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BENJAMIN M. STATLER COLLEGE OF ENGINEERING AND MINERAL RESOURCES

MATERIALS SCIENCE AND ENGINEERING (MS&E) SEMINAR SERIES
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Sputtered Electro-active Coatings for Neural Stimulation and Recording

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Abstract: There is growing interest in multielectrode arrays that electrically record and stimulate neural activity with a spatial selectivity that is on the order of a single cell or nerve fiber. Emerging applications, particularly those employing neural recording for volitional control or neural stimulation for somatosensory feedback, also contemplate multielectrode arrays with hundreds and likely thousands of individually addressable electrodes. Because these electrodes have a small surface area (<2000 μm^2), they are typically coated with an electrode material that is capable of delivering charge to neural tissue via reversible reduction-oxidation reactions that are confined within the three-dimensional structure of the electrode coating. These coatings, typified by sputtered iridium oxide (SIROF), are on the order of 100-1000 nm thick. To achieve a low impedance for recording and high levels of charge-injection at high current densities for stimulation, the coatings are hydrated, mixed electron-ion conductors with a density that is usually <70% of bulk crystalline values. Sputter deposition methods for achieving the desired electrochemical properties of these neural electrode coatings through control of film morphology, density and, when appropriate, hydration are described. Emphasis is placed on SIROF and comparatively new electrode coatings based on ruthenium oxide and mixed oxides of ruthenium and titanium. The use of reactive plasma constituents, derived from hydrogen/oxygen or water/oxygen gas mixtures during sputtering, is discussed as a means of controlling the redox characteristics of the oxides. The manner in which the plasma chemistry might control the properties of the SIROF and ruthenium oxide films is investigated through optical emission spectroscopy and mass spectroscopy (RGA), using x-ray diffraction, XPS, and Raman spectroscopy, as well as electrochemical measurements, to characterize the electrode coatings. In addition, the neural stimulation properties of the oxide-based electro-active coatings are compared with those of alternative coatings such as high-surface-area sputtered titanium nitride (TiN) and porous platinum.

Bio: Dr. Cogan is Professor of Bioengineering at The University of Texas at Dallas, where he conducts research on neural stimulation and recording with an emphasis on thin-film electrodes, materials, and devices. His current research focuses on the development of multielectrode arrays based on amorphous silicon carbide and the application of ultra-microelectrodes as neural interfaces for the brain and peripheral nerve. Prior to joining the UT Dallas, Dr. Cogan was Vice President and Director of Advanced Materials Research at EIC Laboratories. Dr. Cogan received a B.Sc. degree in mechanical engineering and a M.S. degree in materials science from Duke University in 1975 and 1977, respectively. He obtained a Sc.D. from the Massachusetts Institute of Technology (MIT) in 1979. Dr. Cogan was a Visiting Assistant Professor in Mechanical Engineering and Materials Science at Duke University from 1979 to 1980, where he worked on amorphous semiconductor materials for solar cells. He returned to MIT as a Research Associate in 1981. His research at MIT focused on micro-filamentary, metal matrix composites for compound superconductors. In 1983 he joined EIC Laboratories. His research interests have included thin-film electrochromics for optical switching devices and coatings, materials for encapsulating implanted medical devices, and thin-film electrode materials for stimulation and recording in prosthetic and pacing applications.

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