

Polyimide-based Microelectrode Arrays for Epi-retinal Implant

Hyokyum Kim^{* **}, Soonkwan An^{* **}, Sangbum Jun^{* **}
Sung June Kim^{* **}, Hum Chung^{** ***}, Young Suk Yu^{** ***}

^{*}School of Electrical Engineering and Computer Science

^{**}Nano Bioelectronics and Systems ERC

^{***}Department of Ophthalmology

Seoul National University, Kwanak-gu, Seoul 151-742, Korea

ABSTRACT

Microelectrode arrays have been developed for epi-retinal implant system. To minimize the damage during ophthalmic surgery and to get better contact to retina, flexible polyimide is selected as the substrate material of microelectrode arrays. Various shapes of microelectrode arrays are designed to reduce the tissue damage and take more intimate contact to the retina. The arrays are fabricated to maintain planar shape, and have high elasticity to be tolerable to bending or twisting. With the microelectrode arrays, we tested the electrical and mechanical characteristics and observed bio-compatibility by chronic in-vivo experiment in rabbit's eye.

Keywords: microelectrode arrays, epi-retinal implant, planar shape, high elasticity.

INTRODUCTION

Conditions like Age-related Macular Degeneration(AMD) or Retinitis Pigmentosa(RP) result in deterioration of photoreceptors in the retina, and degeneration of vision, eventually giving rise to blindness. And the loss of vision can't be cured by conventional treatments. So researches have been performed to replace the function of impaired retina by electronic devices. These devices have been made by various approaches, such as epi-retinal [1], sub-retinal [2], optic nerve or visual cortex stimulation methods. In this paper we describe flexible and bio-compatible polyimide-based microelectrode arrays [3] for epi-retinal implant system. Planar shaped arrays are desirable for the ease of handing during ophthalmic surgery in the eye. And to minimize the size of incision of vitrectomy, the arrays must tolerate bending or twisting. Furthermore after insertion into eye ball in folded form, they should restore their original planar shapes easily. For these reasons, we choose polyimide as the substrate material and develop fabrication process to meet the conditions above.

METHOD

To prevent tearing of edge, microelectrode arrays are designed to have rounded corners and circle-shaped fixation tack holes. The rounded corners also reduce the retina tissue damage. Fig. 1. shows one example of such design. Controlling the thickness and kinds of polyimide for substrate and passivation layer, we make planar shape arrays. And considering that excessive heating or high-powered plasma process results in the degeneration and shrink of polyimide, we fabricate the arrays to be improved in elasticity and flexibility.

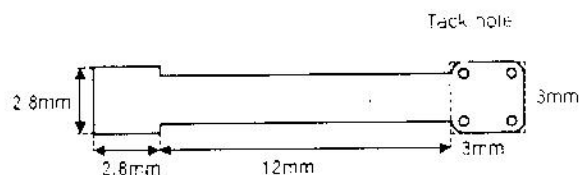


Fig. 1: Design and dimensions of rectangular type microelectrode array.

FABRICATION

The process begins with a clean silicon wafer with 4 inch diameter. PECVD silicon dioxide layer(3 μm) is deposited as a sacrificial layer and polyimide(PI2525, HD Micro Systems) is spin-coated to a thickness of 10 μm and cured. Then gold layer(3000 \AA) is deposited and patterned. After removing residual photoresist, passivation polyimide is spin-coated to a thickness of 8.5 μm . As a mask of site and microelectrode formation, aluminium layer(3000 \AA) is thermally evaporated. Positive photoresist (AZ1512) is patterned over the metal to form the mask for site opening. Aluminium is then patterned by wet etching. Reactive ion etch(100mTorr O_2 , 100W) is used to etch polyimide to open sites. Then a thick photoresist(AZ4620) is coated and patterned to define the whole electrode shape. Aluminum patterning is followed by 3 hours RIE of the same condition above. The electrode structure are then released from wafer by removing the sacrificial oxide layer.

The entire process is done at lower temperature than 300°C. Figure 2 shows the process flow.

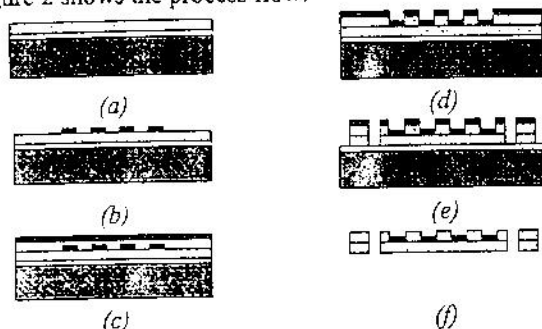


Fig. 2: Fabrication process of the polyimide-based microelectrode array: (a) sacrificial PECVD Oxide deposition and 10 μ m substrate Polyimide coating; (b) gold evaporation and patterning; (c) passivation polyimide coating and aluminum evaporation for mask of site and microelectrode formation; (d) site opening using RIE etch; (e) whole microelectrode shape defined; (f) release total structure in 25% HF and 80% DI water.

RESULT AND DISCUSSION

Fig.3 shows the completed microelectrode array. There are 25(5 \times 5) sites. The size of one site is 50 μ m \times 50 μ m with the site interval being 300 μ m. The width of the interconnection line is 20 μ m.

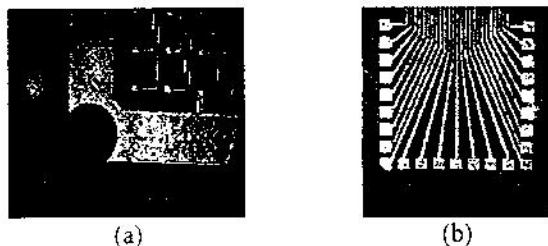


Fig. 3: Fabricated microelectrode arrays based on polyimide, rectangular type: (a) sites and (b) pads of microelectrode arrays.

Using probe station, we measure metal line resistance to be about 95 Ω . To test the restoration ability of the array, it is rolled into a cylinder of diameter of 0.7mm. when it is pulled out after 5min, the array is shown to have restored its original planar shape.

To test the bio-compatibility of the arrays, we implant them in eyes in 4 rabbits. In Fig. 4, we show the surgical procedure and the array fixed on to rabbits retina using fixation tacks. For 60 days after implantation, there is no sign of inflammation or swelling.

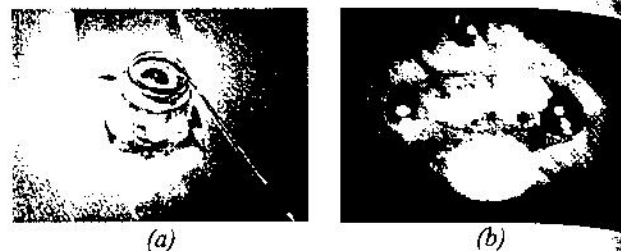


Fig. 4: (a) Insertion procedure of the array into rabbit's eye ball; (b) microphotograph of an array implanted on the surface of rabbit's retina fixed by three titanium tacks.

CONCLUSION

Polyimide-based microelectrode arrays are developed. Advanced design makes the arrays to be more resistive structure against external forces. Elasticity has been proved which is important to maintain ease of folding, and restoration of planar shape have been proven to demonstrate its effectiveness as a microelectrode array that has to make intimate contacts to the retina. Implanted microelectrode arrays in rabbit's eyes show stable conditions for 60 days.

ACKNOWLEDGMENTS

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