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Electroplated Iridium Oxide
EIROF

Product Information and Properties

BACKGROUND

Thin films of hydrated iridium oxide are used as low-impedance coatings for neural stimulation and recording electrodes. The iridium oxide provides a means of injecting charge into tissue while minimizing electrochemically irreversible processes at the electrode-tissue interface where reduction and oxidation reactions occur to mediate between electron flow in the external circuit and ion flow in the tissue. Iridium oxide electrodes have been used in animal studies for stimulation in the sacral spinal cord [1], the cochlear nucleus [2], and in the cortex [3]. A clinical study of microstimulation in the human occipital cortex using iridium oxide electrodes has also been described [4].

Iridium oxide coatings are formed on electrodes by four different processes. For neural stimulation or recording electrodes, iridium oxide is most commonly, formed from Ir metal in an aqueous electrolyte by an activation process in which the electrochemical potential of the metal is cycled or pulsed between negative and positive potential limits close to those for electrolysis of water.[5,6] Iridium oxide formed in this way is often called AIROF (Activated IRidium Oxide Film). Other methods of preparing iridium oxide for physiological applications have included thermal decomposition of iridium salts to form thermal iridium oxide films (TIROFs) [7] and reactive sputtering to form sputtered iridium oxide films (SIROFs) [8]. TIROF has similar electrochemical behavior and charge injection capabilities to AIROF. SIROF is substantially denser than AIROF or TIROF and, while mechanically robust, has low charge injection capacity and higher impedance. Recently EIC Laboratories has introduced a process for direct electrochemical deposition of iridium oxide onto metals. The electrodeposited iridium oxide films (EIROFs) are similar in behavior to AIROF.

EIROF: Substrates and Geometry for Coating

EIROF can be deposited on the following metal substrates:

- Gold,
- Platinum,
- Platinum-iridium alloys,
- Stainless steel (316LVM),
- Carbon

Typical range of substrate geometries:

- Electrode area: ~50 μm^2 to >25 cm^2
- Electrode shape: no restriction

Suitable electrode structures:

- Wires
- Metallized flexible polymers
- Metal ribbons
- Micromachined silicon

EIROF: Electrochemical Characteristics

The thickness of an iridium oxide is usually reported as the charge per unit area associated with the reaction $Ir^{3+} \Leftrightarrow Ir^{4+} + e^-$. The charge is measured from the time integral of the cathodic current flow during a slow-sweep-rate cyclic voltammogram and is called the cathodic-charge-storage-capacity (CSC_c). Adherent EIROF can be deposited with a CSC_c of at least 30 mC/cm^2 on most suitable metals. Higher CSC_c values are not generally useful for physiological applications.

An example of a cyclic voltammogram (CV) of EIROF deposited on a platinum electrode is shown in Figure 1. The CV was acquired in phosphate buff-

buffered saline (PBS) at a sweep rate of 50 mV/s. The EIROF has a CSC_c of 25 mC/cm^2.

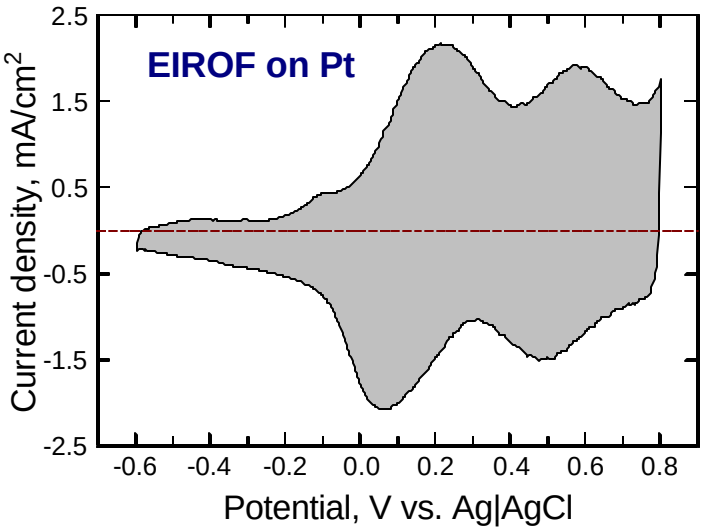

FIGURE 1

The impedance of 25 mC/cm^2 CSC_c EIROF measured in PBS over a frequency range of 0.05 Hz to 10^5 Hz is shown in Figure 2. The impedance modulus decreases by a factor of 10 or more at frequencies lower than 10^3 Hz.

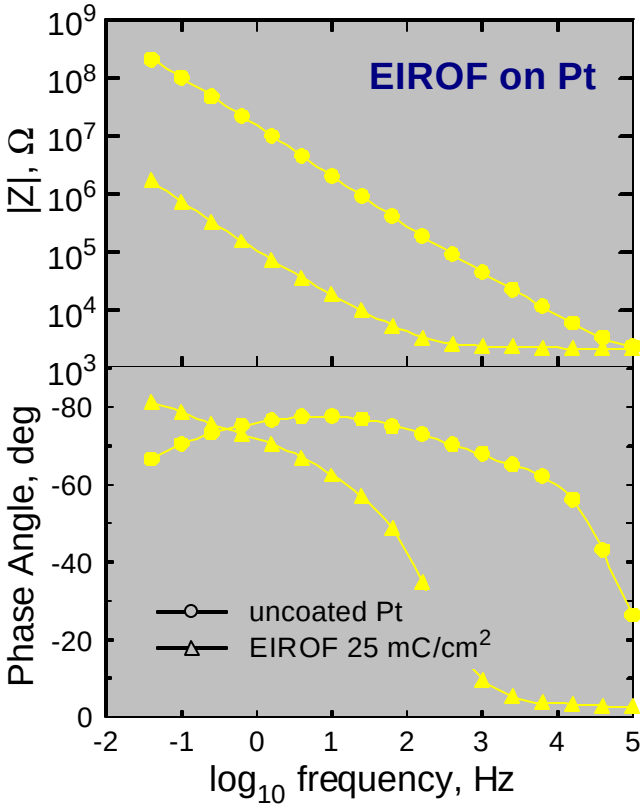

FIGURE 2

EIROF: Stability and other properties

EIROF has similar mechanical properties to AIROF. It will tolerate ultrasonication in water and repeated drying and rehydration. EIROF can be sterilized by ethylene oxide, isopropanol or autoclaving. EIROF cannot by subjected to dry heat over 125°C.

Charge injection limits for EIROF are similar to AIROF [5], varying from 1-3 mC/cm^2 with 0.2 ms pulses depending on the charge injection protocol. EIROF has been subjected to 30 x 10^6, 1.2 mC/cm^2 charge injection pulses with <10% loss of CSC_c.

For more information about EIROF coating services at EIC please contact:

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