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An active pixel sensor and microelectrode array for retinal stimulation

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Degenerative photoreceptor diseases, such as age-related macular degeneration and re-
tinitis pigmentosa, are the most common causes of blindness in the western world. A
potential cure is to use a microelectronic retinal prosthesis to provide electrical stimu-
lation to the remaining healthy retinal cells. Due to the success of cochlear implants in
restoring hearing to the profoundly deaf this is becoming a wide-spread research area.
Here we describe a system capable of detecting the visual scene and translating the
image into a train of electrical pulses that stimulates live retinal tissue. This system
requires a position-sensitive detector to act as a smart retinal chip. We have developed
a CMOS active pixel sensor with a 10 by 10 array of 100μm pixels. Each pixel contains
a photodiode and on-pixel circuitry that translates the intensity of the incoming light
into a certain frequency of output voltage pulses.
The outputs of the pixels are connected to a biocompatible microelectrode array, which
makes contact with the retinal cells. This electrode array has 74-electrodes spaced at
60μm and is fabricated on a flexible polyimide substrate that is only 20μm thick. Each
electrode is a platinum disc of diameter 5μm, which forms the interface to the retinal
cells.
We have verified the electrical contact between the electrodes and the retina by record-
ing the response of the output (ganglion) cells to light. A typical signal to noise ratio
of 30:1 has been achieved with an overall system noise of 5μV rms. Retinal cells of
only 10μm in diameter have been stimulated by a range of voltages from 0.1 to 2V
with pulse durations of 0.1-1μs. The effects of charge spreading within the retina have

been studied and optimal stimulation parameters determined. This system permits the simultaneous stimulation and recording of neural activity on the retina and allows the image processing that occurs within the retina to be studied.

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