Thesis Proposal

Title	Development of an advanced contactless optoelectronic characterization technique based on photoacoustic effect: application on thin films semiconductor material and photovoltaic devices	
Group :	Energies renouvelables (En), Matériaux – nanotechnologies (MN)	
Candidate	Name	TT
Thesis Supervision	Supervisor	Yves BERNARD (U-PSud, Assistant Professor)
	Co- Supervisor	Arouna DARGA (UPMC, Assistant Professor)
Laboratories	Host Laboratory	LGEP-SUPELEC
Institution	Université Paris-Sud	
	IPVF (Institut Photovoltaic Ile de France)	

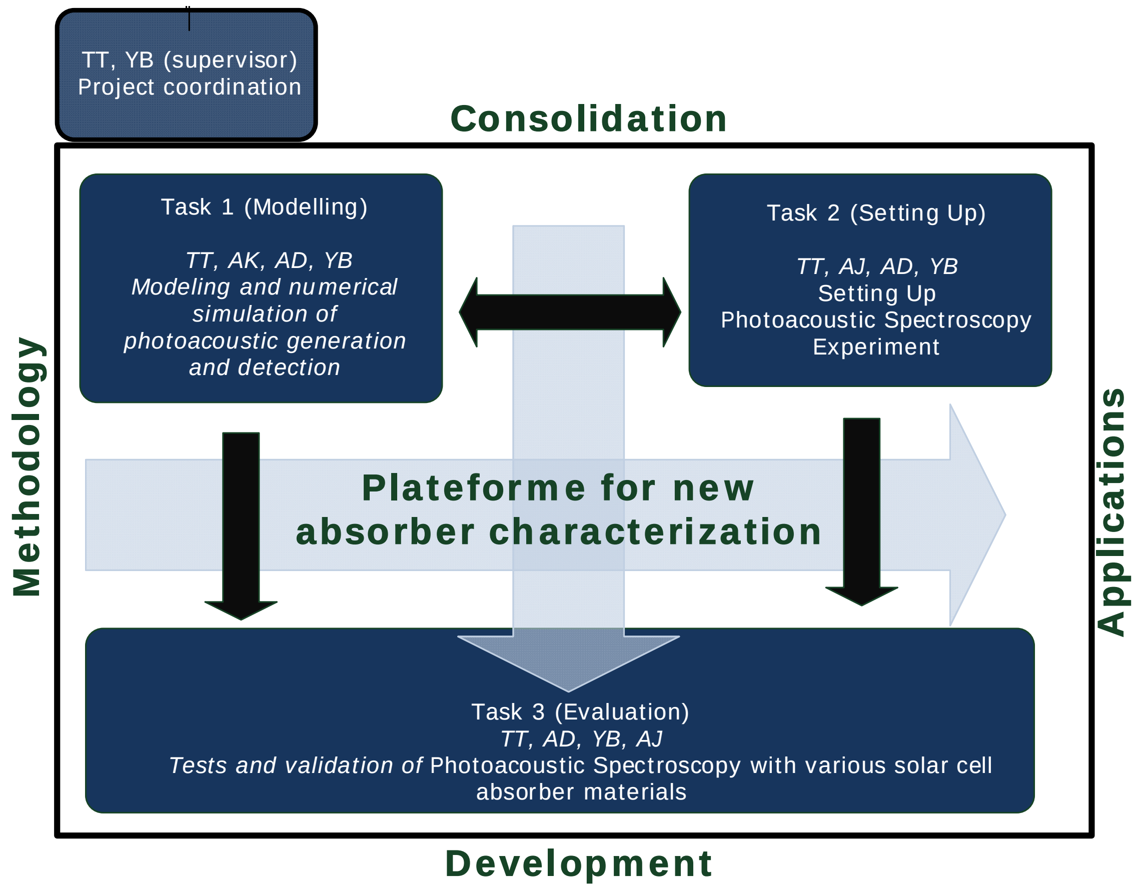
Project Summary:

