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Bionic Eye: Retinal Prosthesis to Restore Eyesight

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ABSTRACT*:*Retinal prostheses is a promising technique to restore eyesight from ophthalmic diseases, such as age-related macular degeneration (AMD) and retinitis pigmentosa (RP), by replacing damaged living photoreceptor cells with electronic photo devices and photo-sensing circuits. Some conventional retinal prostheses require external cameras, and the eyeball direction is different from the view direction, although some proposals are presented.
The outstanding advantages of Retinal Prosthesis are:thin-film photo-transistors are integrated to remove the external camera. To make the eyeball direction and view direction the same, a transparent substrate is employed to achieve the epiretinal implantation smartly and wireless power transfer is adopted to remove the wired connection between inside and outside of the body. It should also ensure the QOL. In this paper, the epiretinal implantation technique of the retinal prosthesis using the thin-film devices on the transparent substrate and wireless power transfer is designed. Because the transparent substrate is employed so that the illuminating light can be irradiated from one direction of the retinal prosthesis and the stimulating signal can be sent to the other direction, epiretinal implantation technique can be smartly achieved.

KEYWORDS:—Retinal prosthesis technique , thin film devices, transparent substrates, wireless power transfer.

I. INTRODUCTION

Retinal prostheses is a promising technique to restore Eyesight for visually impaired people who suffer from ophthalmic diseases, such as age-related macular degeneration and retinitis pigmentosa, by replacing damaged living photoreceptor cells with electronic photo devices and photo-sensing circuits. Some of the conventional retinal prostheses require external cameras, and the eyeball direction is different from the view direction, although some proposals are presented. Implantation techniques are classified into three types, Epiretinal implantation technique, Subretinal implantation technique, Suprachoroidaltransretinal stimulation technique. The epiretinal implantation technique has a potential possibility to create high resolution of recognized image because the stimulus electrode is close to neuron cells and the stimulating signal is effectively transmitted to them.
The surgery operation is easy in comparison with the subretinal implantation technique, and the living retina is not severely damaged, although there is still an inevitable problem of the unintended stimulus of axon bundles. Some conventional retinal prostheses also require a wired connection between inside and outside of the body, and the quality of life is seriously impaired. This paper conveys epiretinal implantation technique of the retinal prosthesis using the thin-film devices on the transparent substrate and wireless power transfer is done.

II. RELATED WORK

In this paper, a retinal prosthesis using thin-film devices on a transparent substrate and wireless power transfer is developed. The outstanding advantages of retinal prosthesis are: thin-film photo-transistor is integrated to remove the external camera and make the eyeball direction and view direction the same. A transparent substrate is employed to achieve the epiretinal implantation and wireless power transfer is adopted to remove the wired connection between inside and outside of the body and ensure the quality of life (QOL).In this paper, the device structure and working principle of the retinal prosthesis is explained and confirms the correct operation in a pig eyeball experiment. The operation in a phosphate-buffered saline (PBS) experiment has been published in a paper and the operation in the pig eyeball experiment is published for the first time in this paper.

III. PROPOSED ALGORITHM

A. Design Considerations:

- The retinal prosthesis or bionic eye is implanted on the inside surface of the living retina at the back of the living eyeballs.
- Thin-film photo-transistor is integrated to make the eyeball and view direction the same.

