M2 INTERNSHIP PROPOSAL
Centre Lasers Intenses et Applications Bordeaux.

Interaction of Phase Change Materials with femtosecond laser pulse.

Femtosecond optical laser pulse interaction with solid create exotic state of matter leading to so called “non-thermal” phase transition (PT). This kind of PT is taking place on the tenths of femtosecond time scale and is mainly driven by the laser induced electronic excitation.
Phase Change Materials (PCM) are materials used for data storage both as bit storage or selector [1]. Most of them are made of chalcogenide alloys (S, Se or Te containing solids) which are know to be easily switchable between their amorphous and their crystalline phase. Both phases have very different optical/electrical properties allowing data storage.
The internship will focus on the study of the melt-quenched phase generated by irradiation of as-deposited material (GeTe) by a fs 1063 nm laser pulse. The characterization of the melt-quenched phase will be performed by x-ray photoeletron spectroscopy. The objective is to characterize the change of the valence band structure induced by the laser induced melting and cooling of the material. The irradiation also lead to formation of nanostructures that will be investigated [2] by means of different microscopies.
The internship will be continued by a thesis focused on the dynamics of the PT of chalcogenide materials used in devices involved in “neuromorphic” computer architecture. Using the Aurore facility [3], the candidate will develop a new type of THz light source based on spintronic emitters to perform pump/probe experiment. The MV/cm THz pulse generated will be used as a pump pulse to trigger the PT mimicking the “in-operando” process that take place in real devices. The PT will be probed by frequency interferometry [4] which will allow us to retrieved the transient dielectric constant (real and imaginary part) The experimental results obtained will be compared to ab-initio simulations. Understanding the PT on the atomic level is mandatory to improve the performance of these alloys in view of practical implementations.

The candidate should have a strong background in solid state physics/materials and a great interest in experimental physics. Programming skills in python is also required to manage the data acquisition/treatment and possibly be involved in the ab-initio simulations. An experience in optics/ultra-fast laser will be a plus but is not mandatory. The PhD thesis funding will be attributed after examination of the candidate records.

[1] Noé *et al.« Toward ultimate nonvolatile resistive memories: The mechanism behind ovonic threshold switching revealed ». Science Advance 6 : eaay2830 (2020)*
[2] Martinez et al. « Laser Generation of Sub-Micrometer Wrinkles in a Chalcogenide Glass Film as Physical Unclonable Functions ». *Adv. Mater.* 32, 2003032 (2020)
[3] Fedorov et al. « Aurore: A platform for ultrafast sciences », *Review of Scientific Instruments*, 91, 105104 (2020)
[4] Martinez et al. «Sub-Picosecond Non-Equilibrium States in the Amorphous Phase of GeTe Phase-Change Material Thin Films. » *Adv. Mater.* 33, 2102721 (2021)

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