HABILITATION A DIRIGER DES RECHERCHES

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Résumé

My last 15 years in academia have been devoted to research in opto-acoustic technologies, whereby acoustic waves are generated and/or detected by lasers. I focused mainly on laser-ultrasonics that operate in the MHz range, time-resolved Brillouin scattering (TRBS, also termed picosecond ultrasonics) and spontaneous Brillouin scattering that both operate in the GHz range.

I started my PhD (2004-2007) under the supervision of Bertrand Audoin at the Laboratoire de Mécanique physique, near Bordeaux, with a deep theoretical analysis of the processes involved in the generation and detection of acoustic and thermal modes in these techniques. When I started, the generation processes in metals following the absorption of a parallel femtosecond laser beam, i.e. a 1D geometry, were well understood since the 90's. My main contributions were the introduction of the focalisation of the pump laser in the modelling of the generation in metals, and how the 3D distribution of photons impacts on the generation a 3D diffracted acoustic field. I also considered how the optical probe beam interacts with this diffracted acoustic field in a 3D time-resolved Brillouin scattering geometry.

I continued with a postdoc in Japan (2007-2009) with Oliver Wright at the Applied Physics Laboratory in Sapporo to develop an experimental approach to contact mechanics using TRBS. The idea was to reproduce the early works that studied mechanics of solid contacts with MHz ultrasound, but in a higher frequency regime. Reaching wavelengths of 100s of nanometers, we were able to observe the impact of the nanoroughness of the interface. As an added value, we were also able to demonstrate that the thermal diffusion through the contact could be used to monitor the state of the interface. During that time I also studied the vibration mechanics of micro-spheres, and demonstrated the impact of sphere-sphere contacts on the selection of acoustic modes.

After this period, I was recruited at the CNRS to work in the Physical Acoustics department of the Institut de Mécanique et d'Ingénierie de Bordeaux. I implemented new microscopy techniques to image the mechanical properties, tribology and thermal properties of single cells. This topic had been initiated in 2008 before I arrived, with the first measurements probing the acoustic wave in the cell at a single frequency. Based on the works of my postdoc, I implemented the measurement of acoustic pulses reflected off the cell-substrate interface, allowing broadband acoustic probing of the stiffness of the cell as well as the cell-substrate interface. I also introduced thermal probing of single cells, which leads to totally new information and with competitive acquisition times. I also started to work on plant cell wall mechanics probed with TRBS, which inspired me one of my major current project. These works were among the first foray of TRBS in biophysics and soft matter and allowed us reach new audiences.

In 2015 I joined the Institut Lumière Matière near Lyon to develop new quantitative imaging techniques for tissues. My first current research topic here is the development of spontaneous Brillouin light scattering (BLS) to study tumours for prognostic and drug screening purposes. I also used this approach to study dental tissues, in view of assessing the quality of the dentin-composite interface in restored teeth. This is an extension of my works on single cells. As a continuation of my works on the plant cell wall, I am also developing a new research direction to create the first biobased phononic material from decellularized plant cell scaffolds.