Centre National de la Recherche Scientifique (CNRS)
University of sciences and technologies of Lille, BP 60069, avenue Poincaré,
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PhD position available:
Towards control of structure and physical properties of graphene nanoribbons

Host laboratory: Institut d'Electronique, de Microélectronique et de Nanotechnologies (IEMN)
Research group: Nanostructures, nanoComponents & Molecules (NCM)
Host University: Université de Lille, France
Contract duration: 36 months
Keywords: surface science, physical chemistry, scanning probe microscopy (STM/AFM), ultra-high vacuum (UHV)

Context of the research project

The focus on interdisciplinary research covering supramolecular chemistry, materials, and surface sciences has sparked a revolution in the design of new microelectronic devices with remarkable features such as low weight, flexibility, scalability, and transparency. One of the main objectives has been to find alternatives to conventional top-down manufacturing, i.e. photolithography, which requires a multi-step process involving the use of clean rooms, complex vacuum fabrication for IC masks, and the release of a lot of chemical waste. To avoid these problems, many attempts are being made to fabricate such devices by bottom-up methods that involve the self-assembly and reaction of functional molecular building blocks on surfaces. Following this strategy, different miniaturised components embedded in these devices - e.g. sensors, transistors, solar cells - need to be interconnected by wires suitable for electronic transport. Therefore, the development of conductive or semiconducting nanowires at the atomic scale from organic precursors appears to be a necessary direction. It has been shown that the electron transfer rate can be significantly improved in flat and rigid molecular wires compared to flexible wires. In this context, graphene nanoribbons (GNRs) grown from π-conjugated tectons are very promising 1D molecular conducting wires to meet the requirements of nanoelectronics. Indeed, GNRs can exhibit both metallic and semiconducting behaviours, and are in fact ideal candidates for integrated circuits in next-generation graphene-based electronics.

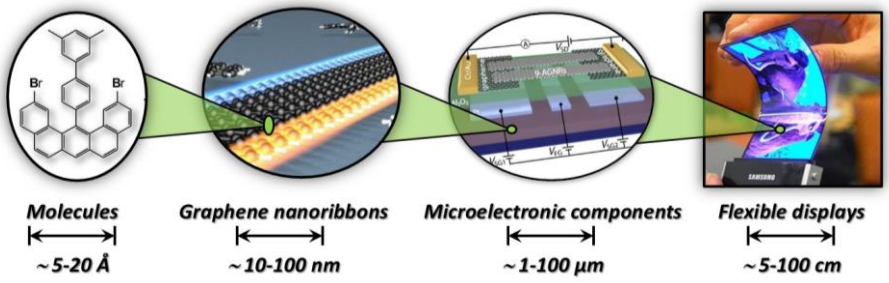

Figure 1: On-surface formation of extended graphene nanoribbons from molecular tectons demonstrating original properties for next-generation of foldable, rollable and stretchable organic electronic devices.

Objectives

This PhD proposal is mainly focused on the development of several methods for on-surface syntheses of graphene nanoribbons for applications in nanodevices. The development of these 1D nanostructures is possible through two thermally activated surface reactions, namely Ullmann coupling and cyclo-dehydrogenation process. Each step of the GNR growth will be monitored by atomic force microscopy (AFM) and scanning tunneling microscopy/spectroscopy (STM/STS) to obtain information on their morphology and electronic structure. In the next step, it is planned to achieve a photo-induced control of the electronic properties of graphene nanoribbons at will and in a reversible way using molecular switches. For this purpose, two distinct approaches will be used, based either on the physisorption of molecular switches on the surface of the GNRs, or on their covalent bonding to the edges of the GNRs. This last aspect is very innovative and has never been done before. From this work, new perspectives are expected for the integration of graphene nanoribbons in flexible molecular electronics.

Candidate profile

We are looking for a candidate with a master's degree in materials science, nanoscience, or physics. The candidate should have a strong interest in experimental work. Knowledge of surface science and ultra-high vacuum (UHV) techniques would be clear advantages for this project.

The candidate will work in UHV conditions:
- Substrate preparation (sputtering/annealing of metal supports, elaboration of thin insulating films on metals);
- Graphene nanoribbons (GNRs) fabrication (molecular deposition/self-assembly, on-surface reactions);
- Acquisition and analysis of the data (STM, AFM, XPS, STS, UPS…).

The candidate might also be involved in studies at ambient conditions:
- Electrical measurement with c-AFM, KPFM, and EFM;
- Transfer of GNRs from the growth to the targeted substrate;
- Fabrication of vertical vdW heterostructures.

The candidate should be able to work both independently and in a collaborative environment (i.e. interact with physicists, chemists and theoreticians). Good communication skills and knowledge of English are required since the candidate will participate in the dissemination of his/her research to the international community: publications in scientific journals, conferences, general public communication, etc.

Working environment

The PhD project will take place at the Institut d'Electronique, de Microélectronique et de Nanotechnologies (IEMN) which is a French major player in the field of micro/nanotechnologies and their applications (https://www.iemn.fr/en/). The IEMN is part of the INSIS institute of CNRS (http://www.cnrs.fr/index.php) and the Université de Lille (https://www.univ-lille.fr/), and located in the metropolitan area of Lille (110,000 students).

The project will involve several research groups of the Nanostructured Materials and Components Department at IEMN. The main part of the project will be carried out in the Nanostructures, nanoComponents & Molecules (NCM, https://www.iemn.fr/la-recherche/les-groupes/groupe-ncm) group working in the physics of nanostructures and micro/nano-devices made of organic materials, self-assembled monolayers, oxide or iono-electronic materials. In addition, the project will benefit from the facilities available at IEMN such as (i) a multi-physics characterization platform (PCMP) and (ii) a clean room (ISO6 1600 m²). In particular, the candidate will work in the Pôle Microscopie en Champ Proche (PCP) which is one of the hubs of the PCMP platform. PCP brings together the means dedicated to the topographic, physical, and electrical analysis of surfaces from 100µm to the atomic scale such as STM, AFM, KPFM, etc. In summary, the facilities of IEMN cover all areas of micro and nanoelectronics from the elaboration and characterization of nanomaterials to their implementation into advanced nanodevices.

Funding

Starting date: October 2023
Contract duration: 36 months
Remuneration: ca. 2047 €/month gross (ca. 1620 €/month net)

To apply

Interested candidates are invited to send a CV, motivation letter and contact details of two referees to

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