Master 2 Internship opportunity: Multimodal sensors for electrochemical and vibrational spectroscopic detection fabricated by 2-photon 3D microprinting

Context: Chemical and biological analyses play a crucial role in both research and society, and have been continuously advanced by the scientific community to benefit researchers and the public. In response to the need for higher-performing analytical tools, we endeavor to develop a novel multiscale-multimodal sensor using 3D-printing technology. Specifically, this sensor aims to integrate electroanalytical and plasmon-enhanced vibrational spectroscopic tools to achieve unprecedented detection capabilities. To achieve this ambitious goal, we aim to develop two-photon 3D-printing of gold-microstructures to render them conductive and gain plasmon enhancement.

Objectives: During the internship, the objective is to implement two-photon induced microprinting of conductive, micro-, and nano-structured sensors. This involves the optimization of the photonic and physico-chemical conditions of two-photon microprinting, optimize the chemical composition of the formulations and then assess sensor performance. The internship will target Surface Enhanced Raman Scattering and electrochemical detection.

The **internship program** will be divided into three main tasks: **1)** During **sensor fabrication**, acrylate- and gold precursor-containing photoresists will be applied for simultaneous 2-photon induced radical polymerization and gold photoreduction. Special attention will be paid to irradiation parameters such as wavelength and repetition rate to mitigate local overheating, a major pitfall of two-photon printing. Sensor geometry will be tuned to improve the analytical performances. Sensors will be contacted to electrochemical circuits by large scale UV lithography. **2)** For the **characterization** SEM and AFM (at SMIS Soleil as external partner) will be used, focusing on surface feature distribution and nanogaps as a function of printing parameters. The conductivity will be measured, searching for the highest values to maximize electrochemical transduction efficiency. **3) Analytical performances** will be assessed on model systems such as NaCl and ferro/ferricyanide redox probe for electrochemistry; glucosamine to quantify SERS enhancement; Raman signature of *Pseudomonas aeruginosa* membrane and SERS/electrochemical response of its biomarker (pyocyanin). Depending on the progress, bacterial growth and the impacts of antibiotics will be also monitored.

This proposed training opportunity is ideal for individuals interested in gaining experience in 3D microprinting, material chemistry, nanotechnology and analytical chemistry. Applicants who participate in this project will be exposed to cutting-edge research and have the opportunity to contribute to the development of advanced analytical tools for complex systems.

Location: Laboratoire de Chimie, ENS de Lyon
Experiments will be performed at Institut des Sciences Analytiques
Depending on the progress the intern will have the possibility to participate to synchrotron experiments at Soleil

Contact: Akos BANYASZ, Research Scientist (akos.banyasz@ens-lyon.fr)
Florence LAGARDE, Research Scientist (florence.lagarde@univ-lyon1.fr)

References

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