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Silicon-micromachined Retinal Tacks: An Economical Tool for Artificial Retina Implantation

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SUMMARY

This paper reports silicon-micromachined retinal tacks, which are used to keep the retina attached to the wall of the eye. The developed retinal tacks are mainly intended to fix a stimulating electrode, which is an artificial retina, to ganglion cells or optic nerves, to show that a functionless retina transmits visual signals to the visual cortex. Although conventional retinal tacks made of titanium are available, they are expensive, invasive, and restricted in shape. Silicon micromachining technology, based on semiconductor manufacturing, can mass produce retinal tacks. Furthermore, the tack is easily shaped and the shapes are reproducible. Three types of retina tacks are proposed and fabricated.

Keywords: Silicon-micromachined retinal tack, Artificial retina, Epiretinal stimulation.

INTRODUCTION

Over 10,000,000 people worldwide are blind because of photoreceptor loss due to degenerative retinal diseases such as age-related macular degeneration (AMD) and retinitis pigmentosa (RP). The retinal prosthesis under development is based on the concept of replacing photoreceptor function with an electronic device. Figure 1 shows an example of the schematic diagram of a retinal prosthesis system.

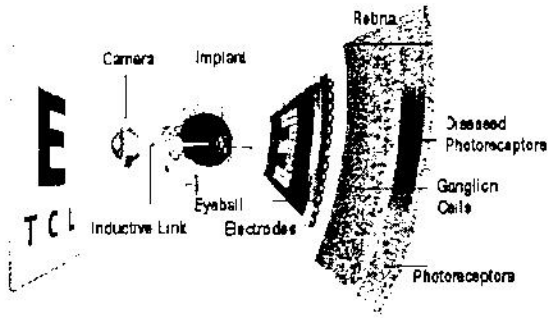


Fig. 1: Schematic diagram of a retinal prosthesis system (adapted from [1]).

Researches on the retinal prosthesis have been reported by many research groups [1-4]. They include artificial retinae by means of epiretinal, subretinal, and visual cortex stimulation. Among these operation methods, epiretinal stimulation needs retinal tacks to fix a stimulating electrode to ganglion cells or optic nerves. Although conventional retinal tacks made of titanium are available, they are expensive, invasive, and restricted in shape. Silicon micromachining technology, based on semiconductor manufacturing, can mass produce retinal tacks. Furthermore, the tack is easily shaped and the shapes are reproducible. This paper reports silicon-micromachined retinal tacks, which are used to keep the artificial retina attached to the wall of the eye.

DESIGN AND FABRICATION

Figure 2 shows an implanted epiretinal electrode made of polyimide and fixed with conventional titanium retinal tacks. The operation is performed on the eye of a rabbit.

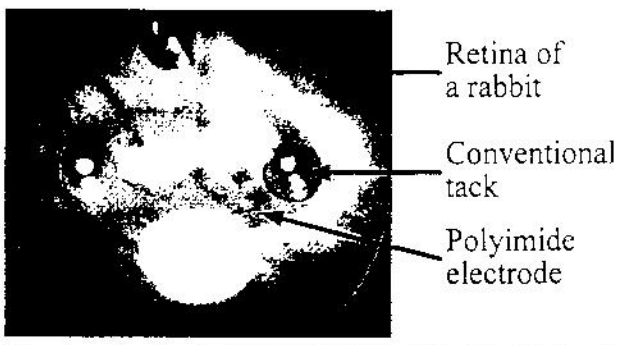
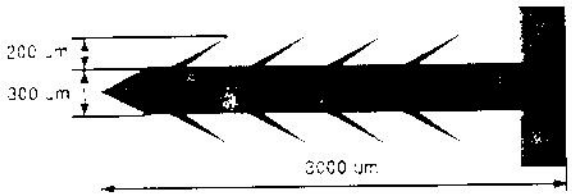


Fig. 2: An implanted polyimide electrode fixed with conventional retinal tacks.

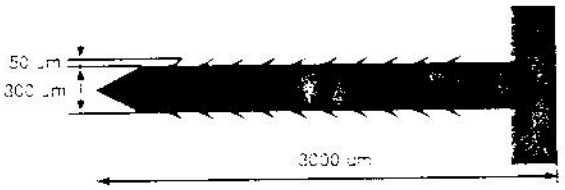
To improve fixing and handling ability of retinal tacks, three types of retinal tacks are proposed as shown in Fig. 3. Each has 3 mm-length and 300 ㎛-width body. The two barbed-wire types are different in the length of the barbs, and the third type is staple shaped.

The fabrication process is very simple as shown in Fig. 4. Silicon dioxide is deposited by PECVD (plasma enhansed chemical vapor deposition), and then the structrure is

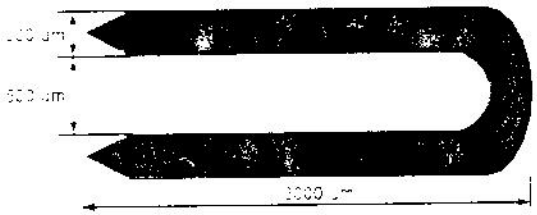
defined by photolithography. After silicon dioxide is etched, deep silicon etch is performed by about 200 ㎛-depth, and another deep silicon etch on the back side of the silicon wafer is done to release the structure.



(a) Type I: long barbed-wire.



(b) Type II: short barbed-wire



(c) Type III: staple.

Fig. 3: Design and dimension of the retinal tack.

(a) Structure define and deep silicon etch. *(b) Deep silicon etch on the back side of the silicon wafer*

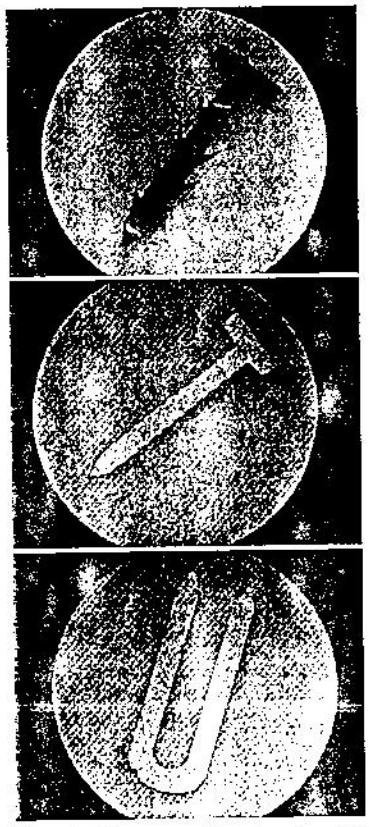
Fig. 4: Process flow

RESULTS AND DISCUSSION

Figure 5 shows some photographs of fabricated retinal tacks. Some of retinal tacks were coated with parylene to enhance chronic biocompatibility. For the purpose of testing the usability of these tacks, operations on the eyes of rabbits are currently being performed. Preliminary results indicate that these retinal tacks are very effective in fixing an epiretinal stimulating electrode.

CONCLUSIONS

Silicon-micromachined retinal tacks, which are used to keep the artificial retina attached to the wall of the eye, are developed. These retinal tacks are intended to fix a stimulating electrode to ganglion cells or optic nerves, to show that a functionless retina transmits visual signals to the visual cortex. Preliminary results indicate that developed retinal tacks are very effective in fixing an epiretinal stimulating electrode.



(a) The photograph of type I, coated with parylene.

(b) The photograph of type II.

(c) The photograph of type III.

Fig. 5: Photographs of retinal tacks. Some of retinal tacks were coated with parylene to enhance chronic biocompatibility.

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