PhD thesis proposal

Thesis title

Study of the mechanisms of injection at the electrode/channel contacts of organic transistors by techniques coupled in electrical and optical near-field

Keywords

"Organic electronics", "charge injection", "organic transistors", "organic semiconductors", "KPFM", "Raman/TERS spectroscopy"

Location

Université de Reims Champagne Ardenne

Laboratoire de Recherche en Nanosciences (LRN)

51100 Reims – France

Date

Planned start of the thesis: October 2023 – Duration: 3 years.

Profile and required skills:

Degree allowing enrolment for a PhD (such as Master 2 de Recherche or equivalent) in physics, materials science, Nanoscience or closely related science.

The candidate should be attracted by experiments.

During the thesis, the candidate will be involved in the fabrication of the polymer-based devices and the exploitation of the experimental setups to characterize the structural properties and the electrical properties of the polymer films.

English spoken and written is mandatory.

To apply

- A detailed Curriculum Vitae
- A copy of your official academic degrees (Master 1 and Master 2) and the corresponding transcripts
- One or two letters of recommendation
- A cover letter

Summary

This thesis falls within the field of organic electronics. It is oriented towards the study of mechanisms limiting the performance of organic transistors. The study focuses on the drifts under stress caused by the degradation of the contacts. It relies in particular on near-field techniques, an electrical KPFM

technique and an optical TERS technique, which will make it possible to characterize these contacts at the nanometric scale. The organic transistor is an essential component for many applications. Its improvement is a major challenge to enable its commercial development.

This thesis is part of the research projects carried out by the 'Organic Electronics' team of the LRN. The team is particularly interested in the fabrication, characterization and modeling of organic transistors. A particular focus is now on the study of the limiting mechanisms of these components, in particular their drifts under electrical stress. We rely on KPFM (Kelvin Probe Force Microscopy) and TERS (Tip Enhanced Raman Spectrometry) techniques to perform local measurements under electrical stress. The project benefits from the favorable environment of the NanoMat platform, as well as collaborations with UTT and EUR NanoPhot for the TERS optical near field part. In particular, the LRN has developed proven know-how in the field of the electrical near-field characterization, correlated with a very good knowledge of the physics of organic transistors.

In addition, the LRN has established collaborations with renowned laboratories able to provide state-of-the-art components, in addition to the achievements of the constantly improving team.

The thesis project aims to support instrumental developments and their use for the characterization of the performance limiting factors of organic transistors. In particular, we wish to study, locally, the electrical and morphological properties of the interfaces of the contacts at the origin of the mechanisms of degradation of these components.

The student will be trained in I(V)-C(V), KPFM and TERS techniques for the first 6 months, as well as in the physics of organic transistors. The samples are transistors based on small molecules (typically sDNTT-10, pentacene and DNTT), made in the laboratory or from our partnerships. He/she will then focus his research on the methodological developments necessary for the study of the interfaces of the contacts of transistors under stress. The available instruments are already customized for the in-situ characterization of biased electronic devices, but further developments are envisaged (such as local electrical measurements using dedicated scripts for example or new electrodes design for specific TERS measurements). The following provisional schedule is proposed:

This PhD thesis topic addresses the problems of drifts and instabilities in organic transistors (OTFT) and has as its main objective the understanding of the degradation mechanisms that induce these problems. Several advanced physical characterization techniques will be involved including near-field techniques. Apart from the usual I-V and C-V electrical characterization techniques, the KPFM (Kelvin Probe Force Microscopy) technique and the NanoRaman/TERS (Tip Enhanced Raman Spectrometry) techniques will be used. The first, KPFM, is an electric mode of the atomic force microscopy (AFM) and allows the local measurement of the electric potential. This type of measurement provides valuable information on the charge injection, trapping and transport mechanisms. These measurements will be performed at the level of the transistor source and drain electrodes.

The second technique, nano-Raman/TERS, is an optical Raman spectroscopy using a conductive AFM probe that enhances the Raman spectral intensity. This technique provides information on the physicochemical structure of the sample (chemical structure, molecular disorder, dipoles orientation and opto-electronic properties). It will also be carried out at the electrodes. The originality of this study is to use in-situ these techniques on operating OTFTs and therefore under electrical stress. This makes it possible to track the degradation mechanisms induced by the electric fields generated by the applied voltages. The PhD student will use these various techniques on OTFTs that will be produced in the laboratory or provided by our partners and collaborators.

In addition to the study described above, the doctoral student will also participate in the instrumental developments envisaged for this study. Specifically, he/she will participate to enable the transistor biasing during the TERS measurement. For the moment only the micro-Raman spectrometer is equipped to allow this kind of measurement.

This PhD thesis will allow a better understanding of the degradation mechanisms in OTFTs which are, at present, one of the technological issues that hinder the development of many applications targeted by organic electronics.