A4

ΔE-Effect Sensors

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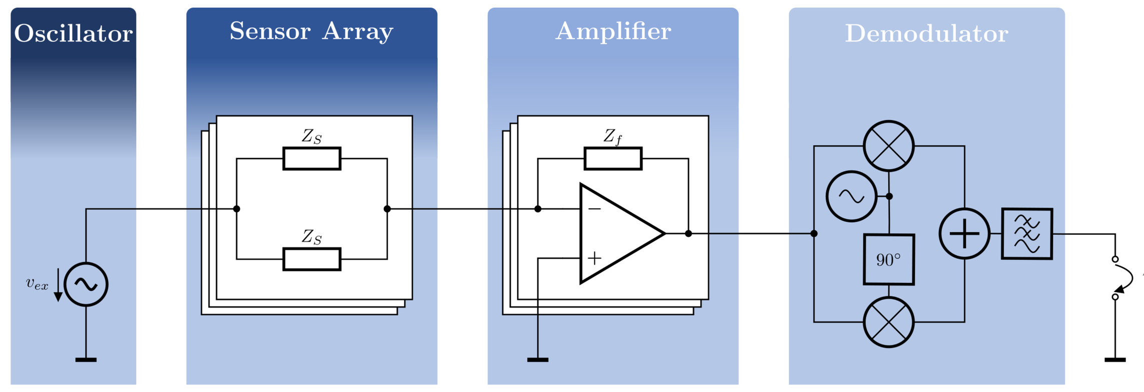
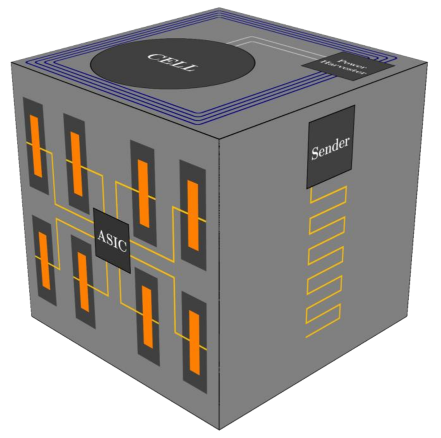
biomagnetic sensing SFB 1261

Motivation and Objectives

Main Objective

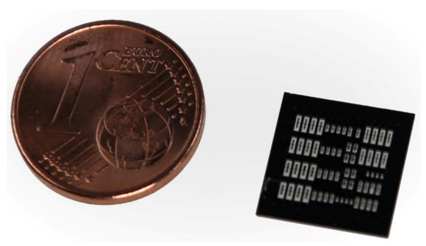
System integration of directive 3D MEMS sensor arrays with CMOS ASIC yielding easily accessable real time measurements usable for the application projects



