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Laboratoire des matériaux et du génie physique
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Grenoble INP

cnrs

# M2 Internship at the LMGP Laboratory in Grenoble

## Elaboration of hydrogel based functionalization layer on neuronal electrode probe in view of *in vivo* implantation.

### Description:

**Context** : The field of Brain Machine Interface (BMI) implies the *in vivo* implantation of neuronal electrode probe inside the brain. This implantation is an invasive action which enables to better understand the origin of neuronal disorder pathologies and to remedy them. It requires the realization of neuronal electrode probe with many specific characteristics and notably a high stability as a function of time which is highly challenging. Indeed the implantation of such probe in the brain is usually accompanied by a progressive loss of electrical neuronal signal. This signal loss is due to the progressive formation of an astrocyte glial cell scar around the probe as a function of time. One of the roles of this scar is to protect the neurons from the foreign object. Minimizing the immune response and implant rejection, the longevity of neuronal probes can be assured relying on two strategical choices that our group is exploring. First regarding the probe material, our group is currently developing new neuronal electrode probes based on full Silicon Carbide (SiC). SiC exhibits exceptional properties: this a high band gap semiconductor chemically inert and biocompatible. Second, the SiC based probe longevity can be increased covering the passive part of the probe by an organic functionalization layer, the aim of which is to make a buffer zone between two regions mechanically different: brain with a very low Young modulus and the SiC probe material with a higher Young modulus. Thanks to this organic buffer zone, the idea is to reduce the formation of the glial scar. However performing a strongly grafted organic layer with optimized mechanical characteristics without inducing any delamination upon probe implantation and able to stay stable for a long duration after probe implantation is highly challenging (1).

**Objective** : The internship will focus on this second part investigating the chemical deposition of a functionalization layer with appropriate characteristics on SiC probe surface. Particularly hyaluronic acid (HA) hydrogel has been selected as a natural organic compound found in human body. A previous study has shown that HA hydrogel can be covalently grafted on SiC thanks to a several step physico-chemical procedure deposition (2). However, strong optimization in this procedure still has to be made to achieve the expected characteristics of deposited HA layer, notably regarding thickness and stiffness. New deposition conditions will be investigated notably by varying deposition parameters and using click chemistry. The effects of these different conditions on HA layer characteristics will be carefully studied: thickness, morphology, homogeneity, roughness, Young modulus, chemical composition, adhesion, and electrical characteristics. This will be performed using various surface analysis techniques (AFM, water contact angle, SEM, FTIR, cyclic voltammetry). Then the time stability will be performed by dipping the samples in buffers mimicking the brain medium. The final aim will be to develop an HA functionalization layer exhibiting optimized characteristics in term of stiffness and time stability in view of future *in vivo* implantation.

This work will be performed in the frame of an ANR project called “SiCNeural” (2021-2025).

*(1) E. Axpe, G.Orive, K. Franze and E. A. Appel, Nature Communications (2020) 11 ; 3423*

*(2) R. M. Kanaan, M2 Internship (2022) GINP*

**Duration** : The M2 internship has a fixed duration of 6 months, starting in February 2023.

**Research profile & skills (required / highly desirable):** film surface chemistry, thin film characterization, biology, soft organic material films, neuroscience.

**Scientific environment:** The candidate will work in a strong collaborative environment including CERMAV (Centre de recherches sur les macromolécules végétales), LMGP (Laboratoire des Matériaux et du Génie Physique) and other partners of the project.

LMGP web Site: http://www.lmgp.grenoble-inp.fr/

CERMAV web site : https://cermav.cnrs.fr/

**Salary:** 550 €/month

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