



HAL
open science

Interfacing artificial and biological neurons: first step towards the development of autonomous implantable neurobiohybrid medical devices

Nathan Schoonjans, Virginie Hoel, Dimitri Henniquau, Vanessa Avramovic, Mohamed Bellaredj, Pascal Mariot, Valerio Farfariello, David Delcroix, Redha Kassi, A. Cappy, et al.

► To cite this version:

Nathan Schoonjans, Virginie Hoel, Dimitri Henniquau, Vanessa Avramovic, Mohamed Bellaredj, et al.. Interfacing artificial and biological neurons: first step towards the development of autonomous implantable neurobiohybrid medical devices. IEEE Lille Engineering for Medicine and Biology Conference, Apr 2022, Lille, France. hal-03770329

HAL Id: hal-03770329

<https://hal.science/hal-03770329v1>

Submitted on 6 Sep 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Interfacing artificial and biological neurons: first step towards the development of autonomous implantable neurobiohybrid medical devices.

Nathan Schoonjans¹, Virginie Hoel¹, Dimitri Henniquau¹, Vanessa Avramovic¹, Mohamed Bellaredj¹, Pascal Mariot², Valerio Farfariello², David Delcroix¹, Redha Kassi¹, Alain Cappy¹, Alexis Vlandas¹, Christel Vanbesien¹

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. Univ. Lille, Inserm, U1003 - PHYCEL - Physiologie Cellulaire, F-59000 Lille, France

ABSTRACT

Energetically autonomous implantable neurobiohybrid devices able to communicate with biological neurons could offer new solutions for durably alleviating symptoms of a variety of neurodegenerative diseases with more flexibility of use for the patient. Designing such devices is however a challenge that several research groups are currently addressing worldwide. Most approaches include voluminous equipments lacking of flexibility (thus preventing their use *in vivo*), require numerical/analogical conversions leading to high-energy consumption, and are subjected to long time constraints thus precluding real time communications between artificial and biological components of the neurobiohybrid. To conceive a device suitable for long-term implantation, we plan to create a fully analogical system, which would therefore be smaller, more energy-efficient and able to communicate in real time with its biological targets. Such autonomous implantable devices have to meet precise specifications ensuring not only their harmlessness for living tissues but also their long-term efficiency. Most importantly, as highlighted above, their ability to communicate in real time with the living tissue is crucial. This presentation will address this key objective.

Based on a biomimetic spiking artificial neuron developed and patented within the SPINE project (<https://spine.univ-lille.fr/research.html>), we aim to create a fully analogical neurobiohybrid system by connecting these biomimetic artificial neurons (AN) to living neurons maintained *in vitro*. In this context, the objective of my thesis project is to establish and characterize the bidirectional communication between AN and biological neurons (BN). To achieve this objective, we developed an interface that allowed us to demonstrate the ability of biomimetic signals (applied with a generator and extracted from artificial neurons) to stimulate living neurons through gold electrodes (thus enabling communication "Emulated AN" -> BN). New interfaces are under development to demonstrate the possibility to detect BN signals. The complete communication loop will be achieved by physically connecting biomimetic AN (excitatory) to living neurons (receiving/responding) themselves linked to other biomimetic AN (listening/recording). In conclusion, this thesis work is a first step towards the creation of a fully autonomous implantable neurobiohybrid for medical applications.

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)".

ACKNOWLEDGEMENTS

The authors would like to thank Dr Aude Sivery and Dr Jérôme Follet for their precious support and advices during cell culture experiments. We are also grateful to the RENATECH network and to the Micro and Nano Fabrication Central of the IEMN, and more specifically to Dr. Francois Vaurette, Dr. Pascal Tilmant and Saliha Ouendi for their advices and support in producing the microelectrode arrays. We also would like to thanks all the researchers from the SPINE project that contributed to the development of the artificial neurons and the artificial synapses. The authors would like to acknowledge the Région Hauts-de-France and the Ministry of Higher Education, Research, and Innovation for funding this project. This work was supported by Interconnect CNRS Innovation, DiSyknow ISite ULNE and Retina CPER Photonics for Society funds. Authors are also very grateful to the IEMN and its director, Pr Thierry Mélin, to the CNRS and to the University of Lille for welcoming our team in their premises.