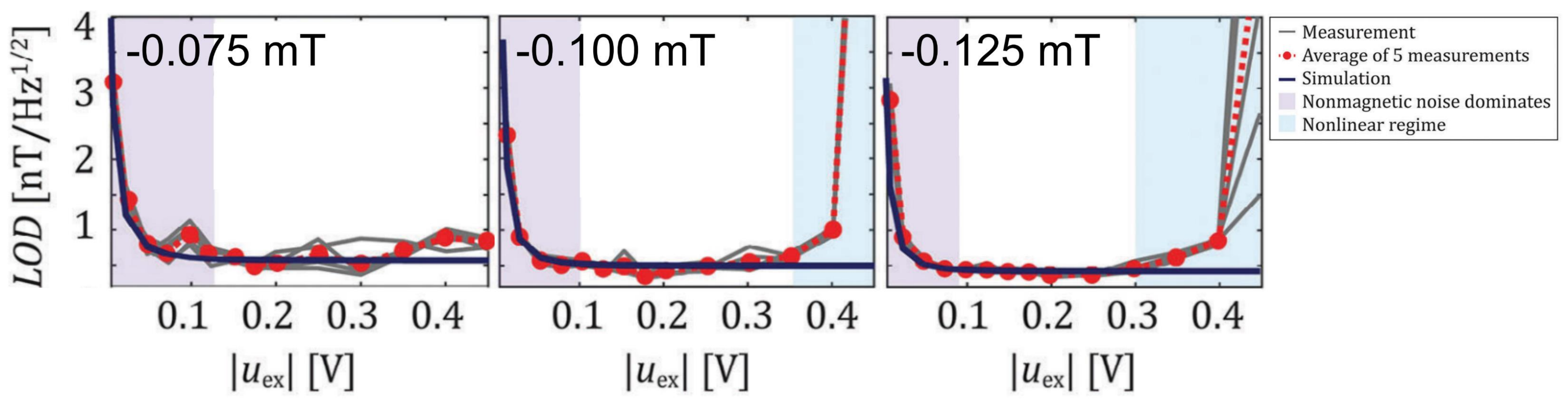


Motivation

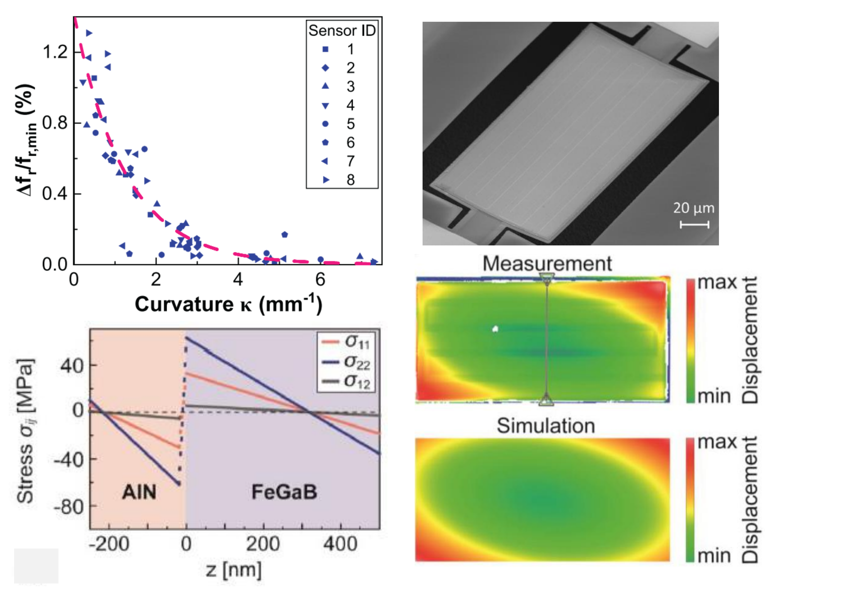
- Low power consumption
- High spatial resolution
- Large bandwidth
- High dynamic range
- Multi-directional detection
- Wireless communication



