complete control and flexibility of the nanoZ via Matlab(T). The *Neuralynx Plating and Lesioning*, (NZPlating), application provides additional control of the nanoZ channels and plating protocols without the need for Matlab. Additionally, Neuralynx provides a variety of adapters for the nanoZ to meet your specific needs.

For plating nichrome and platinum iridium wire, both gold and platinum solutions are available. Research has shown that ultrasonic insonation improves the quality of the plating. Insonation decreases the variability and impedance of the plated set. It also creates more stable electrodes that change less over time. This is particularly true when plating platinum iridium electrodes with platinum black.

Table 1 and Figure 1 list and show the equipment you will need for successful plating.

**Table 1: Recommended Plating Equipment**

| **Item** | **Notes** |
|---|---|
| Additives, (PEG) | **[*Au*]** Polyethylene glycol, optional additive for plating gold onto nichrome. |
| Anode | Stainless Steel anode |
| Beakers | Two 25 to 50 ml beakers |
| Computer | Windows(T) based computer |
| Deionized or Distilled water | |
| Insonicator | Ultrasonic Device that delivers ultrasonic vibration to plating solution |
| nanoZ Software and/or Plating and Lesioning Application | Plating protocal control software |
| nanoZ w/USB cable | Impedance measurement and plating device |
| Latex gloves | |
| nanoZ Return | Connects the nanoZ to Anode |
| Neuralynx nanoZ stereotaxic holder | Attaches nanoZ to stereotaxic apparatus |
| Plating Solution | Platinum black, ***Pt,*** or gold, ***Au***, plating solution |
| Saline Solution | Phosphate Buffered Solution, PBS |
| Stereotaxic apparatus | |
| Waste Container | |

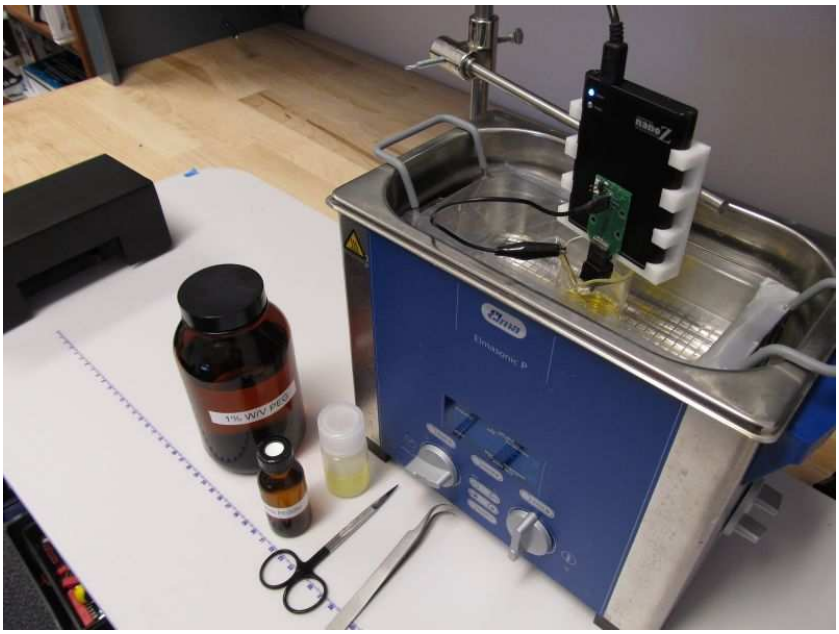

**Figure 1: Plating Equipment**

# 6 Plating Solution

## *6.1Safety and First Aid*

This section discusses general use, safety and disposal issues. Local and/or regional regulations may vary and it is up to the users to be aware of all regulations specific to their application.

**[*Pt*]** The platinum black plating solution provided by Neuralynx contains chloroplatinic acid, lead and a small amount of hydrochloric acid. The lead is in the form of lead acetate in a 10% w/v concentration. Schuettler, et'al found that when lead is used as an additive for platinum black plating, there was no transference of lead to the subject from neurological probes. Thus, plating with lead as an additive is safe for animal subjects. However because of the lead, it is not recommended for human implants [3].

The concentration of lead in the solution is about three times that of common hair coloring products. Disposal of the solution in the sewer should pose no environmental threat. However, it is incumbent on the user to follow all local and regional regulations concerning its disposal. Refer to the included MSDS sheet for further information.

The solution is has a PH of 1.25. Latex or rubber gloves are recommended when handling the solution. Avoid contact with the solution especially if the skin is broken. A fume hood or respirator mask is not necessary. However, check regulations that may apply to your local. If the solution is ingested, or comes in contact with open skin or eyes refer to the included MSDS sheets for appropriate first aid and action.

**[*Au]*** The gold plating solution contains no cyanide and is generally safe although care should be taken to prevent contact with the skin or inhalation. Refer to the included MSDS sheet for further precautionary and disposal information.

