#21: Area of Expertise: Physics Engineering and/or Material Sciences

Research Project Title

2D monolayers of black phosphorus: determination of the band structures using optical transitions and selection rules

University Cycle

1st cycle (undergraduate) and 3rd cycle (Ph.D.)

Background Information

Inspired by the unusual properties of graphene, the search for other 2D materials has unveiled that monolayers of black phosphorus also offer unusual and spectacular characteristics. In contrast to gapless graphene, black phosphorus monolayers are perfectly adapted for logic electronics and optoelectronics with a gap of about 1.5 eV. Carrier mobilities exceeding those of silicon have been reported, which could make black phosphorus the ideal candidate for high performance flexible electronic applications.

However, the properties of thin black phosphorus samples remain to be unveiled, as little is known on its electrical, optical and mechanical properties. One of the most fundamentally characteristic of a material is its band structure close to the Fermi level, as it determines most of the optical and electronic properties.

Main Tasks during the Internship

This project consist in providing the experimental values for reconstructing the band structure of this new 2D material. Using electroreflectance spectroscopy and differential reflectance in a wide spectral range, the student will determine all optically allowed optical transitions, along with their polarization selection rules. Using this information, the student will unveil the evolution of main critical points as a function of the number of monolayers and as a function of perturbations like temperature, strain and magnetic field.

The student will familiarize himself with single monolayer preparation and manipulation, low-temperature cryostats, supercontinuum lasers, advanced optical microscopy techniques at high magnification, and a very exiting research topic.

Required Skills for the Internship

The student should have a background in engineering physics, physics, or any closely related disciplines. We seek students sharing our passion for experimental physics.

Supervisor

Mr Sébastien FRANCOEUR, Associate Professor, Department of Engineering Physics
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=328&Langue=A

#22: Area of Expertise: Physics Engineering and/or Material Sciences

Research Project Title

A promising qubit for quantum computation: excitons bound to small molecules embedded in semiconductors

University Cycle

1st cycle (undergraduate) and 3rd cycle (Ph.D.)

Background Information

Single impurity atoms in semiconductor crystals can be spatially resolved and studied individually. Carefully selecting the nature of the impurity and the host material, an impurity center composed of one, two or three atoms can bind electrons and holes, thereby forming an exciton bound to a quantum structure. Although the electronic properties of these atomic-size quantum dots are similar to those of conventional quantum dots composed of tens of thousand atoms, their size is comparable to the volume of a few atoms. This offers excellent opportunities for the realization of a spin-based qubit of atomic dimensions for the field of quantum computation.

Using ultrafast laser pulses and optical spectroscopy techniques, we have recently demonstrated that it was possible to initialize an exciton qubit and manipulate its state over the whole Block sphere. Doing so revealed a very high optical dipole moment and a very low power induced dephasing, making this system a very attractive building block for high-fidelity quantum operations.

Main Tasks during the Internship

The student will assist a team formed by two Ph.D. students by 1) making samples using low-dose and low-energy implantation techniques at our on-campus state-of-the-art facility, 2) improving our ultrafast pulse preparation system by implementing complex multi-pulse excitation sequences, 3) operating our cryogenic microscope and measuring the luminescence from single molecules, and 4) assisting with quantum control experiments.

The student will familiarize himself with implantation facilities, ultrafast lasers, cryostats, advanced optical microscopy techniques, and a very exiting research topic.

Required Skills for the Internship

The student should have a background in engineering physics, physics, or any closely related disciplines. We seek students sharing our passion for experimental physics.

Supervisor

Mr Sébastien FRANCOEUR, Associate Professor, Department of Engineering Physics
http://www.polymtl.ca/recherche/rc/en/professeurs/details.php?NoProf=328&Langue=A