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THESIS PROPOSAL

CENTRE INTERDISCIPLINAIRE DE NANOSCIENCE DE MARSEILLE – CINaM - FRANCE

Supervisor: Anne Charrier

Collaborator: Yutaka Wakayama, NIMS, Japan

Towards the fabrication of flexible organic field effect transistor ion sensors using ultra-thin organic layers

Organic Field Effect Transistor ion sensors (ISOFET) are integrated devices allowing for ion detection in solution. In these devices the two main components are the semiconducting and dielectric organic layers used as transistor channel and gate dielectric respectively. For both these layers, the organization of the molecules or polymer on the substrate is a key point to obtain good transistor response. In previous work we have developed a sensor based on a unique system composed of two ultra-thin layers: a poly(3-hexylthiophene) layer as semiconductor (20 nm) and a lipid monolayer as dielectric (2.5 nm). The combination of these two materials proved to be highly performant, and we could measure concentrations of Cesium ions in sea water at concentrations as low as the attomolar range with very high selectivity. In this work the sensor was supported on hard silicon substrate.

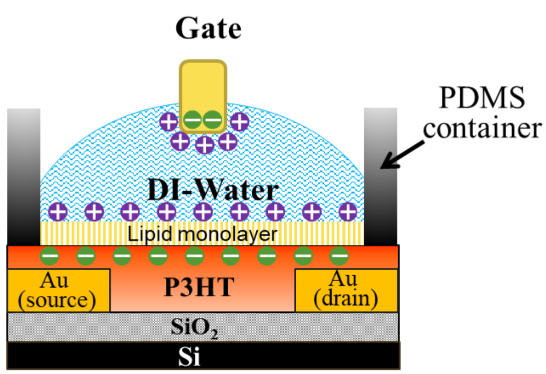

Figure 1 : OFET with a P3HT layer as semiconducting channel and a lipid monolayer as gate dielectric.

In this PhD project we want to pursue this work by developing a new sensor supported on a flexible substrate such as a plastic. In addition to be flexible, light weight and portable the substrate will be disposable. Such flexibility of the substrate generates lots of questioning regarding the properties of the two layers under mechanical stress (tension and compression).

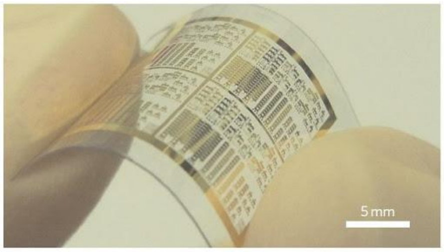

Figure 2: Electronic devices on soft substrates.

We will study: 1) the mechanical stability of the P3HT layer and lipid layer and of their interface under deformation stress; 2) the electrical properties of P3HT. We will measure the change in traps density and carrier mobility; 3) the dielectric properties of the lipid monolayer. We will measure the change in leakage current, dielectric breakdown and capacitance. The two layers will be then implemented in a transistor which we will characterize electrically under variable stress conditions.

This project will be conducted in close collaboration with Prof. Yutaka Wakayama, from the National Institute for Materials Science in Tsukuba, Japan. The candidate will spend several months in Japan.

The candidate shall be a physicist.

Starting date: 1st October 2020

Please send your application to Anne Charrier (charrier@cinam.univ-mrs.fr).
Please provide:
- Master 1 & 2 marks and ranking and list of courses
- Short summary of master 2 internship
- Recommendation letters and references

APPLICATION DEADLINE: 10th MAY 2020

Some references from the consortium:

- Electrolyte gated-organic field effect transistors with engineered lipid monolayers for sensor applications with tunable pH sensitivity. T. P. Nguy, et al., *Applied Physics Express* 13, 011005 (2020)
- Novel and innovative interface as potential active layer in Chem-FET sensor devices for specific sensing of Cs+. V. Kilinc et al., *ACS Appl. Mater. Interfaces* 11, 47635-47641 (2019)
- Stable operation of water-gated organic field-effect transistor depending on channel flatness, electrode metals and surface treatment. T. Phan Nguy, et al., *Japanese Journal of Applied physics* 58, SDDH02 (2019)
- Ultra-thin supported lipid monolayer with unprecedented mechanical and dielectric properties. A. Kenaan et al., *Advanced Functional Materials*, 1801024 (2018)
- Subpicomolar Iron Sensing Platform Based on Functional Lipid Monolayer Microarrays. A. Kenaan, et al. *Analytical chemistry* (88) 3804-3809 (2016)
- A field effect transistor biosensor with a γ-pyrone derivative engineered lipid-sensing layer for ultrasensitive Fe^{3+} ion detection with low pH interference, T. D. Nguyen et al., *Biosens. Bioelect.* 54, 571-577 (2014)
- Label free femtomolar electrical detection of Fe(III) ions with a pyridinone modified lipid monolayer as the active sensing layer, T. Nguyen Duc et al., *J. Mat. Chem. B* 1, 443 (2013)
- Supported lipid monolayer with improved nano-mechanical stability: Impact of polymerization; R. El Zein et al., *J. Phys. Chem. B 116,* 7190 (2012)
- Autonomic Self-Healing Lipid Monolayer: A New Class of Ultrathin Dielectric, C. Dumas et al. , *Langmuir 27*, 13643 (2011)
- Direct stabilization of a phospholipid monolayer on H-terminated silicon, A. Charrier et al. *Langmuir* 26, 2538 (2010)