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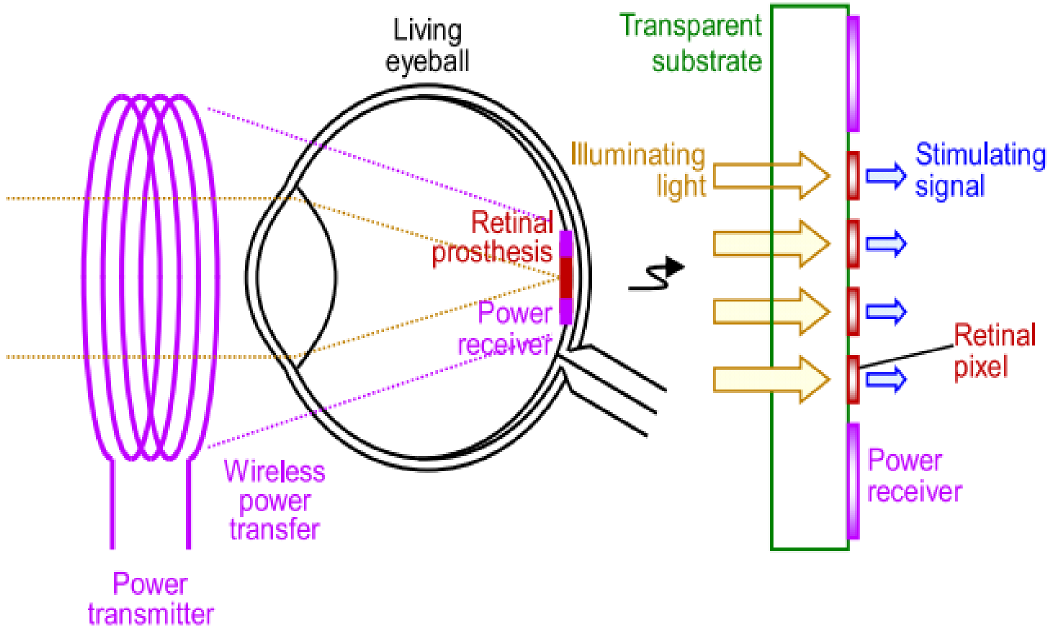
- The transparent substrate is employed so that the illuminating light can be irradiated from one direction of the retinal prosthesis.
- Wireless power transfer is included to remove the wired connection between inside and outside of the body and ensure the QOL(Quality Of Life).

B. Description of the Proposed Algorithm:

The proposed algorithm is consists of three main steps.

Step 1: Retinal Prosthesis

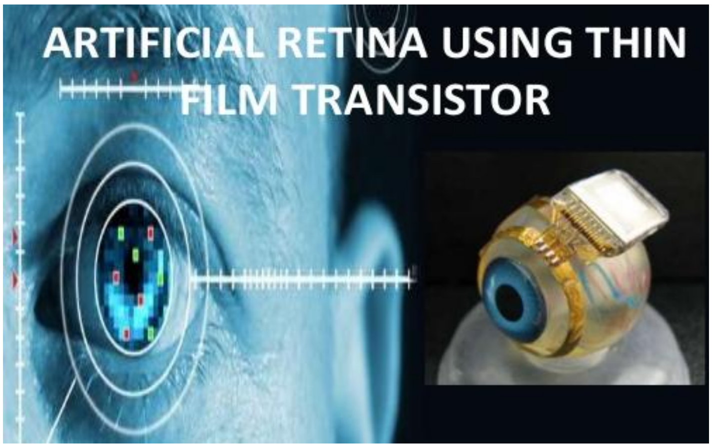
The epiretinal implantation technique of the retinal prosthesis is done using the thin-film devices on the transparent substrate and wireless power transfer. The retinal prosthesis or bionic eye is implanted on the inside surface of the living retina at the back of the living eyeball. The lens and optic nerve of the living eyeball are used as they are for retinal prosthesis. A green board is used to support the retinal prosthesis technique.



The retinal pixels are arrayed on the bionic eye. The lens and optic nerve of the living eyeball are used as they are for the process. As a result, it can be deduced that the retinal prosthesis using the thin-film devices on the transparent substrate and wireless power transfer is one of the ideal forms of retinal prostheses.

Step 2: Thin-film devices:

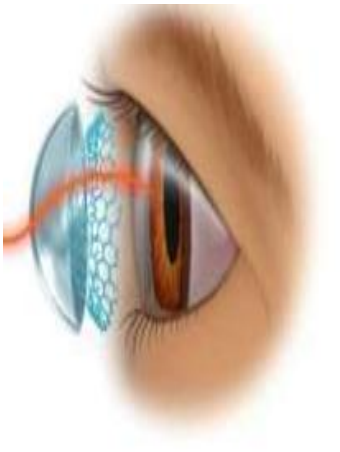
Thin-film photo-transistor is integrated to make the eyeball and view directions the same and the external camera can be removed. A thin-film photo-transistor and photo-sensing circuit using thin-film transistor is included in a retinal pixel. The retinal pixel is encapsulated with SiO_2,which is chemically stable as well as harmless in living bodies.

