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PhD Thesis CARDIOSAW: Wireless surface acoustic wave sensors for the measurement of the intraventricular pressure

PhD objectives

Intraventricular pressure is a fundamental factor for a large number of cardiac pathologies [1]. For implantable biomedical devices, power management is crucial and the need to change/recharge batteries is a real issue. For this reason, wireless and battery-free devices, such as the CARDIOMEMS system [2] are of clear interest, but the latter is very expensive, bulky and with a low interrogation range.
In this context, surface acoustic wave (SAW) sensors, which are wireless, battery-free and remotely queryable up to several meters in the far field using dedicated interrogators, are particularly attractive. Their interest has already been demonstrated in the context of electronics on skin [3]. SAW pressure measurements are carried out using a deformable membrane device with a reference chamber. The deformation of the membrane impacts the geometry of the sensor as well as the velocity of the wave, which is detected by a change in the frequency or the delay [4]. In the past, wireless SAW measurements in environments with high electromagnetic losses were difficult, but recent advances, notably in wireless interrogators, have made measurements possible in aqueous environments [5] or that of the human body [6].
The breakthrough proposed here lies in the use of piezoelectric type composite substrates on POI insulators [7], [8] which constitute a revolution in the field compared to bulk piezoelectric substrates. Among their many advantages, they make it possible to obtain better quality factors, electromagnetic coupling coefficient, and therefore a better level of backscattered signal and a better range. For pressure sensors, they will allow the production of membranes, while maintaining a POI effect thanks to controlled volume machining. In addition to a clear break on the sensor, the project will implement innovative ultra-conformable and stretchable antennas [3] on elastomer, which will allow harmonious implantation.

The main expected result of the PhD work is the production of a high-performance ex-vivo demonstrator of a wireless SAW pressure sensor in a high loss environment.

Applicants profile and research environment

The sought applicant's profile is a master's degree/engineer specialized in one or more of the following fields: mechanics, applied physics, microsystems, microtechnologies, electronics, RF, passionate about the biomedical field and multidisciplinary research.

This doctoral subject includes theoretical and experimental components: mechanical modeling of the sensor, microfabrication of microsensors on membranes in a clean room, creation of a pressure test bench. Depending on the applicant's background, the aspects of antennas/tele-transmissions in the environment of the human body will also be addressed.

The candidate will benefit from a complete research environment at the Jean Lamour Institute (IJL), one of the largest European laboratories in materials sciences, within the Nanomaterials, Electronics and Life department. The IJL has a state-of-the-art research environment (clean room, very high-level SEM/TEM microscopies, anechoic chamber, etc.). The candidate will carry out his/her doctoral project within the "Micronanosystems" research team which benefits from strong expertise in the development of SAW sensors, with an increase in activities around living things and biomedical applications.
All the team's former doctoral students are employed either as researchers or teacher-researchers, or as executives in large companies.

Start of thesis : 01/10/2024
2.100€ gross monthly salary

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