PhD position

"Epitaxy and remote epitaxy of ZnS and $Zn_{1-x}Cd_xS$ thin films with wurtzite crystal phase"

Keywords: Epitaxy, remote epitaxy, MOCVD (MOVPE), II-VI semiconductors, crystal phases, polytypism, transmission electron microscopy.

Study scope

For many decades now, research on semiconductor thin films has been very active, has opened original fields of investigation in fundamental physics, and has enabled unique opportunities for applications in electronics, photonics, sensors, actuators, energy, and health. From the material point of view, this requires to fabricate epitaxial layers as perfect as possible since device performances largely depend on the crystalline quality of the materials used to fabricate them. In addition, semiconductors can be synthetized in other crystal phases than the standard one (phase of lowest energy), with different physical properties. This is known as polytypism, and this area of research offers great opportunities to tailor the properties of electronic materials like silicon or germanium.

The first objective of the proposed PhD thesis is to fabricate and characterize ZnS and $Zn_{1-x}Cd_xS$ thin films in the hexagonal wurtzite phase, with thicknesses of a few tens of nanometers. ZnS commonly crystallizes in the cubic phase (zinc blende, ZB) but, growing on the suitable substrate, the epitaxy can lead to a hexagonal crystalline structure (wurtzite, WZ). The materials will be elaborated by using Metal-Organic Chemical Vapor Deposition (MOCVD), which is an industrial technique commonly employed in microelectronics. The morphology and the structural properties of the grown layers will be accurately characterized by scanning electron microscopy (SEM), atomic force microscopy (AFM), X-Ray diffraction and scanning transmission electron microscopy (STEM). In particular, the observation and study of the crystalline phase will be the focus of our attention.

The second objective is to explore what is called "remote epitaxy" [1] where the thin film will be grown through a 2D material (graphene in this project) previously transferred on the substrate. Graphene suppresses strong chemical bonds, and hence the interaction with the deposited film is given by quasi Van-der-Waals bonds. However, the electrostatic potential of the underneath substrate is not totally screened, allowing for a coupling between the film and the substrate. That is believed to ensure a kind of epitaxy with respect to the underlying crystalline structure. But still, there are many fundamental open questions about this new process and its validity. Studying the remote epitaxy of WZ-ZnS films on ionic II-VI substrates will be unique in the community and of strong interest for the field.

The PhD thesis is part of a national project funded by French National Agency for Research (ANR) and led by C2N Palaiseau.

Techniques/methods in use: the PhD student will use on his/her own a MOCVD reactor available in the group. He/she will carry out structural characterizations by scanning electron microscopy, X-ray diffraction and atomic force microscopy, and will actively participate to STEM characterizations and analysis. Experiments related to remote epitaxy will be conducted in close collaboration with C2N.

Applicant skills:

Knowledge: condensed matter, crystallography, physics of semiconductors.
Skills: experimental work, communication (the PhD student will participate to national and international conferences), team-working, good English, ability to follow safety rules (possibly some work in cleanroom).

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Laboratory and location : the PhD student will join the "Semiconductors" team at GEMAC, (Groupe d'étude de la matière condensée), 78000 Versailles, France. GEMAC lab is affiliated to CNRS, Université de Versailles St Quentin (UVSQ) and Université Paris-Saclay. https://www.gemac.uvsq.fr/

[1] Y. Kim et al. Nature 544 (2017) 340, https://www.researchgate.net/publication/316252232