Stimulation and Recording Electrode Coatings
Polymer and Thin-film Encapsulation
Coatings and Characterization from EIC Biomedical

**Neural Recording and Stimulation Electrodes**

EIC Biomedical provides electrode coatings and electrode characterization services for application in medical devices and biomedical research. The company specializes in electrochemically active coatings that provide a low impedance interface to the body. Applications include neural recording and stimulation in the brain, sensory prostheses for vision and hearing loss and peripheral nerve stimulation [1].

**Electrode Coatings**

<table>
<thead>
<tr>
<th>Metals</th>
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<tbody>
<tr>
<td>Iridium</td>
</tr>
<tr>
<td>Platinum</td>
</tr>
<tr>
<td>PtIr-alloys</td>
</tr>
<tr>
<td>Gold</td>
</tr>
<tr>
<td>Titanium, Tantalum</td>
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</tbody>
</table>

**Iridium Oxides**

- Sputtered iridium oxide (SIROF)
- Activated iridium oxide (AIROF)
- Electrodeposited iridium oxide (EIROF)

**Other Coatings**

- Titanium nitride (fractal)
- Poly(ethylenedioxythiophene) PEDOT

Electrode coatings can often be deposited on customer-supplied electrodes and electrode arrays. EIC Biomedical also offers electrode coatings on a variety of substrates including silicon, glass, polyimide, Parylene-C, liquid crystal polymer, and metal wire and foil. On planar substrates electrode coatings and interconnect metallization are patterned by standard photolithographic and thin-film processing techniques.

**Encapsulation Materials**

EIC Biomedical provides a wide range of encapsulation coatings for implantable devices including polymer and inorganic dielectrics. The inorganic dielectrics include amorphous silicon carbide (a-SiC) and oxycarbide (a-SiOC) both of which show superior stability and barrier properties in physiological saline environments [2].

**Encapsulation Coatings**

<table>
<thead>
<tr>
<th>Polymers</th>
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<tbody>
<tr>
<td>Polyimide</td>
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<tr>
<td>Parylene-C</td>
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<td>Silicones</td>
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<table>
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<th>Inorganic Dielectrics</th>
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<tr>
<td>Silicon carbide (a-SiC)</td>
</tr>
<tr>
<td>Silicon oxycarbide (a-SiOC)</td>
</tr>
<tr>
<td>Silicon nitride and silicon oxide</td>
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</table>

**Testing Capabilities**

Extensive electrochemical testing is available at EIC Biomedical. Standard electrochemical testing includes:

- Cyclic voltammetry
- Electrochemical impedance spectroscopy
- Voltage transients and charge-injection capacity during stimulation pulsing
- Long-term *in vitro* pulsing for electrode stability studies
- Corrosion and dissolution rate measurements
- Potentiodynamic polarization
- Chronoamperometry for biosensor studies

Analytical techniques for electrode and coating characterization also include:

- Scanning electrode microscopy with energy dispersive x-ray chemical analysis
- Surface profilimetry
- IR and UV-VIS spectroscopy, NMR, HPLC, GCMS

Sputtering, PECVD, e-beam and RIE systems in the cleanroom
Long-term Testing

Electrodes are tested for extending periods at 37°C in electrolytes that closely match the inorganic constituents of interstitial and cerebrospinal fluid [6]. Stimulation electrodes are pulsed with multichannel stimulators provided by EIC Biomedical when appropriate or with pulse generators provided by the customer. Electrodes are periodically characterized by CV, EIS, and potential transient measurements and test electrolytes can be analyzed for electrode dissolution products.

EIC Biomedical also provides long-term and accelerated testing of electrode structures and encapsulation. Encapsulation is characterized by leakage current measurements at 37°C in buffered physiological saline, often under continuous voltage bias.

Coating and Testing at EIC Biomedical

EIC Biomedical works to develop coating and testing programs that precisely meet customer needs, including:

- consulting on materials selection and test methods
- development of written specifications and procedures
- electrode coating and patterning
- electrochemical and physical characterization process documentation and reporting.

For more information, please contact us at:

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fax (781) 551-0283

www.eicbiomedical.com

Limitations

The suitability and safety of coatings provided by EIC Biomedical for any intended application is the responsibility of the end-user. The end-user is cautioned that the long-term stability and performance of any coating will vary with the material, geometry and size of coated substrates, on the manner in which the coatings are used, the medium in which the coatings are used; and other factors that may not be readily predicted. Likewise, test results provided by EIC Biomedical will not establish the suitability or safety of test articles for medical or other applications. The use of test results and test articles for any intended application is the responsibility of the end-user. The end-user is cautioned that the results of in vitro testing do not establish in vivo safety.

Useful additional scientific literature


Additional information and literature sources.

From EIC Biomedical see,

- Sputtered iridium oxide, DS01-2008A-0 SIROF
- Activated iridium oxide, DS02-2008A-0 AIROF
- Silicon carbide dielectrics, DS03-2008A-0 SiC
- Electrodeposited iridium oxide, DS04-2008A-0 EIROF
- Evaluation and Testing, DS06-2008A-0
- Multielectrode polyimide arrays, DS07-2009A-0 MEA

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**Supplementary Table:**

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<tr>
<th>Electrode</th>
<th>( Q_{\text{inj}} ) mC/cm(^2)</th>
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**Analyzing voltage transients**

Charge-injection capacities \( Q_{\text{inj}} \) of stimulation electrode coatings

**Figure:**

**Charge-injection capacities (\( Q_{\text{inj}} \)) of stimulation electrode coatings**

**Electrode** | \( Q_{\text{inj}} \) mC/cm\(^2\) | **Ref** | **Comments**
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**Analyzing voltage transients**

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**Useful additional scientific literature**

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**Additional information and literature sources.**

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**Useful additional scientific literature**


Neuroprosthetics: Theory and Practice (Series on Bioengineering & Biomedical Engineering - Vol. 2), by KW Horch (Editor), G. Dhillon (Editor) World Scientific Publishing Company (April 2004)


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