- Axe de GANEX : 7
- Titre du sujet : *Spectroscopy of boron nitride heterostructures*
- Nature de la thèse
  - Simple : GANEX 100%, laboratoire bénéficiaire : L2C
- Date souhaitée de démarrage : 01/10/2015
- Lien avec un projet ANR ou H2020: Non
- Lien avec industriels : Non
- Sujet développé : *(jusqu'au bas de page, police 11-12)*

AlGaN compounds are materials of choice for blue and ultraviolet lasers and LEDs, and consequently the white light domestic lightning. In the last few years, there has been a growing interest in another nitride semiconductor, Boron nitride (BN), which bandgap lies in the 6 eV range (200 nm). On the one hand, bulk BN has appeared as an exceptional substrate for graphene [1] and a promising material for deep-UV light emitting devices [2]. More recently, the possibility to exfoliate BN in a few or single monolayer samples has made BN a fundamental building block of Van der Waal heterostructures, along with graphene and transition metal dichalcogenides [3].

This PhD project consists in investigating Van der Waals heterostructures based on BN by using the optical and transport measurements facilities available in Laboratoire Charles Coulomb (L2C). Optical spectroscopy will be performed, under the supervision of G. Cassabois and B. Gil, with the unique setup allowing for cw and time-resolved photoluminescence experiments under excitation down to 195 nm. The electrical measurements [4] will use a versatile cryostat allowing fast and precise data acquisition from room temperature down to 300mK, with magnetic fields up to 13T, under the supervision of B. Jouault. Samples of increasing complexity will be investigated and we have identified three main steps:

(i) monolayer of BN: optical spectroscopy only can be performed in that case, with the objective to identify the difference in the excitonic recombination dynamics compared to bulk BN [5],

(ii) graphene on a monolayer of BN : we intend to characterize the mobility of the graphene layer and compare our results with the one obtained for SiC substrate [6]; reciprocally, the influence of the graphene layer on the optical properties of the BN monolayer will be studied,

(iii) graphene-BN superlattices: the electronic coupling between the single-layer quantum wells formed by the BN monolayers will be explored by optical measurements, and the counterpart modification of the graphene properties will be studied in transport.

Depending on the preliminary results, we can also decide to perform simultaneous optical and transport measurements (e.g. photoconductivity), although such a combination appears quite challenging given the extreme experimental environments.

This project will be developed in collaboration with A. Michon (CRHEA-Valbonne) and A. Ouerghi (LPN-Marcoussis) for the growth of the different BN heterostructures, the collaboration between A. Michon and B. Jouault being already effective [6]. Some of the first samples consisting in BN monolayers can be provided through other collaborations (A. Loiseau, ONERA) so that the PhD student can start his/her project during the growth tests of BN in CRHEA or LPN.

References

[1] Dean, C. R. *et al.,* Boron nitride substrates for high-quality graphene electronics. Nature Nanotechnol. **5**, 722–726 (2010).
[2] Watanabe *et al*., Far-ultraviolet plane-emission handheld device based on hBN. Nat Photon **3**, 591-594 (2009).
[3] A. K. Geim & I. V. Grigorieva. Van der Waals heterostructures. Nature **499**, 419-425 (2013).
[4] L. Wang *et al*., One dimensional electrical contact to a 2D material, Science **342**, 614 (2013).
[5] G. Cassabois, P. Valvin & B. Gil. *in preparation.*
[6] F. Lafont et al., *under review* in Nature Commun., *available* at arXiv: 1407.3615 (2014); B. Jabakhanji et al., Phys. Rev. B **90**, 035423 (2014); B. Jabakhanji et al., Phys. Rev. B **89**, 085422 (2014).