Master 2 - Laboratory Internship Offer

Fabrication and Analysis of Organic Electrochemical Transistors (OECTs)

Scientific Context and Objectives

Organic Mixed Ionic/Electronic Conductors (OMIECs) have emerged as an excellent materials platform to interface biology with conventional electronics; identified as the "organic or plastic bioelectronics" field [1,2]. The Organic ElectroChemical Transistor (OECT) is considered as one of the key building-block to operate such a transduction [3]. Its efficiency is evaluated following some Figures of Merits: i) the transconductance (g_m) [4], ii) the switching times (τ_{ionic} vs. $\tau_{electronic}$), iii) an in-situ imaging of the dedoping propagating front (e.g. ionic mobility measurement) [5], iv) the electrochemical impedance to establish the electrical equivalent circuit and extract volumetric capacitance. Our current understanding shows that swelling properties of such (macro)molecular OMIECs are vital to properly drive OECTs. Indeed, the swelling of the hydrophilic (thus ionic) rich-phases authorizes the ions to penetrate and to move in vicinity of the hydrophobic π-conjugated rich phases, modulating their doping states and thus the amount of electronic current flowing in the channel of OECTs. Consequently, the total surface that ionic & π-conjugated phases exchange in between and their self-organization may play pivotal roles since such a transduction takes place in all the volume of the channel layer of an OECT.

The recording of OMIECs properties (ionic & electronic mobility) and the understanding of its physical operation are of great importance to improve the OECTs transduction mechanism.

In such a context, the M2 intern candidate will learn to fabricate OECTs using photolitography, optimizing the main channel properties (channel volume due thickness variation, deposition method, etc.). Measurements and analysis of its fundamental characteristics will be carried out (output and transfer curves, transconductance, cutoff frequency, volumetric capacitance, contact resistances,…). Furthermore, a new experimental process flow will be setup with thin-film clean room equipments in order to implement monolithic p- and n-type OECTs fabrication and to characterize CMOS like based-circuits.

Laboratory Location & Collaborative Context

Internship is located in an Excellence and collaborative environment, in the Centre de Microélectronique de Provence (CMP) (880, avenue de Mimet, Gardanne 13120, France). CMP belongs to the IMT – Mines Saint-Etienne Graduate Engineering School. The intern applicant will evolve in the Flexible Electronics Department of CMP.

All the organic (bio)electronics devices will be designed, fabricated, first-proof demonstrated and characterized in the 650 m^2 State-of-the-Art (*SoA*) MicroPackS cleanroom platform of CMP. The candidate will have a full and free access to that *SoA* cleanroom to complete his(her) scientific purposes.

The intern candidate will evolve in a collaborative framework, involving 6 european academics laboratories. He/ she will have hence a close research collaboration with partners, particularly with PhDs and post-docs driving i) design & synthesis of OMIECs, ii) spectroscopic characterization, and iii) OECTs modelling, respectively.

Duration: 6 months-long, **Starting Date**: from February/March 2024

Grant: 600 net euros/ month

Possibility of pursuing a PhD within the framework of an European project

Candidate Profile/ Skills

The Intern candidate is about to earn a Research Master degree or have a university degree equivalent to a European Master's degree in the area of Physics or Materials Science. An ability to work in a collaborative context and to propose scientific investigations that are at the interface between Physics of Electronic Devices and Materials Science is required. Knowledges or past experiences in Materials science and Electronics are advantageously considered.

Application & Selection Process

The Intern application is immediately opened for submission.

Applicants should provide a single pdf file combining i) a copy of passport, ii) a curriculum vitae, iii) a cover letter, iv) a copy of obtained diploma (i.e a certification letter of M1 Degree and anterior diploma) and v) reference letters from past supervisors or professors.

This single pdf e-file should be addressed both to Dr. Luis Lozano (luis.lozanohernandez@emse.fr) and Dr. S. Sanaur (sanaur@emse.fr). We encourage candidates to apply as soon as possible, since applications are evaluated as arising. Applications will be evaluated through the following steps:

1) Eligibility check of applications based on the submitted e-file,

2) Those applications will be evaluated and shortlisted candidates will be invited for an interview session via videoconference. All applicants qualified for videoconference will be notified of the final decision.

