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Chimie – Mathématiques – Physique – Sciences de l'Univers

Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Growth of III-V semiconductors by HVPE process and surface passivation

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Possible co-supervisor :
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Summary :

This worm will be performed within the MINAMAT group of the Pascal Institute. MINAMAT group gathers three teams on the following topics: surface nanostructuration of III-V and III-N semiconductors and surface analysis by electronic spectroscopies (EPES, XPS, Auger) ; growth of III-V and III-N by Hydride Vapor Phase Epitaxy (nanowires, nanogratings) ; development of Chemical Sensor MicroSystems for the selective metrology of weakly concentrated species (air pollutants).

Nanoscale structures (nanowires and nanorods) of group III-V materials have attracted extensive interest for applications in spintronics, quantum electronics, opto-electronics, and sensors. These nanostructures showing a high surface to volume ratio offer great promise for new III-V wire devices. III-V nanowires are good candidates for the integration on silicon wafers.

Among the various epitaxial processes, the nanowires can be synthesized by Hydride Vapor Phase Epitaxy (HVPE) coupled to a VLS (vapor-solid-liquid) process based on metal catalyst. The metal catalyst is deposited on the surface of the substrate before the growth process. Growth of long (50 µm -100 µm) GaAs NWs in a short process (10 min) has been achieved. They have rodlike shape with constant nanometric diameter (<50 nm), defect-free crystals with cubic structure. This process is now mastered [1-3].

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During this internship, the Ga-assisted III-V nanowires growth will be developed by in Hydride Vapor Phase Epitaxy (HVPE) deposited on silicon wafers. Thus, the growth does not require the use of metal catalysts prohibited by the silicon platform. This work will also address the deposit of gallium either by HVPE in-situ deposit using Ga-Chloride precursors or inside an Ultra High Vacuum (UHV) chamber in order to control the size of the gallium droplets and thus the density and the diameter of the nanowires. The gallium quantity will be monitored by electronic spectroscopies (XPS, AES or EPES). The III-V nanowires will be passivated with nitrogen plasma source in UHV conditions. GaN ultra-thin films created on the surface of the nanowires will passivate versus the contamination from ambient air [(4)]. This passivation process will therefore reduce surface defects and thus improve the "electronic" properties of nanowires. The crystallinity of the surface of the III-V nanowires, will be studied using the LEED characterization method, coupled with other spectroscopic characterization techniques (XPS, AES, EPES). During this work the PhD student will take part in the development and calibration of a LEED set-up in order to control and tune the crystallinity of the nanowire passivated surface. The PhD student will be responsible for optimizing the measurement parameters and will study the annealing of these passivated structures by LEED method in real time. The passivation process nanowire will then be validated by measurements based on optical imaging spectroscopy PMC Polytechnic School in Palaiseau. This work will be supported by the PauliNano ANR project, applied in October 2015. The goal of this project is to explore the spin diffusion inside such ultra-long 1D structures based on GaAs nanowires. Optical imaging spectroscopy will be used to validate the passivation in order to improve the "electronic" properties of the III-V nanowires.

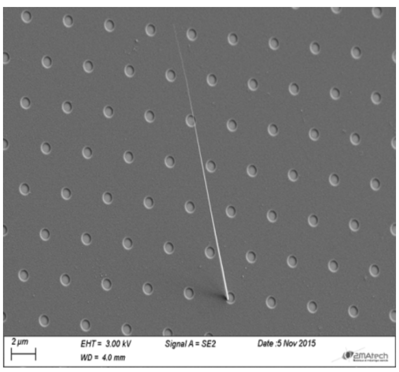

Figure 1 : Ultralong GaAs nanowire grown by HVPE self-catalyzed process on silicon substrate

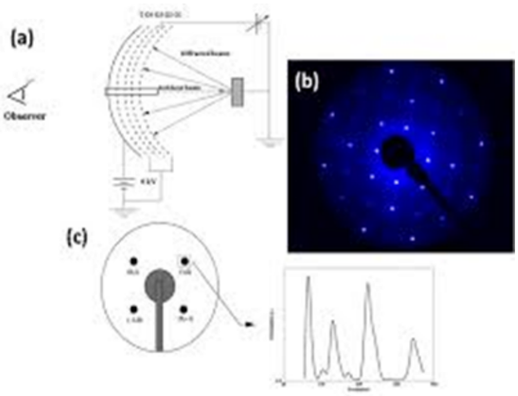

Figure 2 : LEED set-up to tune the surface crystallinity of the nanowires