Master 2 position in Nanotechnology, Toulouse, France

LAAS-CNRS, Paul Sabatier University

Optimizing the hierarchical order of GaAs nanowires for water splitting.

Efficient water splitting using light as the only energy input requires stable semiconductor electrodes with favorable energetics for the water-oxidation and proton-reduction reactions. Strategies to tune electrode potentials using molecular dipoles adsorbed to the semiconductor surface have been pursued for decades but are often based on weak interactions and quickly react to desorb the molecule under conditions relevant to sustained photoelectrolysis. Here, we show that covalent attachment of fluorinated, aromatic molecules to p-GaAs(1 0 0) surfaces can be employed to tune the photocurrent onset potentials of p-GaAs(1 0 0) photocathodes and reduce the external energy required for water splitting.

Topological Insulators (TI) are a new class of materials that are electrical insulators on the inside and conduct electricity on the outer surface. They were discovered less than a decade ago after earlier theoretical work and awarded of the 2016 Nobel Prize in Physics. Among TI, bismuth antimonide ($Bi_{1-x}Sb_x$) was the first experimentally-observed 3D topological insulators[1]. Because of these unique properties, 1D and 2D nanoscale bismuth antimonide alloys are promising candidates for quantum computing, thermoelectrics and spintronics[2].

Controlling the antimony composition, $Bi_{1-x}Sb_x$ is suggested to behave as: a semi-metal ($x<0.07$), an indirect bandgap semiconductor ($0.07<x<0.09$), a direct bandgap semiconductor ($0.09<x<0.15$), an indirect bandgap semiconductor ($0.15<x<0.22$) and again semi-metal ($x>0.22$)[1]. Thus, a precise control of this parameter hold promises for future quantum devices. For instance, if $x=0.03$, 3D Dirac cones should be observed in the structure and could be used to host Majorana zero mode when coupled with a superconducting contact[1]. If $0.08<x<0.24$ the material behaves as a 3D-topological insulator, and for $x>0.23$, the high electron mobility and strong spin-orbit interactions make it an interesting candidate for spintronics[2,3]. Hence, excellent quality of 1D and 2D nanostructure with control of the Sb composition is necessary in order to understand and engineer the material.

This Master 2 position will focus on the synthesis of nanoscale BiSb materials and their structural characterizations (SEM, TEM, EDX). Epitaxial $Bi_{1-x}Sb_x$ nanowires and nanoflakes, with controlled Sb concentrations, will be integrated on silicon.

The research work will be conducted in the MPN group of the LAAS-CNRS under the supervision of Dr. Sébastien Plissard. The Master 2 candidate will benefit from the state of the art clean-room environment of the lab, and from the broad knowledge of the group in the fields of nanowire growth, high mobility materials, nanofabrication and material characterization.

Potential candidates should demonstrate knowledge or experience in nanotechnologies, thin film deposition, materials science, material characterization and nanofabrication.

References:

[1] D. Hsieh, D. Qian, L. Wray, Y. Xia, Y.S. Hor, R.J. Cava, M.Z. Hasan, *Nature* **2008,** 452, 970–974.
[2] S. Tang, M.S. Dresselhaus, *J. Mater. Chem. C* **2014**, *2* (24), 4710.
[2] Z. Hasan, S.-Y. Xu, M. Neupane, *Topological Insulators: Fundamentals and Perspectives*, **2015,** 55–100.

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