Master 2 Internship

Title: Thermoelectricity 2.0 : ZT measurement by a solely optical way

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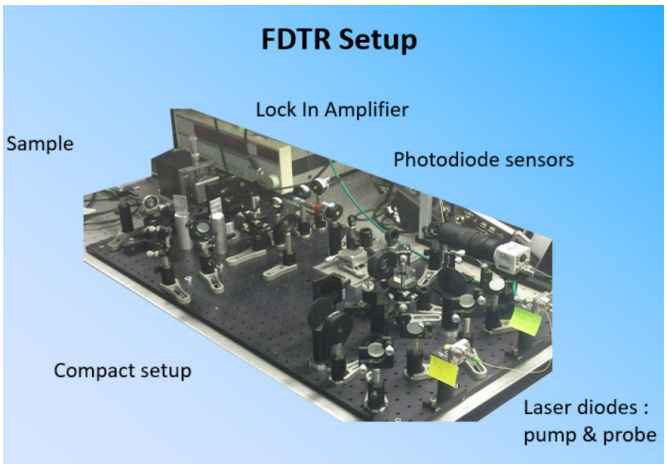
Project:

Renewable energies are at the heart of current and future social concerns. In this context, research is turning towards the development of thermoelectric generators that convert a heat flow into an electrical source. The differences between the classical combustion engines which are used for the production of electricity, these thermoelectric generators have two main advantages like the absence of mechanical movement and their small dimension. However, the performance of these thermoelectric systems is not yet at the same level as the conventional systems.

Many studies are conducted to synthesize new thermoelectric materials, nanostructured or polymer based which could enhance their performance. This aspect is evaluated by the figure of merit ZT which is defined as:

$$ZT = \frac{\alpha^2}{\rho\kappa}T \text{ where } \begin{cases} \alpha \text{ Seebeck coefficient} \\ \rho \text{ electrical resistivity} \\ \kappa \text{ thermal conductivity} \\ T \text{ operating temperature} \end{cases}$$



Instrumental techniques to obtain this figure of merit require several different measurements for each physical quantity. They can also be fully electric[1,5] but with mechanical contacts on the sample.

The originality of this internship lies in the study of the ZT measurement performed solely by an optical way without any contact on the sample. The experimental setup is an optical bench based on laser diodes (FDTR Fourier Domain ThermoReflectance). This one will characterize the thermal behavior of the sample regarding to the excitation frequency[2].

The student will work on the following aspects (depending on the internship progress):

- Experimental: the setup should be characterized with several measurements performed on reference samples.
- A semi-analytical model (including thermal, optical and electrical physics) describing the measured signals must be mastered and developed in order to extract the physical quantities of the sample. The model is based on the quadruple formalism[3,4]; moreover, the FEM approach might be used.

The multidisciplinary aspect of this internship allows the student to access an experimental work and also programming tasks (Labview, Matlab, Comsol) with the aim of a physics modeling and the instrumentation of the setup.

1. Harman, T. C., Cahn, J. H. & Logan, M. J. Measurement of Thermal Conductivity by Utilization of the Peltier Effect. *J. Appl. Phys.* **30,** 1351 (1959).
2. Patiño-Lopez, L.-D. *et al.* Thermal study of PN thermoelectric couple by laser induced Seebeck EMF measurement. *Superlattices Microstruct.* **35,** 375–387 (2004).
3. Ezzahri, Y. *et al.* Coherent phonons in Si SiGe superlattices. *Phys. Rev. B - Condens. Matter Mater. Phys.* **75,** (2007).
4. Ezzahri, Y., Grauby, S., Dilhaire, S., Rampnoux, J. M. & Claeys, W. Cross-plan SiSiGe superlattice acoustic and thermal properties measurement by picosecond ultrasonics. *J. Appl. Phys.* **101,** (2007).
5. Min, G. & Rowe, D. M. A novel principle allowing rapid and accurate measurement of a dimensionless thermoelectric figure of merit. *Meas. Sci. Technol.* **12,** 1261 (2001).