POSTDOCTORAL POSITION IN LASER ULTRASONICS

3-years fellowship in LAUM and IMMM, Le Mans

The Acoustic Laboratory (LAUM) and the Institute of the Molecules and Materials (IMMM) of Le Mans University seek to fill a 3-years postdoctoral research fellowship in the area of picosecond laser ultrasonics funded by National Research Agency of France (ANR).

Postdoctoral research context and positioning

Industrial fabrication and experimental research develop in the direction of miniaturization of functional or structural blocks. This permits saving of resources and reduction of the impact on the environment but requires the objects examination, preferably nondestructively, with a high spatial resolution on sub-μm- or even nm-scale. Picosecond ultrasonics is a promising experimental technique to provide the requested performance (even in-situ) at relatively low costs. In optically transparent materials, picosecond acoustic interferometry (PAI) [1], also called time-domain Brillouin scattering (TDBS) [2], provides imaging of material inhomogeneities traversed by acoustic pulse (Fig.) with nano-scale spatial resolution along its path [3,4].

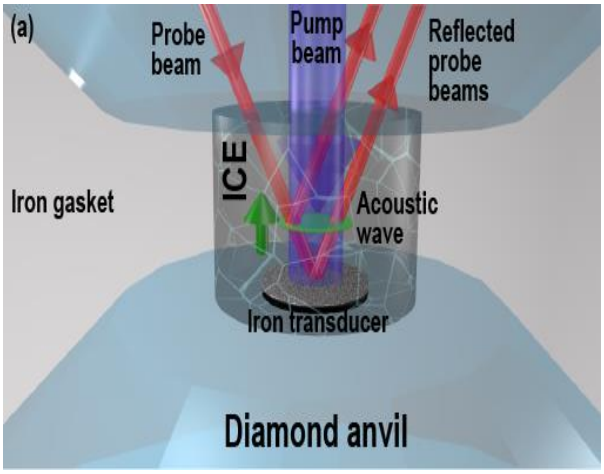

Fig. Principle of TDBS imaging
A transparent inhomogeneous sample (polycrystal-line H_2O ice, as an example) is of micrometers dimensions. A picosecond pulse of the pump laser (violet) hits the absorbing transducer launching a coherent acoustic pulse (green) in the sample volume. Propagation of the acoustic pulse is monitored by a delayed probe laser pulse (red) reflected from stationary (transducer) and moving (acoustic pulse) interfaces

Such inhomogeneities could be caused by elastic anisotropy, presence of two and more phases or compounds. Their visualization by the TDBS technique could permit determining of single crystal elastic moduli (in the case of cubic

crystals), amount and, possibly, nature of the secondary phases or contaminating compounds. If amount of the secondary phase or compound changes with time, then the transformation kinetics can be determined and taken into account in fabrication processes. Moreover, this technique is not dependent on the material crystallinity and can be used for examination of amorphous materials where X-ray diffraction methods fail. A review of recent advances in multiple applications of the TDBS imaging could be found in [2]. It is worth noting that the in-depth spatial resolution of the classic Brillouin Scattering (BS) microscopy [5] applied to three-dimensional (3D) imaging [6] is currently not better than 2 micrometers. This resolution is insufficient for a reliable characterization of material inhomogeneities and related transformation processes.

[1] H. T. Graham et al., IEEE J. Quantum Electron. 25, 2562 (1989). **[2]** V. E. Gusev and P. Ruello, Appl. Phys. Rev. 5, 031101 (2018). **[3]** C. Mechri et al., Appl. Phys. Lett. 95, 091907 (2009). [4] A. Steigerwald et al., Appl. Phys. Lett. 94, 111910 (2009). [5] K. J. Koski et al., Appl. Phys. Lett. 87, 061903 (2005). [6] G. Scarcelli et al., Nature Methods, 12, 1132 (2015).

Postdoctoral research objectives

The main goals of the postdoctoral project are to develop, for the first time, quantitative fast 3D in-situ imaging of complex spatiotemporal material transformations at submicrometric - nanometric scale by upgrading existing technique of time-domain Brillouin scattering and to reach the ultimate limit in spatial resolution of the TDBS imaging technique. The primary scientific objectives are in-situ imaging and quantitative characterization of the stress-induced single crystal fracture, polycrystallization and creep, of the radiation/pressure-induced formation of polymer from monomer, and of the formation of the interfaces between the mutually reacting substrate and film.

LAUM and IMMM laboratories (Le Mans University)

The project will take place in the LAUM and IMMM Laboratories at Le Mans University (1h from Paris by train). Both of these facilities are Mixed Research Units (UMR) and jointly financed by Le Mans University and the National Center for Scientific Research (CNRS: Centre National de la Recherche

Scientifique). Over the last 12 years, our teams members have built an extended platform for picosecond laser ultrasonics (eight sub-ns, ps and fs laser set-ups) and accumulated strong expertise in the processes of ultrafast optoacoustic conversion and nanoscale TDBS imaging. With a staff size of 160, the LAUM is currently one of the world largest laboratories dedicated to acoustics. In late 2017, the French Government decided to inject €4 million in order to sponsor the development of the Institut d'Acoustique - Le Mans University - CNRS Graduate School of Acoustics, as an international reference center for research and education, in relying on the high level of education, research and innovation promoted for several decades at Le Mans University in interdisciplinary acoustics.

Required Qualifications of the Candidates

This position requires a researcher with **strong background in optics and laser metrology.** The researcher should also have **strong expertise in computer-assisted signal processing.** Knowledge of **Matlab or Python** (for signal processing) and of **Physical Acoustics** (especially of picosecond ultrasonics) would be highly appreciated. Although the objectives of the postdoctoral research may seem to be experimentally-oriented and surely require strong experimental skills/interests, the understanding of the underlying physical processes as well as the thoughtful processing of the acquired signals will be as valuable for achieving successful research as the experimental meticulousness.

Submission of the applications

Please send Curriculum Vitae, summary of research expertise, list of the publications, list of three or more references and your questions to:

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The position is available starting from March 1, 2019. The selection procedure will last until the position is filled. The initial duration of the Fellowship is 1 year with the annual extensions up to 3 years in case of the expected progress in the project.