## *6.2 Plating Ingredients*

| Ingredient | Concentration |
|---|---|
| **[*Au*]** Sifco 5355 Gold Plating Solution | 1-5% gold |
| **[*Pt*]** Neuralynx Platinum Black Plating Solution | 1% Choroplatinic acid |
| PEG 8000 MW | 1% w/v (PEG/Distilled water) |

When plating NiCr with gold, we recommend mixing PEG with the gold solution in a 75% v/v PEG to gold ratio.

# 7 PLATING

## *7.1 Plating Setup*

Figure 1: Plating Equipment shows the recommended setup. It consists of a nanoZ, plating adapters, appropriate plating solutions, and optionally an UltraSonic cleaner. The electrodes are plated by applying negative current to the electrodes. The return to the nanoZ is connected to a stainless steel anode which is immersed in the plating solution along with the electrodes.

**[Pt]** The vapor coming off the solution will tend to rust the alligator clip on the nanoZ return wire therefore, we recommend using a disposable wire to connect the anode to the nanoZ alligator clip. This keeps the clip away from the solution.

Plating Tips

- Always perform initial and final impedances in PBS as this approximates biological salinity. The nanoZ target impedance is measured in the plating solution. It will be less than the impedance in PBS, thus the target impedance measured in the plating solution is only a rough guide.

- If possible it is a good idea to use freshly cut the tetrode prior to plating. In addition to cutting the tetrode we recommend cleaning the electrodes by running a +0.1to +0.2uA[1], current for 1 to 2 seconds.

- Make sure that the electrode tips are in the plating solution along with the nanoZ return.

- There are several plating protocols you may use: Direct Current (*DC*), Pulse and Pulse Reverse Current (*RPC*)[4][5], are among the most popular. Pulse and RPC has an advantage over DC in that it is biphasic. This allows a period of time that replenishes fresh material at the electrode for plating. However, for 10 to 18um wire, tests do not show a significant difference. Other protocols call for a multistep process [6][7].

[1] For 10-20um wire

- 10 ml of solution will plate several hundred 0.0007 mil electrodes. However, we suggest that you begin with fresh solution with each plating session.

## *7.2Protocol*

Plating is possible with either the nanoZ software, or the Neuralynx Plating Application, Figure 2. Both the nanoZ software and the Neuralynx Plating Application have options to target a specific impedance across the electrode set. While the nanoZ software can deliver a biphasic pulse, the plating application allows a stepped protocol where the electrode set is plated with successively shorter pulses. Additionally, the application automatically stores the impedances throughout the process along with the protocol for future reference.

The speed that the electrode is plated is a function of the current density. Slower plating provides superior electrodes. The recommended protocol and settings are described in the following sections.

### 7.2.1 [*Pt*] Plating Platinum Iridium Electrodes with Platinum Black

Platinum Black plating creates a fragile matrix. Insonification during the plating process helps to remove the weaker bonded plating while leaving the more strongly bonded particles. If you opt to use insonation, you will need to stabilize the beaker as the vibrations will cause it to move.

**Table 2: Plating Parameters for 18um Platinum Iridium with Platinum Black**

| Parameter | Value |
|---|---|
| Current | -0.1uA |
| Total Time | 50 seconds |
| Insonation Power | 50W |
| Insonation Frequency | 40kHz |

### 7.2.2 [*Au*] Plating Nichrome Electrodes with Gold

While insonification helps plating with platinum black, it does not have a positive effect when plating NiCr with gold when an inhibitor such as PEG is present. However, a stepped protocol, such as tabulated in Table 3, will aid in the plating consistency and longevity.

**Table 3: Stepped Protocol Using the Neuralynx Plating Application**

| Step | Time | uA | Target (MΩ) | Attempts |
|---|---|---|---|---|
| Cleaning | 1 | +0.1 | n/a | 1 |
| 1 | 15 | -0.05 | 2 | 3 |
| 2 | 10 | -0.05 | 1.5 | 3 |
| 3 | 5 | -0.05 | 0.5 | 3 |
| 4 | 3 | -0.05 | 0.25 | 3 |
| 5 | 2 | -0.05 | 0.1 | 3 |
| 6 | 2 | -0.05 | 0.07 | 3 |

