MAP-fis Essay Proposal, 2016-2017

(*please write in English*)

Supervisor

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Title

Optoelectronic characterization of chalcogenide solar cell and 2D materials

Area

(*Materials, Optoelectronic characterization*);

Photovoltaic Materials, 2D Materials, Optoelectronic characterization

Summary of Proposal

Semiconducting chalcogenide materials are of high interest for a large variety of applications. The chalcopyrite materials of the Cu(In, Ga)(S, Se)$_2$ family are used as solar cell absorber material giving the currently best performing thin film solar cells reaching efficiencies of 22.6%. On the other hand, the semiconducting transition metal chalcogenides in their 2 dimensional form, e.g. MoS_2 or WSe_2, have recently received much attention due to their interesting properties, a consequence of quantum confinement and surface effects that are associated with their low dimensionality. Among these properties are tunable bandgaps – bandgap dependence on the number of layers forming the material -, intense photoluminescence, and large excitonic binding energy, which suggest their application in optoelectronic devices such as solar cells, photodetectors or light-emitting diodes. Other types of devices that could benefit from the optical and electronic properties of such 2D materials are chemical and biosensors.

Clearly, the optoelectronic characterization of such semiconducting materials is at the heart of developing a more profound understanding of the materials properties and essential for the development of the above mentioned devices based on those materials.

The main technique to be applied in this project will be photoluminescence characterization, which provides information about band gap energy, defect states, potential fluctuations, etc. Within the course of the work, the existing setup, consisting of a spectrometer configured to accept several gratings, equipped with high performance detectors, and using different possible monochromatic and white light sources, is also to be further developed to allow additional measurement possibilities, e.g. measurements at variable temperature, imaging by raster scanning the sample, etc.

Spatially resolved photocurrent measurements will be done in a confocal micro-Raman system using the laser light as illumination source, leading to a diffraction limited resolution. The dependence of the photocurrent on the applied voltage bias will be studied. The photosensitivity will be obtained from comparison of measurements made in the dark and under constant illumination. The dependence of the carrier generation rate on the incident photon flow will be studied, by monitoring the current at constant bias while varying the incident laser light intensity. A higher resolution will be achieved by using scanning probe microscopy (SPM) methods. A Constant Photocurrent Measurement (CPM) set up will be used to measure the middle gap absorption and the absorption in Urbach tails of the conduction and valence bands, thus providing crucial information about the electronic deep defect states and those lying at the band edges. The work function of each relevant layer will be measured using Kelvin probe force microscopy (KPFM). Using the above described methods, the homogeneity of materials and devices will be assessed and optimized.

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References

(*to allow students first look at topic*)

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Further relevant references can be found at https://wwwfr.uni.lu/recherche/fstc/physics_and_materials_science_research_unit/people/susanne_siebentritt