Development of a silicon substrate thinning process for a flexible and self-sufficient neuroelectronic implant

C-A. Chhuon* [1,2], H. Moulet [2], A. Vlandas [1], P. Mariage [1], M. Faucher [1], F. Braud [1], C. Vanbesien [1], V.Hoël [1]

[1] Univ. Lille, CNRS, Centrale Lille, Univ. Polytechnique Hauts-de-France, UMR 8520 - IEMN - Institut d'Electronique de Microélectronique et de Nanotechnologie, F-59000 Lille, France
[2] Axorus, Loos, 59120, France
*e-mail: anna.chhuon@axorus.com

ABSTRACT

With the aging of the population, the number of people suffering from neurodegenerative diseases such as age-related degeneration (AMD) increases. AMD consists in a vision loss in the center of the field of vision due to the degeneration of the photoreceptors in the center of the retina. There are two forms of AMD, wet AMD which is associated with an anarchic vascularization of the eye, and dry AMD where a part of the retina thins and degrades causing an alteration of the sight. Currently, wet AMD can be treated with therapeutic solutions, but there are no treatments for dry AMDs. Solutions using retinal implants are therefore being developed. Aiming to restore visual capacities of AMD patients in the least cumbersome and restrictive way possible, the Institute of Electronics, Microelectronics and Nanotechnology (IEMN), and Axorus, a startup founded in 2019, have set up a collaboration to develop and design the prototype of an autonomous retinal implant. To do this, Axorus has integrated an "artificial neuron", which is an electronic circuit reproducing the electrical signature of a biological neuron developed and patented by the IEMN, into an implant. It consists of a microelectrode array on a silicon substrate, powered by light.

One objective of this thesis is to facilitate the surgical insertion and the adaptability of such retinal implants, by following the shape of the eye and the thickness of the retina. In this purpose, a thinning process using DRIE (Deep Reactive Ion Etching) technology has been developed to make the silicon substrate bendable. In addition, a flexible substrate will be added on the backside as a support, to avoid breakage and keep the mechanical (bending) properties of silicon. Our aim is to reach a thickness of 10 µm to push the limits of substrate thinning.

The other objective of the thesis is to find other energy sources than photovoltaic source for the implant. In this view, we must find and select an energy source able to provide the implant enough energy to stimulate biological neurons and which can replace photovoltaic energy in cases where it is not usable. In addition, the energy should be stored and encapsulated into a biocompatible miniaturized device. In addition, it must provide enough energy to the implant for at least 10 years.

The manufacture of a thin, bendable and energy autonomous implant will open the doors for other applications using artificial neurons, such as nerve stimulation to cure hemiplegia or urinary disorders. If the implant answers all above-mentioned challenges, it could be implanted for a long period in areas without access to light and will be adapted to areas with important dimensional constraints.

This work has been presented the 26th of April 2022 at the "IEEE Lille Engineering for Medicine and Biology Conference", sponsored by "IEEE", "IEEE Engineering in Medicine and Biology (EMB)" and "IEEE Circuits and Systems (CAS)".

AKNOWLEDGEMENTS

We acknowledge the CMNF (plateform Centrale de Micro Nano Fabrication), and the Labex LEAF. This work is partly supported by the French RENATECH network (French national nanofabrication platform), Interconnect CNRS Innovation, DiSyknow ISite ULNE and Retina CPER Photonics for Society funds. This work is also financed by Axorus