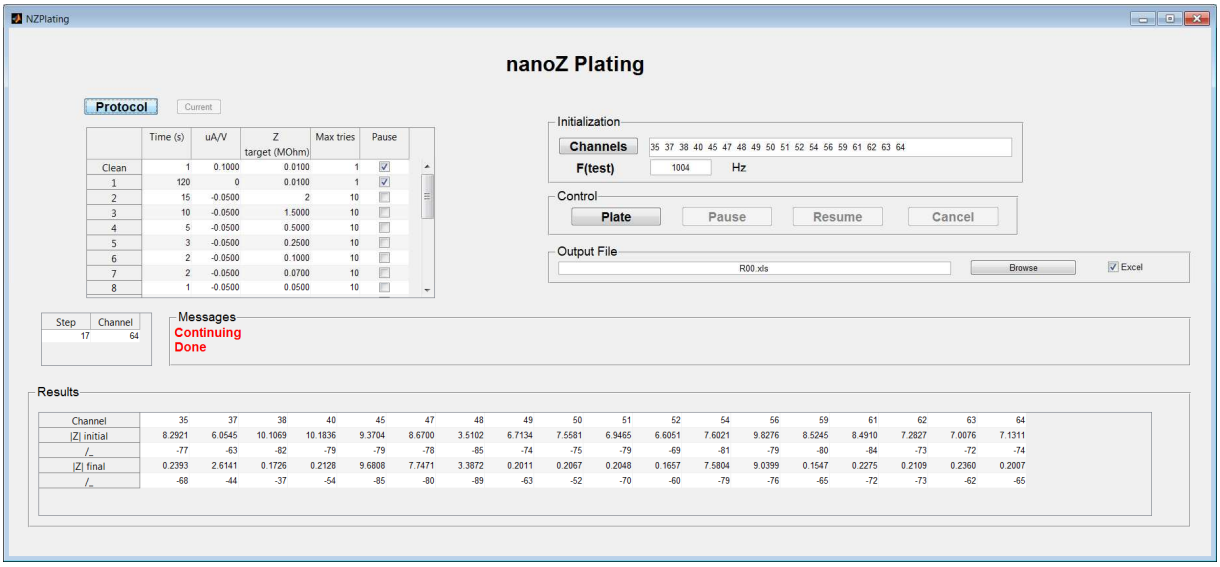


**Figure 2: Plating and Lesioning, NZPlating Application**

Please refer to nanoZ and nanoZ Plating and Lesioning User manual for directions on operation.

## *7.3Plating Steps*

### 7.3.1 Preparing the Electrodes

1) Refer to the Neuralynx Tetrode Assembly Station user manual for information on making tetrodes.
2) Before you plate it is best to perform a fresh cut of the tetrodes to remove any debris or oxidation from the tip.

### 7.3.2 Initial impedance, (optional)

1) Fill a 50 ml beaker with PBS.
2) Attach the nanoZ return from the adapter board to the anode.
3) Lower the tetrodes or probe into the PBS solution so that the tips are at least 1mm in the solution.
4) Take impedance measurements and record.
5) Fill another beaker with distilled water and rinse the anode and tetrodes for a 1 to 2 minutes.

### 7.3.3 Plating

1) Fill a 50 ml beaker with 10ml to 15ml of plating solution.
2) Gently lower the tetrodes or probe into the solution at least 1mm.
3) Attach the nanoZ return from the adapter board to the anode.
4) Immerse the anode into the plating solution.
5) Plate with either the nanoZ software or the NZPlating application.
6) Review the final impedances for indications of shorted electrodes or tetrodes. If two or more electrodes are exactly the same while the other electrodes in same tetrode are significantly higher, you may have a short, [9].
7) If shorts are suspected, test explicitly with an Ohm meter, if you are using an EIB36, the EIB36 plating adapter will provide easy access to each of the electrodes.
8) If you have a shorted tetrode or probe you can apply a +1 uA to the electrode for a few seconds to remove the plating and then replate. The NZPlating application will come in handy for this since it gives you control over specific electrodes. If this does not work, then recut the electrode tip.

### 7.3.4 Post Plating

1) When you are satisfied with your plating, rinse the electrodes in distilled water for 1 to 2 minutes.
2) Do a final impedance test in saline.
3) Rinse the probes again in distilled water.
4) Allow the probe to dry. Note that the impedance of dry electrodes will be greater than when your electrodes have been soaking in solution or saline for a long time. This is expected. After the electrodes are inserted for a period of time the impedance will decrease.

# 8 REFERENCES

[1] J. D. Weiland and D. J. Anderson, “Chronic neural stimulation with thin-film, iridium oxide electrodes,” *IEEE Transactions on Biomedical Engineering*, vol. 47, no. 7, p. 911, 2000.
[2] Robblee, Lefko, and Brummer, “Activated Ir: An Electrode Suitable for Reversible Charge Injection in Saline Solution.” .
[3] Schuettler, Doerge, Wien, and Becker, “Cytotoxicity of Platinum Black,” 2005.
[4] M. S. Chandrasekar and M. Pushpavanam, “Pulse and pulse reverse plating–Conceptual, advantages and applications,” *Electrochimica Acta*, vol. 53, no. 8, pp. 3313–3322, 2008.
[5] “The Theory behind Pulse Plating Reversal Current - Web Exclusives - CircuiTree.” [Online]. Available: http://www.circuitree.com/Articles/Web_Only_Editorial/6ef3097bf18d7010VgnVCM100000f932a8c0____. [Accessed: 07-Jan-2011].
[6] J. E. Ferguson, C. Boldt, and A. D. Redish, “Creating low-impedance tetrodes by electroplating with additives,” *Sensors and Actuators A: Physical*, vol. 156, no. 2, pp. 388–393, 2009.
[7] Ferguson, Boldt, and Redish, “Low Impedance Tetrode plating procedure.” .
[8] S. A. Desai, “Improving impedance of implantable microwire multi-electrode arrays by ultrasonic electroplating of durable platinum black.”
[9] Gregoire, “Determining Shorted Electrodes with the nanoZ.” Neuralynx.