GaNeX

Thèse/PhD

Axe 7 : Matériaux, Technologie et Fondamentaux

Titre: Hétérostructures à base de h-BN et Graphène

Laboratoire d'accueil : Laboratoire de Photonique et de Nanostructures (LPN) and Centre de Recherche sur l'Hétéro-Epitaxie et ses Application (CRHEA)

Contexte du sujet : Low dimensional materials have been emerging recently as new systems with unique structure and size dependent properties. While having lateral dimensions typically at the micron scale, the thickness of layers spans only one or a few unit cells, rendering layers "true" nanoscale materials with significant anisotropic properties. With graphene undoubtedly being the archetypical 2D material, inorganic layers derived from layered transition metal oxides or dichalchogenides have potential to increase as well as diversify the portfolio of 2D systems available to date. In this proposal we utilize the regular hexagonal boron nitride (h-BN), a planar isomorph of graphite with small lattice mismatch (1.7%) as a substrate. It is an insulator having a wide band-gap (5.5 eV), higher optical phonon energy (2 times that in SiO_2), and chemical inertness, making it an excellent choice as the substrate or top gate for graphene. It also exhibits excellent thermal conductivity which is desirable for reducing heat-induced failure and improving power dissipation in electronic devices. Even for graphene monolayer, h-BN has been shown to be an excellent substrate which dramatically improves performance for example of the quantum yield. Thus, h-BN, produced on a large scale and possibly in an integrated process with graphene is a strong candidate for new heterostructures. Even more fascinating are "designer" materials, where different 2D crystals (Graphene and h-BN) are combined in a vertical stack, thus fabricating heterostructures, which may be tailored for a specific application. Indeed, the increase in graphene mobility due to the high quality of the h-BN encapsulating material, has being crucial for unveiling interesting physical phenomena like quantum tunneling, metal-insulator transition and coulomb drag.

Descriptif du sujet : In this PhD project we target two objectives:

1. *Growth of h-BN/graphene/SiC on large scale:* the first objective is to provide an atomically flat, ideal substrate and capped layer for exploiting the full potential of 2D materials like graphene by preparing them on h-BN substrates on a large scale. This will allow the investigation of physical properties in the true two-dimensional limit where, typically, charge instabilities and van-Hove singularities are stronger. The PhD student will be involved in the growth of graphene on BN films using propane CVD during regular short term missions in CRHEA.
2. *h-BN doped graphene:* The electrically insulating h-BN and semi-metal graphene may open good opportunities to realize a semiconductor by manipulating the morphology of the 2D hetero-structures (different concentration of h-BN on partial monolayer graphene). Even with a proper description of the chemistry of the monolayer/h-BN interface, many questions remain. Can a given h-BN-doped monolayer graphene become semi-conductor? Will it be a sizeable band gap? Do the electronic states and phonon modes of the h-BN participate in the gap?

The PhD student will use different experimental techniques at LPN: Epitaxial growth of h-BN, AFM, LT-STM/STS, Raman spectroscopy and magneto-transport to describe the structural and electronic properties of h-BN and 2D heterostructures. These experiments will be further supported by complementary structural (LEEM, µ-LEED) and spectroscopic (X-PEEM, µXPS, µARPES) at synchrotron SOLEIL.

Profil du candidat recherché : The candidate should have a Master's degree in Physics with specialization in condensed matter physics. Preferably, candidates should have a background in surface physics and in particular about the surface science characterization techniques (XPS, STM…). Knowledge of the ultra-high vacuum is beneficial. The candidate should be highly self-motivated and have a passion for experimental research.

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