ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title: TIGERsens -TiO_2-Gated organic Electrochemical TRansistor (OECT) for light-activated sensing

Internship supervisor

Name, first name	Bardagot, Olivier
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Laboratory	ICPEES
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Cottineau, Thomas

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☐ Chemistry ☐ Physics
Other indications if necessary	An interest in organic semiconducting polymers, electrochemistry and device manufacturing is preferred.

Internship description

The main task of this **6-month M2 internship** is to manufacture and characterize **original organic electrochemical transistors** (OECTs) for the **detection** of biomarkers. OECTs are a fast-growing technology used mainly for **heath applications** (e.g.: biosensors, electrophysiologic devices) whose detection limit are significantly lower than the current applied technologies. The main objective of the internship is to investigate the benefit of using a mesoporous **gate electrode made on TiO_2 nanotubes**. TiO_2 nanotubes present a **high capacitance** and can be **activated by light**, thereby offering unique features such as **spatial resolution** and **regeneration** of the sensor.

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 OECTs** made of **PEDOT:PSS** channel and of **synthesizing mesoporous TiO_2 gate electrodes**. The student will then investigate the properties of these novel OECTs in different conditions of **irradiation** in 'test' aqueous electrolyte. Finally, the performances of the resulting biosensors will be tested in **'applicative' conditions** by replacing the test electrolyte by an **analyte containing bilirubin** for its detection. Bilirubin is a biomolecule generated during the breakdown of red blood cells. Its accurate and reversible detection would contribute to the early diagnosis of liver-related diseases in the hope of better treatment.

High quality results are expected, as demonstrated by our manuscript reporting record OECT performance for highly aligned polymers (10x higher than state-of-the-art), currently under review for publication in Nature Materials (https://www.researchsquare.com/article/rs-3221543/v1).

Daily work will include:

- Bibliographic study of the impact of the gate porosity on the OECT response
- Processing of (semi)conducting polymers in solution (mainly PEDOT:PSS)
- Synthesizing TiO_2-Nanotubes gate electrodes
- Scanning electron microscopy (SEM) to visualize the resulting thin films and electrodes
- OECT manufacture
- Electrical characterization of electrochemical transistors (transfer, output)
- Time-resolved Vis/NIR absorbance spectroscopy during electrochemical doping
- Data analysis using Python (computing)
- Calibration and use in ‘test’ and ‘applicative’ conditions of novel biosensors

Hard skills which will be learnt:

- Bibliographic search
- Database management
- Semiconducting polymer design
- Electrochemical synthesis
- 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**, 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.