Research Topic for the ParisTech/CSC PhD Program

Field: *Energy, Processes, Materials Science, Physics, Design, Industrialization*

Subfield: (Applied Physics, Chemistry, Mathematics, Mech. Eng. etc…)

Title: Novel 2D Nanomaterials and hierarchical nanostructures for next generation electronics and optoelectronics

***ParisTech School*:** LPICM-Ecole Polytechnique/ CNRS

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Short description of possible research topics for a PhD:

One of the hottest topics in materials science, focus nowadays on the 2D layered materials and particularly the possibility of stacking them on top of each other, thus obtaining various 2D heterostructures with new properties, generating a new family of hybrid materials. Recent advances have shown that combining two or more thin layer materials together can generate interfaces with properties significantly different from that of a single component. Particularly, vertically stacked TMDs heterostructures can result in band alignment that facilitates efficient electron-hole separation, and thus enabling fast charge transfer for advanced applications like photodetectors, photovoltaics and light emitting diodes etc. The aim of the thesis project is the development of an original in-place synthesis process of new 2D- materials and their heterostructures for applications in the field of next generation electronics and opto-electronics. The project articulates around three main topics: i) development of new routes for in-place synthesis and characterization of new 2D transition metal dichalcogenides (TMDCs) nanomaterials with tailored properties in the form of M Y2(1-x)Y'2x with M = W and Y,Y' = S, Se, ii) bottom-up assembly and characterization of new 2D-heterostructures and iii) integration of such nanostructures into optoelectronic devices (photo-detectors, transistors…..). The original approach of the project relates to the usage of FENIX equipment (Facility for Elaboration of Nanomaterials with In-situ analysis at X), an unique platform for synthesis and characterization of nanomaterials that Thématiques /Domaine /Contexte Objectifs Méthode enables the in-situ, real time monitoring by surface analysis (angle resolved XPS, UPS, high resolution Auger spectroscopy and reflection low energy EELS), as well as high resolution LEED and mass/ion energy spectroscopy. With the simultaneous availably of more than 8 various (vapors, free radicals, ions) focused matter beams this facility allow future breakthroughs on understanding the growth mechanisms of ultrathin 2D materials and heterostructures, their doping, surface interactions or defects creation.

K. Novoselov, et al. Nature 438 (2005) 197 ;
L.F. Mattheis, Phys. Rev. B 8 (1973) 3719 ;
F. Xia, et al. Nat. Photonics 8 (2014) 899 ;
K. Novoselov, et al. Proc. Natl Acad. Sci. USA 102 (205) 10451 ;
A.K. Geim, et al. Nature 499 (2013) 419

Required background of the student:

We are seeking an excellent young scientist, eager to carry out leading edge research in a multidisciplinary field at interface of materials science, surface science and nano(opto)electronics. The candidate should have a good background in condense matter physics. He (she) will work in strong interaction with a multi-disciplinary team made up of physicists, chemists and engineers.