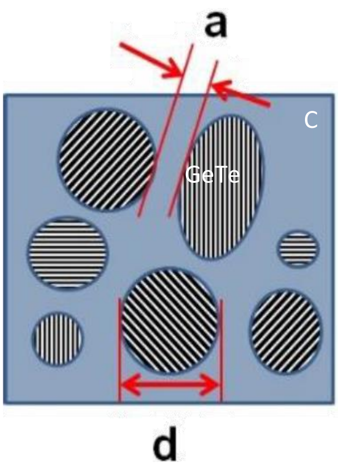
Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

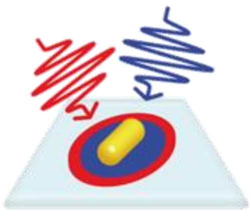
Laboratory name: **Institut Lumière Matière - FemtoNanoOptics group**
CNRS identification code: UMR5306
Internship director'surname: Dr. Paolo Maioli / Dr. Valentina Giordano
e-mail: paolo.maioli@univ-lyon1.fr Phone number: 04 72 44 81 82
Web page: http://ilm.univ-lyon1.fr/femtonanooptics
Internship location: Campus LyonTech-La Doua,
Bâtiment Kastler, 10 rue Ada Byron
69622 Villeurbanne CEDEX, France
Thesis possibility after internship: YES Funding: Bourse Ecole Doctorale

Thermal transport in nanostructured thin films: the challenge of a microscopic understanding

One of the main challenges for our society consists in reducing the heat losses associated with energy consumption: indeed, about two thirds of the globally produced energy is lost as heat. In this context, nanostructuration has arisen as a most promising approach: the presence of interfaces and the intertwining of different materials at the nanoscale has shown to effectively act on the quasi-particle responsible for heat transport (phonon) and not on other functional properties. Phonons are strongly diffused by the interfaces and their mean free path (distance over which they efficiently transport heat) is reduced. As a result, thermal conductivity can be greatly limited. We propose here to investigate phonons and thermal transport in nanostructured thin films: nanocomposites made of nanocrystalline GeTe surrounded by amorphous carbon (figure), for which nanostructuration has been reported to reduce the thermal conductivity by a factor of 6 compared to non nanostructured GeTe thin films, and multilayers made of nanocrystalline GeTe alternating with amorphous carbon. By tuning the size of GeTe nanocrystals (sample 1) and layers (sample 2) and the amount of amorphous carbon, we expect to observe different regimes of thermal transport. We will combine the macroscopic measurement of thermal conductivity with microscopic measurements of the mean free path of acoustic phonons, to track modifications of phonons properties due to the nanostructure and link them to thermal transport.



The phonons properties at frequencies of ~10 GHz will be investigated by time-resolved ultrafast optical spectroscopy, a technique which is at the heart of the activity of FemtoNanoOptics group (https://ilm.univ-lyon1.fr/femtonanooptics): an acoustic wave is coherently excited by a femtosecond laser pulse and its propagation in the solid is investigated by optical methods. Thermal conductivity will be measured with a thermoreflectance equipment available in the Energy group: a nanosecond pump laser is used to impulsively heat a metallic coating on the material under study, causing a sudden change of its reflectivity. Its relaxation time at the nanoscale depends on the thermal diffusivity of the underlying sample towards which heat flows. The Trainee will participate to experiments with ultrafast optical spectroscopy and thermoreflectance and to the analysis of the signals and their interpretation. Numerical modeling for connecting the time-resolved optical signals to the physical properties of specific phonons will also be carried out in the FemtoNanoOptics group. This internship is part of a funded project (ANR) where the thermal optimization of these materials for memory and thermoelectric applications is investigated. The trainee will interact with a large and rich consortium during her/his internship.



Condensed Matter Physics: YES	Macroscopic Physics and complexity: NO
Quantum Physics: YES	Theoretical Physics: NO