Iridium-Ruthenium Oxide Coatings as High-Charge-Injection Neural Stimulating Electrodes

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Neural stimulation is one of the emerging clinical procedures applied for the treatments of various neurological disorders or spinal cord injury-related diseases, such as Parkinson's, epilepsy, Alzheimer's, uncontrolled night urination. In addition, neural electrodes are used for interfacing the brain with artificial limbs, vision restoration and other sensory deficits. Basically, the implanted neural electrodes enables the transfer of information between an artificial device and the nervous system by acting as a bridge between two different sources, the external electronic control device and the human biological system. Much attention has been given to the design/functionality of neural stimulating electrodes regarding its size, sensitivity, reaction to human tissue, its stability, service time and fouling, etc.

Stimulus selectivity is one of the major issues in the clinical applications of neural stimulating electrodes. This occurs mostly during the activation of neurons, and is the result of the imperfect size of the implanted neural stimulating electrode relative to the targeted neighboring neuronal population. Hence, neural electrodes should be of small size, but should have the capability of delivering sufficiently high charge density for the neural stimulation, without causing any negative side effects to the functionality of neurons and the surrounding tissues. Controlled and safe neural stimulation can be achieved by avoiding any unwanted reactions such as water electrolysis, gas evolution, or metal dissolution if sufficient charge injection is done within the safe limits.

The aim of the work was to develop new oxide-based coatings for stimulating neural electrodes that would offer higher intrinsic and extrinsic charge injection (delivery) than currently-available stimulating electrodes. This would enable miniturization of the electrodes, and also narrow down the cyclization potential limits, thus decreasing the negative effect of the stimulating electrodes to the surrounding tissues. The initial development of the coatings was based on producing Ir/Ru oxide coatings of various compositions, prepared by thermal decomposition on a Ti substrate. Electrochemical study showed that specific Ir/Ru-Ox coatings offered a significantly larger electrochemically-active surface area than the currently used state-of-the-art, Ir-oxide (control). These binary coatings were also capable of delivering significantly higher charge than the control, both from the intrinsic and extrinsic point of view. The produced coatings were demonstrated to be stable, with improved charge-delivery performance with cycling use, due to the gradual increase in surface roughness. The biocompatibility of these electrodes is evaluated by *in vitro* experiments using a cortical cell culture.