Bibliography

1. Someya, T., Bao, Z. & Malliaras, G. G. The rise of plastic bioelectronics. *Nature* **540**, 379–385 (2016).
2. Berggren, M. & Richter-Dahlfors, A. Organic Bioelectronics. *Advanced Materials* **19**, 3201–3213 (2007).
3. Rivnay, J. *et al.* Organic electrochemical transistors. *Nature Reviews Materials* **3**, 1–14 (2018).
4. Khodagholy, D. *et al.* High transconductance organic electrochemical transistors. *Nature Communications* **4**, 2133 (2013).
5. Stavrinidou, E. *et al.* Direct Measurement of Ion Mobility in a Conducting Polymer. *Advanced Materials* **25**, 4488–4493 (2013).

Master 2 - Laboratory Internship Offer

OECTs working mechanisms investigated by electronics instrumentation

Scientific Context and Objectives

Organic and Polymeric Mixed Ionic/Electronic Conductors (OMIECs & PMIECs) have emerged as an excellent materials platform to interface biology with conventional electronics; identified as the "organic or plastic bioelectronics" field [1,2]. The Organic ElectroChemical Transistor (OECT) is considered as one of the key building-block to operate such a transduction [3]. Its efficiency is evaluated following some Figures of Merits: i) the transconductance (g_m) [4], ii) the switching times (τ_{ionic} vs. $\tau_{electronic}$), iii) an in-situ imaging of the dedoping propagating front (e.g. ionic mobility measurement) [5], iv) the electrochemical impedance to establish the electrical equivalent circuit and extract volumetric capacitance. Our current understanding shows that swelling properties of such (macro)molecular OMIECs are vital to properly drive OECTs. Indeed, the swelling of the hydrophilic (thus ionic) rich-phases authorizes the ions to penetrate and to move in vicinity of the hydrophobic π-conjugated rich phases, modulating their doping states and thus the amount of electronic current flowing in the channel of OECTs. Consequently, the total surface that ionic & π-conjugated phases exchange in between and their self-organization may play pivotal roles since such a transduction takes place in all the volume of the channel layer of an OECT.

The recording of OMIECs properties (ionic & electronic mobility) and the understanding of its physical operation are of great importance to improve the OECTs transduction mechanism.

In such a context, the M2 intern candidate will develop an original experimental setup and instrumentation to record and analyze the dedoping propagating front in PMIECs. Practically, the candidate will learn to fabricate PMIECs thin-film devices in clean-room using photolithography, vacuum thermal evaporation,.. in order to record the dedoping propagating front. Such instrumentation and automated setup will give us ionic mobility measurements of several PMIECs, in order to correlate the structure-property relationships in those mixed materials. Furthermore, the candidate will setup a new experiment to monitor *in-situ* the OECT's channel and push the knowledge of PMIECs structuration's optimization up to OECTs circuits applications.

Laboratory Location & Collaborative Context

Internship is located in an Excellence and collaborative environment, in the Centre de Microélectronique de Provence (CMP) (880, avenue de Mimet, Gardanne 13120, France). CMP belongs to the IMT – Mines Saint-Etienne Graduate Engineering School. The intern applicant will evolve in the Flexible Electronics Department of CMP.

The intern candidate will evolve in a collaborative framework, involving 6 european academics laboratories. He/ she will have hence a close research collaboration with partners, particularly with PhDs and post-docs driving i) design & synthesis of OMIECs, ii) spectroscopic characterization, and iii) OECTs modelling, respectively.

Duration: 6 months-long, **Starting Date**: from February/March 2024

Grant: 600 net euros/ month

Possibility of pursuing a PhD within the framework of an European project

Candidate Profile/ Skills

The Intern candidate is about to earn a Research Master degree or have a university degree equivalent to a European Master's degree in the area of Instrumentation, Spectroscopy, Physics or Materials Science. An ability to work in a collaborative context and to propose scientific investigations that are at the interface between Instrumentation for Physics and Materials Science is required.

Application & Selection Process

The Intern application is immediately opened for submission.

Applicants should provide a single pdf file combining i) a copy of passport, ii) a curriculum vitae, iii) a cover letter, iv) a copy of obtained diploma (i.e a certification letter of M1 Degree and anterior diploma) and v) reference letters from past supervisors or professors.

This single pdf e-file should be addressed both to Dr. S. Sanaur (sanaur@emse.fr). We encourage candidates to apply as soon as possible, since applications are evaluated as arising.

Applications will be evaluated through the following steps:

1) Eligibility check of applications based on the submitted e-file,

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Bibliography

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