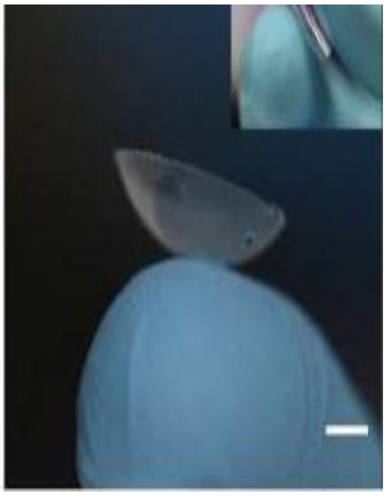


A thin-film photo-transistor and photo-sensing circuit using thin-film transistors are included in a retinal pixel. They are fabricated using low-temperature poly-Si processes, whose maximum temperature is less than 400 ◦C. They are fabricated on a non alkali glass transparent substrate, whose visible light transmittance is almost 100% precision. The thickness is 0.7mm, which is thin enough for the epiretinal implantation technique. The retinal pixel is encapsulated with SiO_2 except for the stimulus electrode, which is chemically stable and also harmless in living bodies. The pixel size is 400 μm square, and also the stimulus electrode size is 140 μm square. The output of the stimulus electrode corresponds to the drain impedance of the thin-film transistor and is in the order of 10 k, which matches roughly that of the PBS.

Step 3: Transparent substrate:

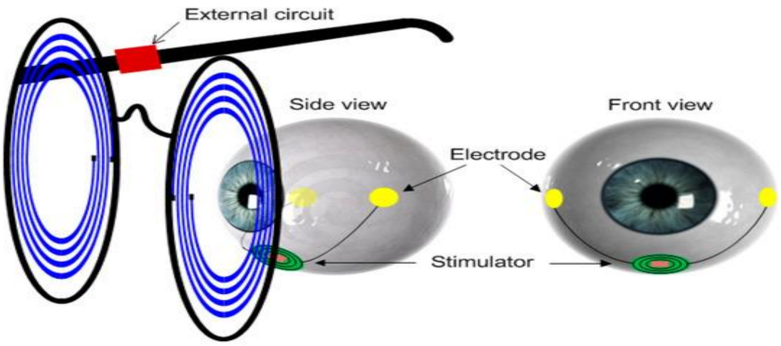
A transparent substrate is employed to achieve the epiretinal implantation. The transparent substrate is employed so that the illuminating light can be irradiated from one direction of the retinal prosthesis and the stimulating signal can be sent to the other direction, epiretinal implantation technique can be achieved.





Step 4: Wireless power transfer

The wireless power transmitter is located on the frame of spectacle. The power receiver is embedded and fabricated simultaneously with the thin-film photo-transistor in the retinal pixels. Wireless power transfer is adopted to remove the wired connection between inside and outside of the body and it also ensures the QOL(Quality Of Life). From these results, it is concluded that the correct operation necessary for a retinal prosthesis as an implanted organ is confirmed and can be executed.



IV. PSEUDO CODE

Algorithm

Step 1: The retinal prosthesis has to be implanted on the inside surface of the living retina at the back of the living eyeballs.
Step 2: The lens and optic nerve of the living eyeball have to be used as they are.
Step 3: A green board is used to support the retinal prosthesis technique.
Step 4: Thin-film photo-transistor has to be integrated to make the eyeball and view directions the same. Thus the external camera is removed.
Step 5: The transparent substrate is employed so that the illuminating light is irradiated from one direction of the retinal prosthesis.Whereas the stimulating signal is sent to the other direction, epiretinal implantation technique is smartly achieved.
Step 6:Wireless power transfer is adopted to remove the wired connection between inside and outside of the body and ensure the QOL(Quality Of Life).
Step 7: From these results, it is concluded that the correct operation necessary for a retinal prosthesis as an implanted organ is confirmed and executed.

V. SIMULATION RESULTS

The simulation result of the pig eyeball experiment is shown in Fig. 7. Here, it is shown when the pig eyeball experiment is executed in a dark or bright atmosphere, where the light illuminance is 12 000 lx roughly. It is found that the stimulating current is 3 μA roughly. The oscillating frequency is dependent on the light illumination, which is within the range, and the stimulating frequency is in the order of several tens or hundreds Hz. Once the stimulating current is an appropriate value, it is clear that the oscillating frequency increases as the light illumination increases, as the oscillating frequency is decided inside the photo-sensing circuit. From the mentioned results, it is concluded that the correct operation necessary for a retinal prosthesis as an implanted organ is confirmed.