To reduce the dependence of our industrialized society on fossil fuels and nuclear energy, cheap and sustainable 'sources' of energy have to be developed and commercialized. Among the different renewable energies, the power from the Sun is probably the most lasting and striking in terms of its potential. Among the various ways to transform solar irradiance into power, solar cells based on the photovoltaic (PV) effect with the advantages of decentralization and sustainability have attracted great attention in the past 50 years. To realize this potential however, we need to capture this diffuse energy (1–2 MWh m^{-2} $year^{-1}$) with large areas, and with good enough efficiencies, which imposes constraints in the type and amount of materials to be used. Thus, there is a strong research effort to develop a sustainable, low cost and high efficiency solar cell in order to reach the ultimate cost potential of this technology. Different strategies are being investigated: earth abundant material (CZTS, perovskites…), low cost fabrication methods, new geometries using ultrathin film for light absorption or trapping. In order to accelerate the research and development (R&D), it is important to have a characterization tool for a rapid evaluation of material electronic and optic quality. Optical properties of textured and or ultrathin film material are difficult to obtain with traditional techniques like transmission/reflection measurements. Also, near band electrically active defects, which determine the electronic transport properties of the material, are difficult to probe with conventional techniques. PhotoAcoustic Spectroscopy (PAS) technique, based on the generation and detection of photoacoustic (PA) effect can be used to study both near band defects and optical properties of semiconductor materials, as the technique is sensitive to radiative and non-radiative relaxation processes. Indeed, PA effect, discovered by Alexander Graham Bell, consists in the production of acoustic waves, subsequent to modulated or pulsed light absorption by a sample. The pressure or the elastic wave which strongly depends on the sample thermal and optoelectronic properties can be detected as a PA signal, by a suitable sensor such as a microphone or a piezoelectric transducer (PAS).

In the Semiconductor Characterization and Modelling (SCM) team at LGEP, we have developed a set of tools for electrically active defects characterization. These tools are essentially based on photoluminescence, photocurrent and capacitance measurements. **The aim of this PhD project is to build the PAS technique. The PhD project will take benefit from the strong partnership and collaboration between LGEP and the other laboratories that participate to the French PhotoVoltaic federation, FedPV (www.fedPV.cnrs.fr), and the new photovoltaic institute (IPVF, Institut Photolvoltaïque d'Île-de-France) which includes major French companies (Air-Liquide, EDF, TOTAL…).**

Scientific description and organization

To achieve the objectives that we set for this PhD project, the work will articulate around three interconnected tasks illustrated in the graphic of figure 1.



TT = PhD candidate
YB = Yves Bernard (Univ. Paris-Sud (LGEP), Professor)
AD = Arouna Darga (UPMC (LGEP), Assistant Professor)
AK = Abelin Kameni (Univ. Paris-Sud (LGEP), Assistant Professor)
AJ = Alexandre JAFFRE (CNRS (LGEP), IR)

Figure 1: project workflow diagram

In Task 1 the PhD student will work on modelling and simulation the photoacoustic generation and detection. The free multi-physics three dimensions simulation tools ONELAB, Open Numerical Engineering LABoratory (http://onelab.info/wiki/Main_Page) will be used. The aim is to build a model which can be used to predict the photoacoustic generation and detection. The final result should be a guideline for the task 2 and task 3. This task will be supervised by Dr. Abelin Kameni (Assistant professor).

The task 2 consist of the development of the experiment setup which will be built around a powerful and smart lock-in amplifier from Zurich Instruments. The experiment consist of the illumination of the sample with a modulated monochromatic light (Halogen light with monochromator) and the detection of photoacoustic signals by a piezoelectric transducer (PZT) which will be attached directly to the sample. The output signals from the PZT will be amplified by a digital lock-in amplifier and processed by a personal computer in order to extract material optoelectronic properties.

Task 2 will be supervised by Dr. Darga Arouna (Assistant Professor). An optical Engineer Alexandre JAFFRE (CNRS) will be involved for optical and light generation setups.

Finally, Task 3 will gather all the work done in the previous tasks to propose and to test photoacoustic spectroscopy setup. Measurement of optical absorption spectra of different thin film semiconductor will be compared to classical measurements techniques.