Nano-thermics and nano-acoustics on composite materials

Scientific Context:

The sudden absorption of electromagnetic energy by a nano-object induces a cascade of relaxation processes (internal thermalization, acoustic vibrations, thermal cooling, ...) involving femtosecond to nanosecond timescales. Their study is of major interest in fundamental physics, as it allows to clarify how the macroscopic laws ruling electronic interactions, elasticity, thermal transport or interfacial energy transfer are modified at the nanoscale.

We will use femtosecond time-resolved pump-probe technique to investigate nano-acoustics and nano-thermal behaviors of composite materials, in order to characterize modifications of thermal and mechanical properties of the bulk material induced by the inclusions of small nano-objects.

Missions:

We will first focus on systems made by carbon nanotubes inside a polymer matrix (collaboration with Politecnico di Torino), to elucidate the thermal transfer mechanisms at the external surface of carbon nanotubes, a phenomenon which has been very little explored. Experimental results will be coupled to analytical and numerical modeling (by Finite Element Methods), which will allow to quantitatively predict the influence of carbon nanotubes and external material temperature variations on the ultrafast optical response of the whole system.

In the framework of a collaboration with the group "(nano)Materials for Energy" of Institut Lumière Matière in Lyon, we will also investigate nano-acoustic and nano-thermal phenomena in carbon glasses (2D films in amorphous or crystalline phase) with inclusions of GeTe nanoparticles. We will focus here on the modifications of sound speed and of energy transfer at the interfaces of the solid induced by internal inclusions, and we will use theoretical modeling to analyze the transient optical signals, induced by optical excitation of the fundamental breathing mechanical mode of the glass (homogeneous excitation of the film) and by the propagation of acoustic wave packets (excitation of a transducer at one interface of the film).

Outlooks:

This internship can be extended into a PhD.

Bibliography:

Please visit ilm.univ-lyon1.fr/femtonanooptics for more information about this internship/PhD thesis proposal.