Master 2 - Physical Chemistry and Materials internship

Functionalization of TiO_2-gated organic photo-electrochemical transistor for light-activated sensing

The main task of this 6-month M2 internship is to manufacture and characterize original organic photo-electrochemical transistors (OPECTs) for the detection of biomarkers (bilirubin involved in liver diseases and neuropathologies). OECTs are a fast-growing technology used mainly for health applications (e.g. biosensors, electrophysiologic devices) whose detection limits are significantly lower than the currently applied technologies. Our group recently obtained promising results on OPECT using a mesoporous gate electrode made on TiO_2 nanotubes. The main objective of the proposed internship is to graft molecules, that selectively attach to the targeted biomarker (here bilirubin), on the surface of TiO_2 nanotubes and investigate how it improves the sensitivity and the selectivity of the sensing OPECT.

The student will work on this hot topic in a pluri-disciplinary environment including two teams of the ICPEES. He/she will be in charge of fabricating OPECTs made of PEDOT:PSS channel and of synthesizing and functionalizing mesoporous TiO_2 gate electrodes. The student will then investigate the properties of these novel OPECTs and determine their response under illumination. Finally, the performances of the resulting biosensors will be tested in 'applicative' conditions by replacing the test electrolyte by an analyte-containing bilirubin to determine the sensitivity, selectivity and reversibility of its detection.

High-quality results are expected, as demonstrated by our manuscript reporting record OECT performance for highly aligned polymers, currently under review for publication in Nature Materials (https://www.researchsquare.com/article/rs-3221543/v1). Besides, this already mature project is a follow-up of a previous internship. By combining the promising results already achieved by Wissal Errafi (PhD student) and the foreseen outputs of this internship, publication of the work in a high-impact journal (aim: Journal of Materials Chemistry C, RSC) is planned. The student will hence develop his/her English writing skills and promote his/her career by writing a scientific article together with W. Errafi.

This project is for a master 2 student in the field of Chemistry, Physico-Chemistry or Material Science. It requires a strong motivation for experimental work and an ability to understand the multidisciplinary aspects of the project such as electrochemistry, optic, materials synthesis *etc*. For more information and to apply please contact **Thomas Cottineau (cottineau@unistra.fr)** or **Olivier Bardagot (bardagot@unistra.fr)** ICPEES (campus Cronenbourg ZRR).

Daily work will include:

- Bibliographic study of the bilirubin/TiO_2 interactions
- Processing of (semi)conducting polymers in solution (mainly PEDOT:PSS)
- Synthesizing TiO_2-Nanotubes gate electrodes
- Molecule grafting on TiO_2 (physico-chemistry of interfaces)
- Scanning electron microscopy (SEM) to visualize the resulting gate electrodes
- OPECT manufacture
- Electrical characterization of OPECT (transfer, output)

- Time-resolved Vis/NIR absorbance spectroscopy during OPECT operation
- Data analysis using Python (computing)
- Calibration and use in 'test' and 'applicative' conditions of novel biosensors
- English writing and oral presentation

Hard skills which will be learnt:

- Bibliographic search
- Database management
- Electrochemical synthesis
- Surface chemistry
- Polymer processing
- Vis-NIR absorbance spectroscopy
- Electrochemistry
- Computing (Python for heavy data analysis and graph plotting, LabVIEW if interested)

Soft, transferable, skills which will be learnt:

- Collaboration, teamwork
- Effective communication
- Scientific data presentation (oral and written in English)
- Project management (time management, supply management, etc)
- Progress reporting
- Creativity/independency (depending on the will of the student)

References:

1. **High-performance OECT manufacture:** O. Bardagot*, P. Durand, S. Guchait, G. Rebetez, P. Cavassin, J. Réhault, M. Brinkmann, N. Leclerc, N. Banerji, *In Review - Nature Materials*, **2023**, Link: 10.21203/rs.3.rs-3221543/v1
2. **OECT doping kinetics:** B. T. DiTullio, L. R. Savagian, O. Bardagot, M. De Keersmaecker, A. M. Österholm, N. Banerji, J. R. Reynolds, *J. Am. Chem. Soc.* **2023**, *145*, 122–134.
3. **TiO_2 Nanotube synthesis:** F. Gelb, Y.-C. Chueh, N. Sojic, V. Keller, D. Zigah, T. Cottineau*, *Sustainable Energy Fuels* **2020**, *4*, 1099–1104.
4. **TiO_2-based sensors:** D. Spitzer, T. Cottineau, N. Piazzon, S. Josset, F. Schnell, S. N. Pronkin, E. R. Savinova, V. Keller, *Angewandte Chemie International Edition* **2012**, *22*, 5334–5338.
5. **TiO_2-gated OECT:** M.-J. Lu, F.-Z. Chen, J. Hu, H. Zhou, G. Chen, X.-D. Yu, R. Ban, P. Lin, W.-W. Zhao, *Small Structures* **2021**, 2, 2100087.