ANR funded PhD:

Characterization of ultrafast (photo)transport and electroluminescence in TMDC

Keywords: 2D, TMDC, (photo)transport, electroluminescence

The PhD candidate will be involved in the development of a new experimental technique, which combines the spatial resolution of scanning probe microscopy with the temporal resolution of a femtosecond optical pump-probe setup, for applications to vdW heterostructures and devices.

Context

The genuine craze for nanomaterials and their heterostructures is intimately linked to their potential for a wealth of applications, from drug delivery to quantum communications. Over the past few years, low dimensional systems, in particular 2D materials have benefited from tremendous material-oriented efforts that enabled growing intrinsic systems, such as encapsulated 2D transition metal dichalcogenide (TMDC)1 or colloidal CdSe nanoplatelets2 with minimal spatial inhomogeneity and inhomogeneous broadening effects. These striking structural and optical properties make 2D materials ideal candidates to take over conventional materials in opto-electronic applications. So far, the understanding of their electronic and optical properties, in correlation with their growth, has been sought at the expense of the most challenging properties to measure at the nanoscale: transport. Such properties make the direct link between the fundamental research and the actual device. Any opto-electronic application based on nanomaterials requires a holistic knowledge on how fast charge carriers can be injected or extracted after electrical or optical excitation at the nanoscale. There is no instrumental technique available yet to characterize the charge carriers with simultaneous high spatial and temporal resolution.

Objectives

This is the key objective of the project (ANR-INFERNO): the development of an innovative instrument capable of performing multiscale spatial and temporal in-situ analysis of the basic physical mechanisms that underpin the operation of opto-electronic materials and devices. This new correlative spectroscopy will allow for performing a tomography of the intrinsic properties of nanomaterials and their heterostructures such as the carrier mobility, the resistivity, the free carrier dynamics across interfaces, or the nature of the transport (ballistic, diffusive). Not only setting a hallmark on fundamental parameters, this technique will enable the local injection of charge carriers to unveil the hitherto unknown physical mechanisms limiting the electroluminescence of nanostructure-based device.

Ultraclean van der Waals heterostructures (vdWh) will be custom-designed by the partners of this project (IPCMS, Strasbourg). They will be the materials of choice for test, development and benchmarking of the project and lay the ground for advanced fundamental studies using this new platform.

Environment

The PhD candidate will join the team “Physics of nanostructures and quantum devices” at IEMN, a team of 4 PhD students, 3 CNRS researchers, 5 assistants professors and 2 research engineers (more information at https://www.iemn.fr/la-recherche/les-groupes/physique/nanostructures-quantum).

The IEMN is a joint research unit located on the campus of the University of Lille with a staff of 450 people. Ideally located 1 hour by train from Paris, London and Brussels, the IEMN is one of the 5 major French technology centres of the RENATECH network. In addition to internal requests (22 research groups), the

multi-physics characterization platform welcomes requests for analyses from the University of Lille, academic partners, and industrialists in a stimulating multidisciplinary atmosphere.

In this context, the laboratory supports technological developments in the scanning probe microscopy and optical fields with the joint HORIBA-IEMN laboratory and the start-up companies hosted by the laboratory (e.g. VMICRO, Zymoptiq). It benefits from the support of internal prototyping services, access to fablabs and a strong link with several engineering schools.

Profile of the candidate:

We are looking for an excellent and highly motivated candidate with a Master degree in physics, solid state physics, semiconductor physics, engineering or a relevant field. The candidate is expected to be self-driven, to have strong work-capacity, enthusiasm for science and appetite for instrumental development. A good command of English language, with excellent oral and written skills are required.
Knowledge in STM, AFM, electron microscopy, UHV or pump-probe microscopy is required, experience is a plus. Engineering skills are highly appreciated.
Applications are encouraged from all sectors of the community, reflecting the team's commitment to equality and diversity.

Starting date:

From May 2023.

References

1. Cadiz, F. et al. Excitonic linewidth approaching the homogeneous limit in MoS2-based van der Waals heterostructures. Phys. Rev. X7, 021026 (2017).
2. Ithurria, S. et al. Colloidal nanoplatelets with two-dimensional electronic structure. Nat. Mater.10, 936–41 (2011).

Contact

You can contact directly Maxime Berthe or Louis Biadala at Iemn or submit online:
https://www.abg.asso.fr/fr/candidatOffres/show/id_offre/111105/job/characterization-of-ultrafast-photo-transport-and-electroluminescence-in-tmdc-inferno