Bio-Fuel Cell Operational Enhancements using Nanoscale Electrodes

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There is tremendous interest in developing a high power bio-fuel cell for bio implants such as: targeted drug delivery, physiological monitoring and control, synthetic organs, prostheses, and other advanced medical devices, which include pacemakers, insulin pumps, glucose and pressure sensors, and bionic devices for stimulating the brain and spinal cord [1]. In addition, bio-fuel cells are also being investigated for commercial mobile applications such as: smartphones, tablets, and laptops. Bio-fuel cells have the advantage that they produce electricity from glucose and oxygen, both of which are cheap and readily available. In the case of bio implants, both glucose and oxygen are available in the blood stream, allowing for self-powered devices. Despite their tremendous potential, they have not been able to achieve high power densities due to internal losses [2]. Here we present a novel planer device based on single walled carbon nanotubes and enzymes with a cathode/anode separation of 2 microns. These devices are the smallest fuel cells reported to date. The devices are fabricated using standard CMOS (Complementary Metal–Oxide–Semiconductor) technology, allowing them to be easily integrated with microchips. Considering the active area of nanotube, our fuel cells achieve one of the highest reported open circuit voltages of approximately 1V with current and power densities approaching $1A/cm^2$ and $30mW/cm^2$. The exceptional performance is attributed to the minimization of the ohmic losses due to the close electrode spacing. These devices can easily be scaled up for high demanding power applications such as bio implants, advanced medical devices, and mobile devices. They can also be scaled down to power individual transistors in integrated circuits.

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