Lab-on-a-Chip with Integrated Elastic Metamaterials for Biosensing

Lab-on-Chip (LOC) are miniaturized devices designed for the detection, preparation, manipulation and analysis of biological substances (DNA, viruses, bacteria, cells, etc.) on a micrometric scale. They offer the advantage of miniaturizing the analysis areas with low energy consumption, which considerably reduces costs and the chemical impact on the environment. LOCs also allow the multiplication and parallelism of experiments by a multiplexing approach while offering a better control of the processes. All these advantages provide LOCs with a wide range of biological applications (food processing, medical diagnosis, military defense …). Translational research at the ISS National Lab provides unprecedented opportunities to study the effects of a microgravity environment on the human body. It is widely known that symptoms of accelerated aging occur after prolonged exposure to microgravity such as muscle deterioration, osteoporosis (bone loss), reduced cardiopulmonary function and immune deficiency, …

We recently proposed a design of an acoustic sensor that uses pillared phononic crystal structure for Love wave manipulation to achieve high mass sensitivity. The phononic crystal is made of a lattice of pillars, where each pillars behaves as a resonator that exhibits torsional mechanical motion which can provide interesting approach to increase the detection performance of Love wave based bio-sensors [1]. Moreover, we have tested a first prototype of Love wave device working at low frequency for the detection of modification of bone cells adhesion [2].

Project and tasks

In this PhD project, the PhD student will develop a LOC that combines both surface acoustic waves (SAW: Surface Acoustic Waves) technology and acoustic metamaterials designs to achieve ultra-sensitive bio-detection. The construction of such device would facilitate understanding the mechanobiological mechanisms of cells. The missions of the PhD student are thus essentially summarized in the following parts:

- Development of multi-physics models to study the involved physical mechanisms and their interaction in the acoustic sensing process, and to design and optimize the metamaterial and the device.
- Microfluidic cell development for the full LOC and the integration of SAW technology and microfluidic trapping.
- Experimental characterization applied to bio-detection, and mechanobiology of cells.

Candidate profile

Master's degree or Engineering degree in one or more of the following fields: Physics, Acoustics, Materials science, Mechanical engineering, Optics, Scientific Computing, Micro and Nanotechnologies, Biomedical and/or Biotechnology Engineering, or similar.

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References

[1] J. Bonhomme et al. "Love waves dispersion by phononic pillars for nano-particle mass sensing", Appl. Phys. Lett. **114**, 013501 (2019)

[2] J. Bonhomme et al. "Numerical Characterization of Love Waves Dispersion in Viscoelastic Guiding-Layer Under Viscous Fluid", Journal of Applied Physics **128**, 154502 (2020)