

PhD offer

Understanding doping mechanisms in organic semiconductors at the molecular scale

<i>Etablissement</i>	Université de Lorraine
<i>Unité de recherche</i>	IJL - INSTITUT JEAN LAMOUR
<i>École doctorale</i>	C2MP - CHIMIE MECANIQUE MATERIAUX PHYSIQUE
<i>Spécialité</i>	Physique
<i>Domaine Scientifique</i>	Physique
<i>Durée de la thèse</i>	du 01-10-2026 au 30-09-2029
<i>Date limite de candidature</i>	17 avril 2026
<i>Rémunération</i>	2300€ brut mensuel
<i>Lieu de travail</i>	Campus Artem, Nancy

Project description

Doping of organic semiconductors is a key step for controlling and optimizing their electronic properties, thereby improving the performance of optoelectronic devices such as organic transistors, organic photovoltaics, and organic light-emitting diodes. Unlike inorganic semiconductors, where doping mainly relies on atomic substitution within the crystal lattice, doping in organic materials is governed by molecular interaction mechanisms, including charge transfer and electronic hybridization at the interface between the semiconductor and the dopant molecule. The efficiency of dopants is strongly influenced by their chemical nature as well as by their distribution at the donor/acceptor (D/A) interfaces [1]. A detailed understanding of these mechanisms, particularly at the molecular scale, is therefore a major challenge for the development of more efficient, stable, and sustainable materials, paving the way toward precise electronic engineering of organic systems.

This PhD project aims to characterize, at the molecular scale, the interactions occurring at the D/A interface in order to achieve a comprehensive understanding of doping mechanisms in organic semiconductors. To this end, carefully selected molecules will be deposited under ultra-high vacuum (UHV) on various types of substrates (metallic, semiconducting, insulating, etc.) by thermal evaporation and/or electrospray deposition — an innovative method enabling the transfer of molecules from the liquid phase to the gas phase, particularly suitable for non-volatile macromolecules [2]. The submolecular structure of the D/A mixture will be investigated using scanning tunneling microscopy (STM) [3], while the energy-level alignment at the D/A interface will be characterized by scanning tunneling spectroscopy (STS) [4,5]. These local measurements will be correlated with X-ray photoelectron spectroscopy (XPS) to identify the chemical environment of the semiconductors and dopants, ultraviolet photoelectron spectroscopy (UPS) to characterize the valence electronic states (occupied HOMO levels), and angle-resolved photoemission spectroscopy (ARPES) to determine the band structure of the D/A system, carried out both in the laboratory and at synchrotron facilities [6].

References

- [1] Pei, K. Recent advances in molecular doping of organic semiconductors. *Surf. Interfaces* 30, 101887 (2022).
- [2] Wu, X., Kumar, D., Ham, J., Huang, S. & Anggara, K. Soft landing mass-selected ions for single molecule imaging. *American Chemical Society In Focus* (2025).
- [3] Wu, X. et al. Revealing polymerisation defects and formation mechanisms in aldol condensation for conjugated polymers via high-resolution molecular imaging. *Nat. Commun* 16, 7031 (2025).
- [4] Wu, X., Néel, N., Brandbyge, M. & Kröger, J. Enhancement of graphene phonon excitation by a chemically engineered molecular resonance. *Phys. Rev. Lett.* 130, 116201 (2023).
- [5] Granet, J. et al. Adsorption-induced Kondo effect in metal-free phthalocyanine on Ag(111). *J. Phys. Chem. C* 124, 10441–10452 (2020).
- [6] Vasseur, G. et al. Quasi one-dimensional band dispersion and surface metallization in long-range ordered polymeric wires. *Nat. Commun* 7, 10235 (2016).

Working environment

The Institute Jean Lamour (IJL) is a joint research unit of CNRS and Université de Lorraine. Focused on materials and processes science and engineering, it covers: materials, metallurgy, plasmas, surfaces, nanomaterials and electronics.

By 2026, IJL has 258 permanent staff (33 researchers, 133 teacher-researchers, 92 IT-BIATSS) and 389 non-permanent staff (146 doctoral students, 43 post-doctoral students / contractual researchers and more than 200 trainees), from some seventy different nationalities.

Partnerships exist with 150 companies and our research groups collaborate with more than 30 countries throughout the world.

The candidate will join the Surfaces, Spectroscopies and Modeling group (E102). She/he will have full access to various UHV fabrication and characterization techniques, including STM/STS, XPS, UPS, and ARPES. The candidate will also benefit from access to the D.A.U.M. platform, a unique UHV competence center at IJL dedicated to the preparation of various types of substrates (metallic, semiconducting, insulating, etc.). Samples will be prepared under UHV conditions and characterized in situ using the techniques mentioned above, which are available within the laboratory and the research team. The E102 team also has regular access to synchrotron facilities for high-resolution photoemission measurements.

The PhD student will be supervised by Professor Bertrand Kierren (PhD advisor, HDR) and Dr Xiaocui Wu (co-supervisor), with daily guidance provided within the laboratory. Training in the experimental techniques and the scientific context of the project will be provided by both supervisors. Regular progress meetings will ensure continuous scientific advancement throughout the duration of the PhD.



Profile and skills required

The candidate should hold a Master's degree (or equivalent) in physics, chemistry, materials science, or a related discipline. A strong background in condensed matter physics, surface science, or nanoscience will be appreciated. Experimental skills in surface characterization techniques (e.g., scanning probe microscopy and spectroscopies under ultra-high vacuum) will be considered an asset. The candidate is expected to demonstrate autonomy, scientific rigor, initiative, and strong motivation for research. Good scientific communication skills, as well as the ability to work effectively within a multidisciplinary team, are also required.

To apply

Please send your CV, cover letter, the contact details of two references, together with academic transcripts and ranking for both years of the Master degree to Bertrand Kierren (bertrand.kierren@univ-lorraine.fr) and Xiaocui Wu (xiaocui.wu@univ-lorraine.fr).