MEMS REQUIREMENTS FOR AN EPI-RETINAL PROSTHESIS

Robert Greenberg

Second Sight Medical Products Inc.
Sylmar, California 91342
bob@2-sight.com

ABSTRACT

Two approaches have been pursued to restore vision to blind patients – electrically stimulating the visual cortex and the retina. MEMS techniques have played a role in each of these research efforts and will continue to play a role going forward. Progress towards these goals will be discussed in the talk.

I. INTRODUCTION AND BACKGROUND

In 1755 LeRoy discovered that an electric charge delivered to the blind eye produced a sensation of light [1]. Ever since, humanity has pondered the possibility of making the blind see. However, it was not until the age of modern electronics that building such a device became possible.

II. STIMULATING THE VISUAL CORTEX

In the 1960's, Dr. Brindley in England elicited sensations of light in blind subjects by electrically stimulating their visual cortex (the back side of their brain) [2]. In the 1970's, Dr. Dobelle in the U.S. repeated these experiments with some success [3]. However, the resolution achieved by these early devices was very poor. At best, these patients could read Braille by the flashing lights (phosphenes).

By the time the visual image has reached the brain, a significant amount of processing has already occurred - making fine resolution difficult to achieve. Another problem with this approach was that the surgery was very invasive and dangerous for these volunteer patients.

Fig. 1. Visual cortex electrode array courtesy of Dick Normann at the University of Utah.

III. STIMULATING THE RETINA

Over the past decade at Johns Hopkins and now at USC, we discovered that there is a subpopulation of blindness (outer retinal degenerations such as Retinitis Pigmentosa and Macular Degeneration) in which a majority of the retina and visual system is intact, allowing stimulation more peripherally - at the retina [4].

By electrically stimulating the retinas of over two dozen of these patients in the operating room, we were able to achieve formed vision. Stimulating the retina has the potential to provide a much higher resolution device than stimulating the visual cortex and there are now half a dozen groups around the world pursuing this line of research. In the Los Angeles area, we formed a company called Second Sight, which has embarked on creating the first artificial retina (a long-term implantable system which will allow the blind to see) [5].

At the time of this writing, three patients have been chronically implanted with a first generation retinal prosthesis. This device has 16 independently controllable electrodes. The completely blind patients are able to perceive individual spots of light corresponding to each of the electrodes and perform simple visual tasks despite the simplicity of the device.

Fig. 2. Visual prostheses concept based on simulating the retina.

Fig. 3. Second Sight / USC Model 1 retinal prosthesis

IV. MEMS APPLICATIONS IN RETINAL PROSTHESES

Second Sight Medical Products is working on future-generation devices with higher resolution. This is where the need for MEMS technology comes in. In order to produce higher electrode counts, MEMS-like approaches for the fabrication of the electrodes are necessary. As we continue down our path towards 1000 electrodes and beyond, new techniques will need to be

developed. The following technology areas must be advanced for truly high-resolution retinal prosthetics to be developed:

- a method of producing small high-resolution electrodes that do not degrade when passing high current levels in saline
- high-density hermetic packaging
- fully integrated electronics including power supplies
- bidirectional high-rate data telemetry

Research towards these goals is underway at Second Sight in conjunction with its partners [6-8]. Details of the progress accomplished to date will be presented.

III. CONCLUSIONS

Although significant progress has already been made, the challenges are great and more progress is needed. Feel free to contact us if you have an interest in this area.

ACKNOWLEDGEMENTS

I would like to thank Jack Judy for his help and advice in preparing this manuscript.

REFERENCES

- [1] J. Clausen, "Visual Sensations (Phosphenes) Produced by AC Sine Wave Stimulation", *Acta Physiol. Neurol. Scand. Suppl.* Vol. 94, pp. 1-101 (1955)
- [2] G.S. Brindley, "The Site of Electrical Excitation of the Human Eye", *J. Physiol. (Lond)*, vol 127, pp. 189-200 (1955)
- [3] R.A. Normann, "Visual Neuroprosthetics – Functional Vision for the Blind", *IEEE Eng. Med. & Biol.*, Jan/Feb, pp. 77-83 (1995)
- [4] M.S. Humayun, E. de Juan, Jr., G. Dagnelie, R.J. Greenberg, R. Propst and D.H. Phillips, "Visual Perception Elicited by Electrical Stimulation of the Retinal in Blind Humans", *Arch. Ophthalmol.*, vol. 114, pp. 40-46 (1996)
- [5] Second Sight Medical Products, Inc., www.2-sight.com
- [6] Andy Hung, David Zhou, Robert Greenberg, and Jack W. Judy, "Micromachined Electrodes for High Density Neural Stimulation Systems", IEEE Micro Electro Mechanical Systems Workshop (MEMS 2002), Las Vegas, Nevada, (January 20-24, 2002), pp. 56-59.
- [7] Andy Hung, David Zhou, Robert Greenberg, and Jack W. Judy, "Dynamic Electrochemical Simulation of Micromachined Electrodes for Neural-Stimulation Systems", 1st International IEEE EMBS Neural Engineering Conference, Capri, Italy (March 20-22, 2003).
- [8] W. Liu, R. Bashirulla, G. Lazzi, M. Humayun, and J. Weiland, "A Smart Bi-directional Telemetry for Retinal Prosthesis," ARVO 2002