SU2P Entrepreneurial Fellows

Case Study:- Keith Mathieson

Title: Towards a retinal prosthesis for the blind

Introduction

Retinal degenerative diseases lead to blindness due to loss of the 'image capturing' photoreceptors, while neurons in the 'image-processing' inner retinal layers are relatively well preserved. Electronic retinal prostheses seek to restore sight by electrically stimulating the surviving neurons. Most implants are powered through inductive coils, requiring complex surgical methods to implant the coil-decoder-cable-array systems that deliver energy to stimulating electrodes via intraocular cables.

During my SU2P fellowship at Stanford I worked in the group of Prof Palanker. We developed a photovoltaic subretinal prosthesis, in which silicon photodiodes in each pixel receive power and data directly through pulsed infrared (IR) illumination and electrically stimulate neurons. It represents a step forward in the field and is attracting significant commercial interest.

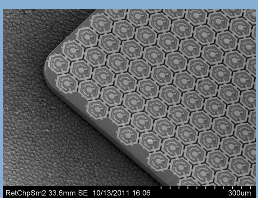
Project

The aim of the fellowship was to develop the implant device, test the system and compare how healthy and diseased retinas respond to IR-induced electrical stimulation. Over the course of the SU2P fellowship I led a team that microfabricated a silicon photodiode device (see figure) thin enough (30 microns) to be implanted in the subretinal space and capable of activating diseased retina. We examined how retinal tissue responded to in-vitro IR-induced electrical stimulation from this device. We were able to illuminate the device with a dynamic image and monitor the response of the retinal output cells, the RGCs. We discovered that we were activating inner retinal neurons and could elicit responses at IR intensities two orders of magnitude below the safety limits in both healthy and diseased retina. The success of the in vitro studies allowed us to progress to in vivo experiments, where we were able to record visually evoked potentials in blind rats implanted with a prosthesis.

Benefit

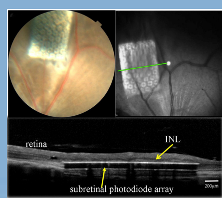
There has been significant benefit to my career in that it allowed me to establish international connections and improve my academic track record. This has led to me being appointed to a senior position at the University of Strathclyde (Head of Institute of Photonics) and allowed me to establish my own research group back in the UK that builds upon the research direction initiated by the SU2P fellowship.

The potential benefit to society from this is work is demonstrated by the fact that degenerative retinal diseases are the leading causes of blindness in the western world and places a significant burden on the NHS. The development of an implant to restore a degree of vision to patients could have a substantial effect of the quality of life to the patient. The commercial aspects of the device are currently being explored. There are several companies worldwide developing retinal implants and this technology offers a powerful and simplified approach to activating retinal neurons in diseased retinas.



Left: The microfabricated prosthesis device, showing the array of IR-sensitive diodes capable of retinal stimulation.

Right: Fundus and optical coherence tomography images of the device implanted in vivo.



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