Low-Impedance Tetrode Plating Procedure

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Here is the detailed procedure for creating low-impedance coatings on tetrodes. If you use this method in your research, please cite our paper "**Creating low-impedance tetrodes by electroplating with additives**" by John E. Ferguson, Chris Boldt, and A. David Redish. It is currently in press in *Sensors and Actuators A: Physical*.

We used tetrodes made from Kanthal's 12.7-µm Rediohm-800 wire. If you use another wire diameter, wire material, or type of electrode, you may need to modify some of the plating parameters to obtain optimal results.

Cutting:

-Extend a tetrode to project directly at the lens of a stereo microscope.
-Focus on the tip using at least 80X magnification.
-Use scissors to make a cut perpendicular to the tetrodes length, removing the tip.
We have found FST micro-serrated stainless-steel scissors (14054-13) to produce clean cuts—especially when the tetrode is placed within the notch of a serration.
-Refocus, inspect, and re-cut until an acceptable tetrode cross-section is obtained.
Look for four circular wire cross-sections and for uniform insulation between the wires. Common failures include wires with unequal diameters, damaged wires or insulation, and wires pinched together.

Preparing the equipment and plating solution:

-Use a controlled current source and an impedance tester.
We used a World Precision Instruments Stimulus Isolator (model A365D) connected to the input of a Bak Electronics Metal Impedance Tester (model IMP-1).
-Set the stimulus isolator to output a unipolar 0.1 µA direct current.
-Extend two insulated leads, each terminating in a 25mm-long (0.25mm diameter) bare Pt/Ir wire.
-Combine 0.375mL SIFCO 5355 Non-Cyanide Gold Plating Solution and 1.125mL inhibitor solution [either (Cheap Tubes, Dispersed MWNTs, 95wt% <8nm, 1g/liter concentration, DI water solvent, PVP surfactant) or (Fisher Scientific or Sigma-Aldrich, PEG 8000 MW, 1g/liter concentration, DI water solvent)] within a 1.5mL centrifuge tube.
-Sonicate or vortex the electroplating solution for one minute.

Cleaning and Plating:

-Insert a Pt/Ir lead 15mm into the electroplating solution.
-Immerse the tetrode tip in the electroplating solution.
(1) Clean the tetrode by applying a one-second 0.1 µA unipolar DC pulse to each wire of the tetrode (with the lead in solution assigned positive polarity)
-Resultant impedance values should be 2 to 3 MΩ

(2) Use up to 15 second current pulses, switching channels after each pulse, to gradually and uniformly reduce the impedances across the tetrode. Plate each wire within the tetrode to 2MΩ, and then to 1.5MΩ.
(3) Use up to 5 second current pulses, switching channels after each pulse, to gradually and uniformly reduce the impedances across the tetrode. Plate to 1MΩ, and then to 500kΩ.
(4) Use up to 2-3 second current pulses, switching channels after each pulse, to gradually and uniformly reduce the impedances across the tetrode. Plate to 250kΩ, and then to 100kΩ.
(5) Use up to 1-2 second current pulses, switching channels after each pulse, to gradually and uniformly reduce the impedances across the tetrode. Plate to 70kΩ.
(6) Use one-second or shorter current pulses, switching channels after each pulse, to gradually and uniformly reduce the impedances across the tetrode. Plate to 60-50-40-30kΩ.
(7) After plating, soak the tetrode in DI water for five minutes (to remove traces of the electroplating solution) and then air dry. Finally, use the impedance tester to check for shorts.

Plating Notes:

-To reach the same impedance value with all four tetrode wires at each plating step, the pulse durations can be varied across channels as long as the max recommended duration is not exceeded.
-If the tetrode wires resist impedance reduction even after repeated pulses, then briefly withdraw the tetrode from the electroplating solution and reinsert.
-While we found plating to be easier to control with only one tetrode in solution at a time, improved cycling speed and efficiency may allow for multiple tetrodes to be plated in parallel.