MAR05-2004-000218

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Design of a High-resolution Optoelectronic Retinal Prosthesis

DANIEL PALANKER, Dept. of Ophthalmology and Hansen Experimental Physics Lab, Stanford University

It has been demonstrated that electrical stimulation of the retina can produce visual percepts in blind patients suffering from macular degeneration and retinitis pigmentosa. So far retinal implants have had just a few electrodes, whereas at least several thousand pixels would be required for any functional restoration of sight. We will discuss physical limitations on the number of stimulating electrodes and on delivery of information and power to the retinal implant. Using a model of extracellular stimulation we derive the threshold values of current and voltage as a function of electrode size and distance to the target cell. Electrolysis, tissue heating, and cross-talk between neighboring electrodes depend critically on separation between electrodes and cells, thus strongly limiting the pixels size and spacing. Minimal pixel density required for 20/80 visual acuity (2500 pixels/mm2, pixel size 20 um) cannot be achieved unless the target neurons are within 7 um of the electrodes. At a separation of 50 um, the density drops to 44 pixels/mm2, and at 100 um it is further reduced to 10 pixels/mm2. We will present designs of subretinal implants that provide close proximity of electrodes to cells using migration of retinal cells to target areas. Two basic implant geometries will be described: perforated membranes and protruding electrode arrays. In addition, we will discuss delivery of information to the implant that allows for natural eye scanning of the scene, rather than scanning with a head-mounted camera. It operates similarly to "virtual reality" imaging devices where an image from a video camera is projected by a goggle-mounted collimated infrared LED-LCD display onto the retina, activating an array of powered photodiodes in the retinal implant. Optical delivery of visual information to the implant allows for flexible control of the image processing algorithms and stimulation parameters. In summary, we will describe solutions to some of the major problems facing the realization of a functional retinal implant: high pixel density, proximity of electrodes to target cells, natural eye scanning capability, and real-time image processing adjustable to retinal architecture.