UPSIDE

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UPSIDE Website: https://project-upside.eu

Executive Summary

This deliverable reports on the fabrication procedures of high-efficient backing layers towards the lossless integration of piezoelectric ultrasound transducers directly on top of integrated circuits implemented in a Complementary Metal-Oxide-Semiconductor (CMOS) technology. The findings reported in this deliverable are pivotal for developing the epidural focused ultrasound device (eFUS) in the context of the UPSIDE project.

Piezoelectric ultrasound transducers have emerged as a promising tool for various medical applications, including imaging, diagnostics, and therapeutic interventions. One particularly captivating avenue of exploration is the utilization of ultrasound for neuromodulation – a technique that involves non-invasive or minimally invasive stimulation of neural tissues to modulate their activity. The success of such applications critically depends on the efficient transmission of ultrasound intensity to target neural regions. A key factor influencing the effectiveness of ultrasound neuromodulation is the optimization of backing layers positioned behind the piezoelectric active elements within the transducer. This optimization plays a key role in maximizing the transmitted ultrasound intensity and, consequently, the modulation of neural activity.

In the context of ultrasound neuromodulation, backing layers, composed of materials with tailored acoustic properties, are strategically positioned between the piezoelectric transducers and the CMOS electronic chip to enhance the transmission efficiency of piezoelectric transducers. These layers act as an ultrasound reflector and mitigate undesirable effects such as energy loss and reverberations, allowing for improved energy delivery to the target tissue. Achieving precise and controlled stimulation requires effective energy delivery and minimizing side effects and unwanted interactions with adjacent tissues. In addition, effective energy use also plays a vital role in the power management of the epidural device, mainly in terms of battery size and capacity requirements.

This deliverable describes our research on using microfabricated high-efficient backing layers. The backing layer material was simulated, and a microfabrication process was conceptualized and tested for its validation. Careful characterization has demonstrated that the developed backing layers can be manufactured at the microscale towards high-power efficient two-dimensional ultrasound phased arrays. This work will impact the development of the eFUS device by allowing the transmitted ultrasound intensity to increase, thus allowing for the driving voltage of each ultrasound transducer to decrease. Since the dynamic power consumption is directly proportional to the square of the driving voltage, this can lead to substantial power savings towards minimizing the battery size. The content of this report shows promising results toward enabling the deployment of the eFUS device below the skull in a minimally invasive fashion.