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Towards a miniaturized cuff implant for highly selective US neuromodulation of peripheral nerves

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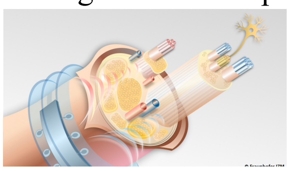
In an attempt to reduce the side effects caused by the chemically-based drugs used to treat neurological disorders, the field of bioelectronics has been focusing on the development of smart and reliable solutions that could, ideally, interact with the tissue at a resolution of individual cells.[1] Conventionally, electrically-based systems have been used.[2] However, increasing the resolution at which they interact with the body leads to the development of invasive electrode arrays, which can cause long-term side effects.[3] Another approach, based on acoustic waves, has recently emerged. Ultrasound (US) neuromodulation has been proven to be effective in modulating the response of peripheral nerves, in an *in-vivo* setup[4] and has the potential to achieve higher spatial selectivity.[5]
In this work, we aim to fabricate an implantable cuff for US neuromodulation, which would employ an array of US transducers to deliver focused US to specific nerve areas in a non-invasive manner. To this end, the potential of different US transducer arrays for peripheral nerve applications is evaluated, assessing the acoustic performances as well as ease of assembly and integration. More specifically, two of the most important parameters that affect neural excitation are the frequency and output pressure generated by the US transducers.[4] Conventional bulk PZT transducers can generate a wide range of output pressures but these are not small enough for this application. PZT-based arrays, integrated on CMOS have recently emerged, and will be part of this evaluation[6]. However, these have not yet been integrated on flexible substrates. On the other hand, micromachined US transducers (MUTs) have been gaining a lot of interest, particularly capacitive MUTs (CMUTs) which can operate at high frequencies, thus reducing the focal point significantly.[5] CMUTs can be fabricated on flexible substrates, using biocompatible materials, rendering them a very attractive candidate for the envisioned cuff. However, CMUTs usually feature lower Q factors compared to PZTs, hence the output pressure still has to be evaluated for neuromodulation. In addition, this work will also discuss important characteristics of the materials used for encapsulation, as these should ensure the required flexibility of the cuff without negatively affecting the acoustic performance of the transducers.



Concept of the US-based cuff implant for peripheral nerve stimulation.

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