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Master / Engineering student project – 6 months

Development of a capacitive micromachined ultrasound transducer (CMUT)-based high intensity focused ultrasound (HIFU) probe for endocavitary HIFU therapies.

Context of the study

Thermal ablation of localized prostate tumors via endocavitary high-intensity focused ultrasound (HIFU) faces challenges that could be alleviated by better integration of dual modalities (imaging/therapy). Capacitive micromachined ultrasound transducers (CMUTs) may provide an alternative to existing piezoelectric technologies by exhibiting advanced integration capability through miniaturization, broad frequency bandwidth, and potential for high electroacoustic efficiency. An endocavitary HIFU probe was was built to investigate the potential of using CMUT technologies for transrectal prostate cancer ablative therapy.

CMUTs are an emerging technology presenting several advantages over piezoelectric materials for the design of HIFU applications. Standard HIFU devices using piezoelectric technology are confronted with miniaturization challenges that impose limitations on the quality of ultrasound imaging and effectiveness of therapy. CMUT technology can mitigate such challenges given the size of regular elementary CMUT cells (tens of micrometers) composing CMUT transducer arrays, and the reduced mechanical losses associated with these microelectromechanical systems (MEMS) structures that provide them with a potential for high electroacoustic efficiency. Furthermore, the large bandwidth offered by CMUT technology presents a significant technological advantage over piezo bulk technology in providing the capability for spatially fine-tuned therapy [1,2,3]. In the context of an ANR-RHU funded project PERFUSE, a new generation of CMUT HIFU probes were developed and built. Characterization and further development of the electronics driving the probes is thus necessary for eventual testing of these novel devices in *in vitro*, *ex vivo* and *in vivo* conditions.

Project objectives

The aim of this master's or engineering degree internship will be to characterize the electromechanical and electroacoustic properties of CMUT HIFU probe prototypes. Additionally, the intern will participate in the design and development of the electronics and mechanical components driving the CMUT HIFU probe. At a later stage, after ex vivo validation on living tissue, the probe will be integrated into a clinical treatment platform for in vivo experimentation on porcine models.

Activities

- Bibliographic studies, training, disseminations and valorizations of the research results
- Realization of electromechanical and electroacoustic measurements.
- Design and realization of software and electronics necessary for driving the CMUT HIFU system.
- Preclinical studies: validation of the prototype's focusing and steering capabilities; measurement of acoustic power levels generated by the CMUT HIFU probe prototype; preliminary *in vitro* experiments on excised living tissue; *in vivo* experimentation on porcine models.

Skills

- General knowledge in physics, acoustics, and signal processing.
- Previous experience with electronics and/or metrology.
- Proficiency in programming with languages such as Python or Matlab
- Appreciation for experimental work, and analysis of experimental datasets.

[1] Suarez-Castellanos, Ivan M., et al. "Dynamic ultrasound focusing and centimeter-scale ex vivo tissue ablations with a CMUT probe developed for endocavitary HIFU therapies." IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control (2023).
[2] N'Djin, W. Apoutou, et al. "Capacitive micromachined ultrasound transducers for interstitial high-intensity ultrasound therapies." IEEE transactions on ultrasonics, ferroelectrics, and frequency control 64.8 (2017): 1245-1260.
[3] Bawiec, C. R., et al. "Preliminary investigation of a 64-element capacitive micromachined ultrasound transducer (CMUT) annular array designed for high intensity focused ultrasound (HIFU)." IRBM 39.5 (2018): 295-306.

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Additional information

This project is funded by a RHU PERFUSE, Université Claude Bernard Lyon 1 (UCBL), within the Program "Investissements d'Avenir" operated by the French National Research Agency (ANR). The projects seeks to develop a new generation of state-of-the-art CMUT HIFU probes for endocavitary treatment of prostate cancer. The successful candidate will conduct the project's research work at the Laboratory of Therapeutic Applications of Ultrasound (LabTAU, Inserm U1032) located in the Grange-Blanche area, in Lyon, France. The duration of the internship will be 6 months. Remuneration will be assigned according to national standards: 4.05 euro per hour.

Contacts

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