The Application of Thin Film Transistors (TFTs) used in Assisting the Human Eye

Introduction

Sight is one of the most valuable human senses and is imperative to our survival in nature. As a consequence, several research groups are developing artificial implants to improve or restore sight. In recent years the combination of increased life expectancy, and retinal degeneration in elderly people, has resulted in an increased demand for research in the field of retinal prosthesis. In Germany, 17,000 people become blind annually, for whom there are no easy cures. Additionally, 50% of blindness related conditions are caused by damage to the retina, of which all can benefit from retinal prosthesis [1].

Background

There are two types of implants; subretinal and epiretinal [2]. The main differences between them are their sensitivity to light, and how far embedded they are into the retina. Subretinal implants can interpret their own signal and send it to existing, intact cells. However, the epiretinal implant requires an external device to convert light into electrical signals. As a result, it does not require a remaining network of optical sensing cells. Both types will benefit people with varying severities of blindness.

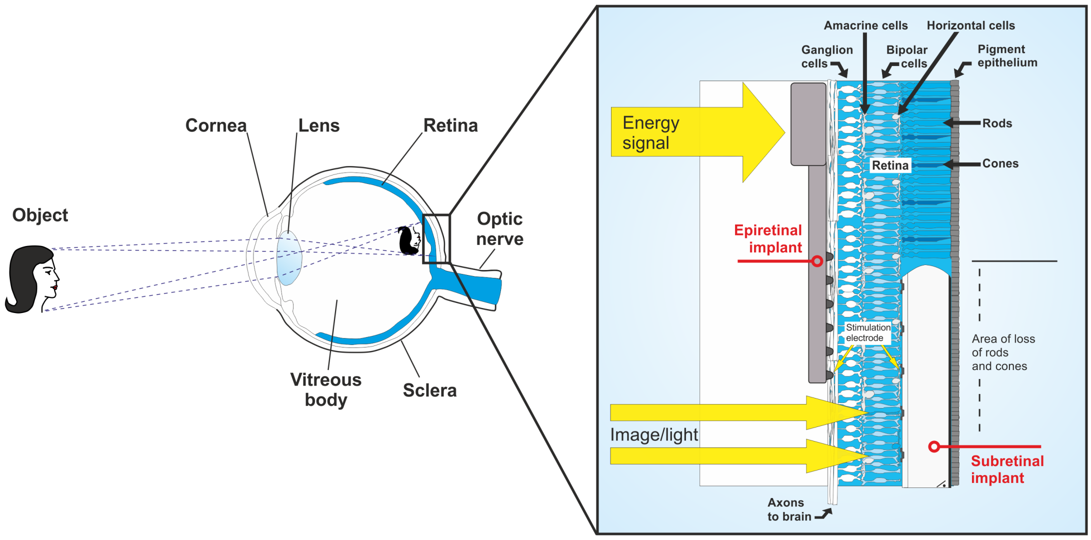

Figure 1: This shows where a subretinal or epiretinal device would go (labelled in red) and the structure of the cells in a retina [3]. Rods and cones are types of photoreceptors.

Definitions

Photoreceptors: cells in the retina that detect light.
Retina: a section of tissue at the back of the eye that is packed with Photoreceptor cells (figure 1).
Conductors: a type of material that allows electricity to flow; these are almost always metals.
Crystals: a substance with its atoms arranged in a repeating structure.
Doping: is a process involved in the production of semiconductors, it changes the electrical properties of a material by introducing one or more impurity(s).

Technical Information

The critical component in the manufacture of the implant is the phototransistor, its job is to detect variations in light intensity and output a corresponding signal. The signal is interpreted as an image. There are various types of phototransistors used in retinal implants, most are made using silicon that exhibits crystalline properties [4]. These properties allow for control of the current flowing through the circuit, which is dependent on factors such as light and temperature [5]. This is not possible for typical conductors. Silicon is often doped with small amounts of impurities that change the total charge. For example, Aluminium doping of poly-Si (polycrystalline silicon) decreases the operating voltage making the TFT more sensitive in low light conditions [6].

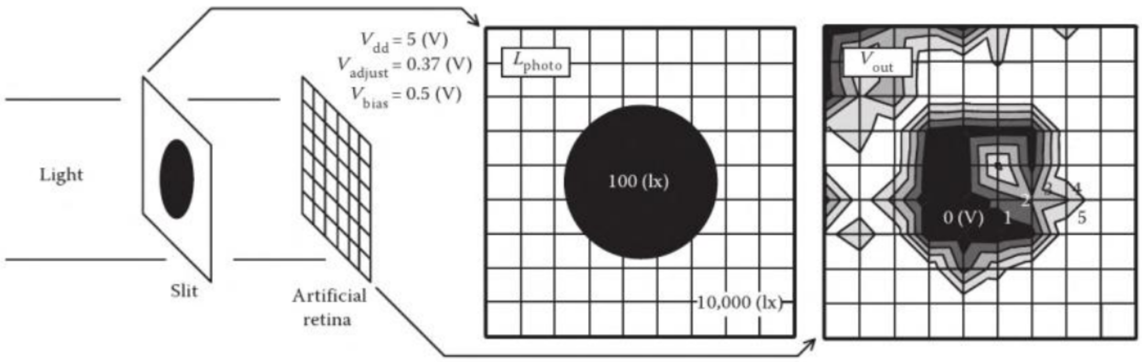

Figure 2: A diagram of a grid of pixels/TFTs in the implant, detecting a circle of light. Imperfections can be seen in the detected image due to deviations in doping the silicon [7].

TFTs in the implant are arranged as a grid shown in figure 2, to create a screen where each transistor corresponds to a single pixel. After the implant has converted light into electrical signals, it then communicates with the ganglion cells located in the retina (figure 1). These cells are responsible for sending the image received by the implant to the brain [8]. Recent achievements include the manufacture of flexible TFTs and the ability to make them transparent [9]. Implants also no longer need batteries because magnetic resonance coupling allows wireless powering. As a result, the amount of artificial material necessary in the eye is dramatically reduced [10], decreasing the risk of infection. Long term biocompatibility is one of the most vital issues to tackle in the future, as potential side effects are yet to be determined due to insufficient long term studies. The technology in this field is advancing closer to what is considered normal vision but still needs extensive research to overcome challenges.

Clinical Trials

The Argus II implant is the first approved in Europe and the US, out of 30 subjects in a trial lasting up to 38 months, 27 of them experienced improvements and went on to use it in their daily lives [11]. The trial included identification of household objects, movements and characters. Unfortunately, only a minute proportion of subjects were capable of this. Since most patients had lacked visual function decades prior, any increase in the ability to see was still a significant step forward.

Conclusion

In recent years, as nutrition and medicine have advanced, the average life expectancy has risen dramatically. However, the quality of life at the later stages decreases, and visual deterioration is a main cause. The ability to be independent and active at an old age is a substantial contributor to positive mental health [12]. Further research into retinal prosthesis and crystalline silicon will improve the quality of life for many people - not just the elderly, thus alleviating stress on our healthcare system. In the future, the implant could one day be used to not only restore sight, but to enhance it.

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