PhD Fellowships

in Nanoscience

Two PhD fellowships, funded by the Severo Ochoa Centres of Excellence acreditation programme, are available to work on the physics of two dimensional materials at the Catalan Institute of Nanoscience and Nanotechnology (ICN2) which is located 30 minutes north of downtown Barcelona, Spain (www.icn.cat). Both projects will start in January 2015 although other dates can be considered. Their expected duration is 3 years with a possible extension of up to one additional year.

Candidate´s profile

The applicants must show motivation, excellent disposition towards challenging research problems and a good level of the English language. A strong background on solid-state physics and experience in experimental methods (optics and/or electric transport) will be valued. A completed degree in Physics at the Master level (or *Licenciatura*) is required at the time of joining ICN2, with an average grade above 8.

Project#1

"Tailoring the thermal and thermoelectric properties of topological insulators and graphene towards smart heat management for next generation nanodevices"

Supervisors:

Prof. Sergio O. Valenzuela (sov@icrea.cat)
Dr. Juan S. Reparaz (sebas.reparaz@icn.cat)

Project#1 description

Some of the best thermoelectric materials are also topological insulators (TIs). This is no coincidence, TIs require heavy elements to generate large spin-orbit coupling (SOC), which drives the formation of the topological surface state, and a small bandgap so that the SOC can lead to band inversion. Thermoelectric semiconductors consist of heavy elements to obtain a low phonon thermal conductivity and have a small bandgap for a strongly energy dependent electrical conductivity and large thermopower. Bi_2Se_3 has one of the largest thermoelectric figures of merit ZT, and is a TI with a single Dirac cone on the surface. Because of their recent discovery, the Dirac states have not been taken into account in thermoelectrics, however it is now believed that they can help enhance it significantly. Here, we will study the thermal and thermoelectric properties of Bi_2Se_3 and prototypical Dirac material graphene using nanodevices, two-laser Raman thermometry and scanning thermal microscopy. We will then tailor the TI and graphene by (periodical) nanopatterning in order to tune the energy dependent Dirac carrier transmission and the phonon dispersion relations across the structure. By controlling charge and heat propagation, we aim at enhancing ZT.

Project#2

"Engineering electronic and magnetic properties of metal organic-topological insulator heterostructures"

Supervisors:

Dr. Aitor Mugarza (aitor.mugarza@icn.cat)
Prof. Sergio O. Valenzuela (sov@icrea.cat)

Project#2 description

Engineering the transport properties of the recently discovered topological insulators is the forthcoming challenge that will condition their succesful integration in nanodevices.This project aims to build novel strategies to tune electronic and magnetic properties by interfacing metalorganic (MO) and topological insulator (TI) thin films. Specific objectives of the project are: i) To grow and characterize MO/TI heterostructures with atomic precision (epitaxial growth of TI thin films on gate oxides, molecular self-assembly on TI surfaces); ii) To identify mechanisms for the simultaneous control of chemical (band alignement, n-p doping) and magnetic interactions (band gap opening, long-range magnetic order of impurities); iii) To extend the MO/TI heteroepitaxy to nanodevice geometry for transport measurements; iv) To correlate atomic scale interfacial properties with the transport behavior of the nanodevices. The project will combine molecular beam epitaxy, scanning tunneling microscopy and spectroscopy, X-ray absorption and electron spectroscopy (ARPES, XPS, XMCD), and magnetotransport measurements. The experimental study will be supported by ab-initio theory and large-scale simulation of the interfacial and transport properties

Websites of interest:

http://www.icn.cat/index.php/en/research/core-research/physics-and-engineering-of-nanodevices/overview
http://www.icn.cat/index.php/en/research/core-research/phononic-and-photonics-nanostructures/overview
http://www.icn.cat/index.php/en/research/core-research/atomic-manipulation-and-spectroscopy/overview