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Fast total field OPM for muscle measurements: first in vivo recordings in MyoQuant project

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The measurement of magnetic muscle signals requires sensors that go far beyond state-of-art in terms of their bandwidth and angular accuracy. In addition, practical applications require sensors that can tolerate elevated background fields. Magnetic muscle measurements were performed with the sensor developed within the MyoQuant project and promise new insights into the understanding of these signals. As part of this project, a compact demonstration setup is developed that utilises robust components to the highest possible extent, thus forms the basis for a future measuring instrument on the International Space Station or its follow-up.
These magnetometers are housed in a small half-open magnetic shield in which a test person can place arm or leg [1]. To measure the magnetic muscle response, the sensors [2] are then placed along the muscle to be analysed, for example the one of the little finger (abductor digiti minimi, ADM). The sensor prototype is integrated into the transportable demonstrator, and a sensitivity of 0.3 - 0.9 pT/$\sqrt{\text{Hz}}$ in a bandwidth of 1 kHz is currently achieved. In this setup, the pilot sequential vector field recordings of ADM response were successfully performed, i.e. the first OPM-based measurement of muscle activity not limited by the sensor bandwidth and nonlinearity.
Based on the sensor concept proposed by the PTB, a miniaturised, fibre-coupled sensor head is being designed and constructed at the FBH. Additively manufactured technical ceramics serve as the chassis for the alkali vapour cell and the optical and electrical components, which are precisely aligned and bonded to the ceramic substrate using hybrid microintegration. Broader range of the muscle measuremnts with array of such sensors is planned.

[1] S. Nordenström et al, Sci. Rep. 14, 18960 (2024).
[2] V. Lebedev, S. Hartwig, T. Middelmann, Adv. Opt. Technol. 9, 275 (2020).
[3] M. Christ et al, Adv. Quant. Techol. 7(12), 2400076 (2024).

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