DEVELOPMENT OF A NOVEL NEAR-ULTRAVIOLET TRANSIENT GRATING SETUP FOR PHONON MEASUREMENTS AT THE NANOSCALE

LABORATORY : Institut Lumière Matière
IN COOPERATION WITH : iLM

LEVEL : M2
TEAM(S) : ENERGIE

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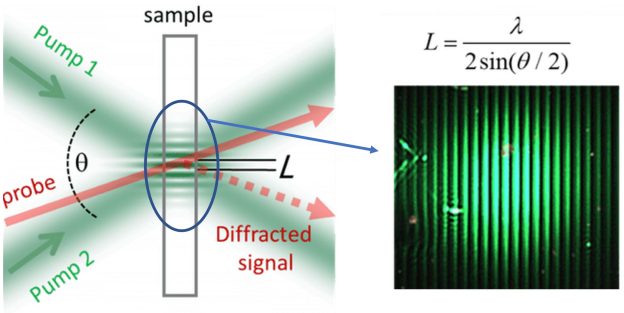
KEYWORD(S) : phonons / optics / ultrafast laser

SCIENTIFIC CONTEXT :

Nowadays, thermal transport represents a major societal challenge. Of all the energy produced, whatever the source, up to 70% is actually lost under the form of heat. It is critical today to change this balance, reducing heat dissipation or recycling waste heat. This points to another critical challenge in current miniaturized technologies: understanding thermal transport to control it, specifically in nanostructured and nano-scale materials, which are abundantly used in microelectronics, thermoelectricity, photovoltaïcs, optoelectronics.... The main heat carriers in semiconductor materials are the atomic lattice vibrations, whose quantum is the phonon. To understand thermal transport, we need thus to directly look to phonons, measuring the energy they carry and the distance over which they can carry it in the different materials of interest. Nanostructuration introduces interfaces able to scatter phonons with wavelengths from tens to hundreds of nanometers, attenuating them and reducing their hability in transporting heat [1]. Periodic interfaces can also induce interference phenomena, even modifying phonon energies. As phonons with these wavelengths are also the ones mostly interacting with other particles (electrons, magnons...), other functional properties may be modified. At this day, it is however still very difficult to access experimentally phonons with wavelenghts of few hundreds of nanometers with the resolution needed for measuring their attenuation.



Optical sketch (left) of the transient grating technique. Right: grating realized on the sample

MISSIONS :

The trainee will participate to the development of a new experimental setup, for measuring energy and attenuation of phonons with wavelengths in the 200-400 nm range, today existing only in the US [2]. The setup will be based on a four-wave mixing technique called transient grating, where two pump laser pulses create a transient interference grating in the sample (see Figure). This grating generates phonons travelling along it, with a wavelength dictated by the laser wavelength and experimental geometry. A third laser pulse impinges on the sample and is diffracted by the grating. The resulting diffraction signal, measured as a function of time, contains informaiton on the thermal relaxation of the sample after the impulsive heating due to the pump lasers, and on the excited phonons, whose energy and attenuation can be thus accessed. The trainee will be involved in the mounting and commissioning of the optical setup, until the creation of a transient grating in a reference sample, and the first measured signal. He will gain knowledge on four-wave mixing phenomena, phonon physics and physics of thermal transport. Background in laser physics or optics is desiderable but not mandatory

OUTLOOKS :

Motivated and skilled trainees can apply for a PhD thesis (grant requested to ANR, answer in July)

BIBLIOGRAPHY :

[1] R. Cravero et al. Small , 2310209 (2024) , R. Cravero et al. ACS Applied Materials & Interfaces (2026)

[2] E. Nelson et al. Phys. Rev. Appl. 22, 054007 (2024)

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