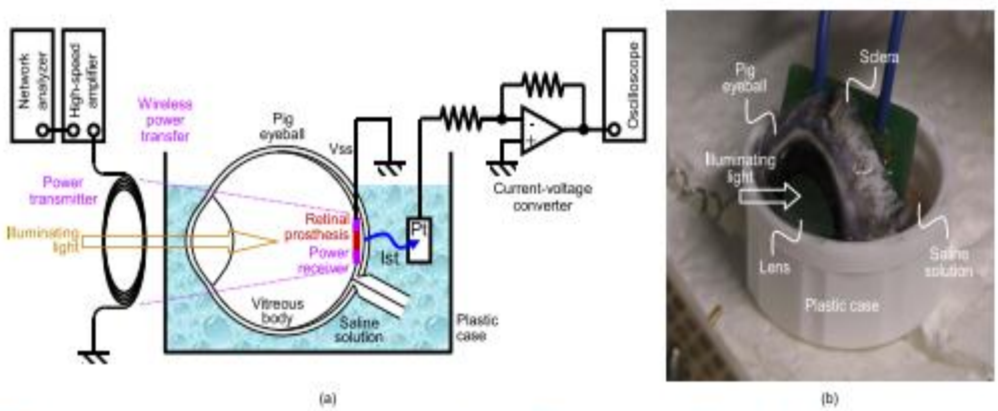


Fig. 6. System schematic and actual photograph of the pig eyeball experiment. (a) System schematic. (b) Actual photograph.

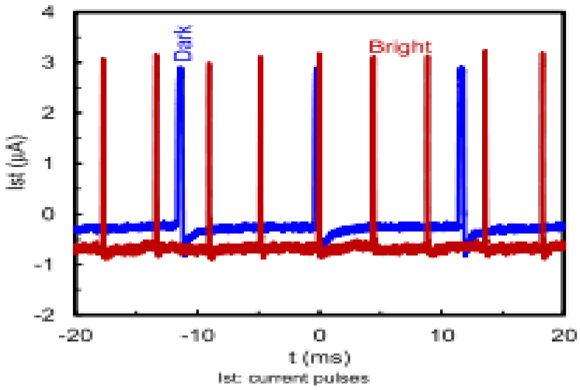


Fig. 7. Experimental result of the pig eyeball experiment.

VI. CONCLUSION AND FUTURE WORK

A retinal prosthesis using thin-film devices on a transparent substrate and wireless power transfer is developed. The outstanding advantages of retinal prosthesis are: thin-film photo-transistor is integrated to make the eyeball and view directions the same, a transparent substrate is employed to achieve epiretinal
implantation technique, and wireless power transfer is adopted to ensure the QOL. Particularly in this paper, a pig eyeball experiment was executed. From these results, it is concluded that the correct operation necessary for a retinal prosthesis as an implanted organ is confirmed. Restoration of sight for the blind is no more a dream, Bionic Eyes have made this true. The application of the research work done is directed towards the people who are visually impaired and of low vision. People suffering from low vision to, people who are completely blind will benefit from this project mentioned in this page. The findings regarding bio compatibility of implant materials will help in other similar attempts for in human machine interface.

A Cyborg Future:Beyond healing blindness, bionic eyes could make us superhuman. A bionic eye could let us see the entire electromagnetic spectrum from radio waves to gamma waves. We would be able to “see” heat identify types of gases by sight even look through walls.We may also be able to zoom in and out of our field of vision, record what we see and automatically sync it to the net with our Wi-Fi- ready eyes.

Visions of The Future:Bionic eye open up an array of applications in several fields: such as Studying microbes could be done without equipment. Soldiers can detect mines in a filed. Manual airport security could beef up surveillance. It is all speculation, but nobody can deny that innovative technology is making science fiction into reality.It may be several decades before we get bionic eyes that perfectly does all the above mentioned functions, until then scientists will be keeping a sharp eye out for every development.

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BIOGRAPHY

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