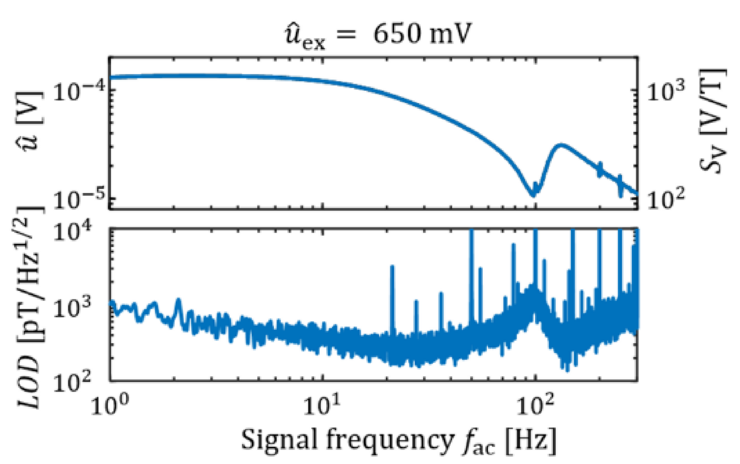
Results of the Second Funding Period



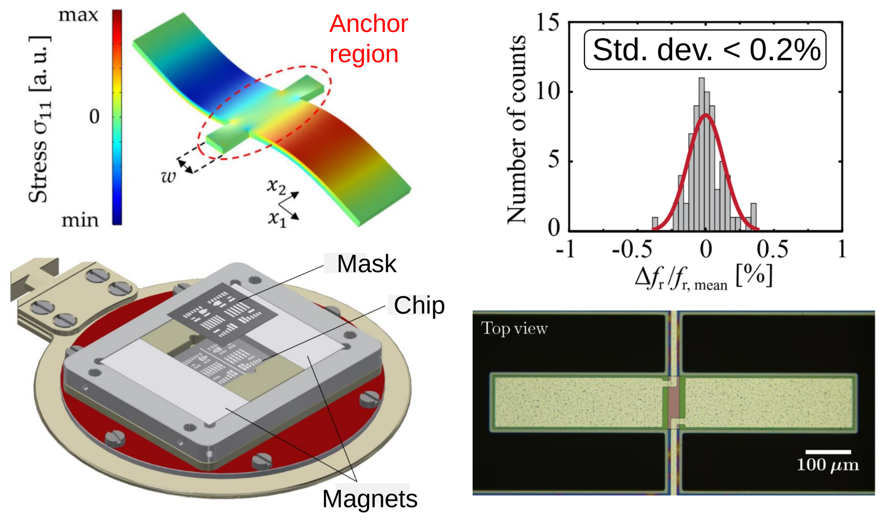
Understanding the origin of the magnetic noise with combined system model [A4-3]



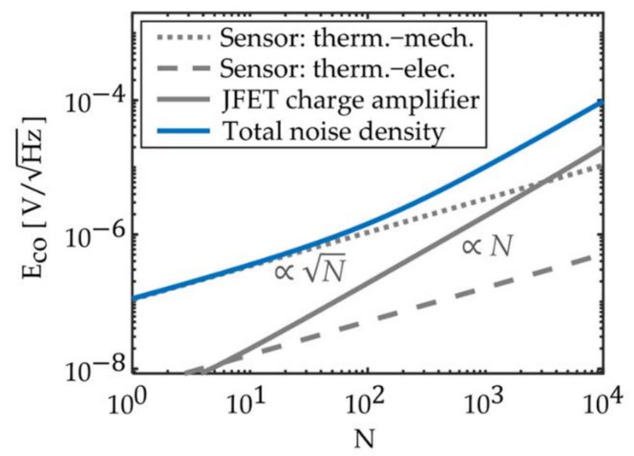
Contour-mode microresonators [A4-5]



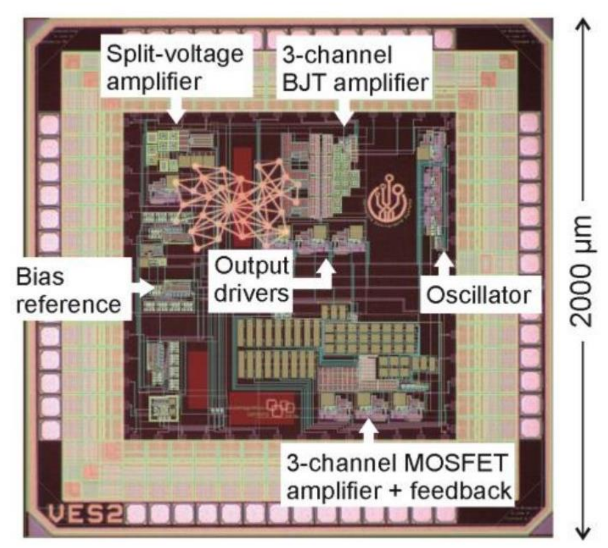
LOD < 450 pT/$\sqrt{\text{Hz}}$ (10-50 Hz) with exchange-biased multilayers at zero bias [A4-8]



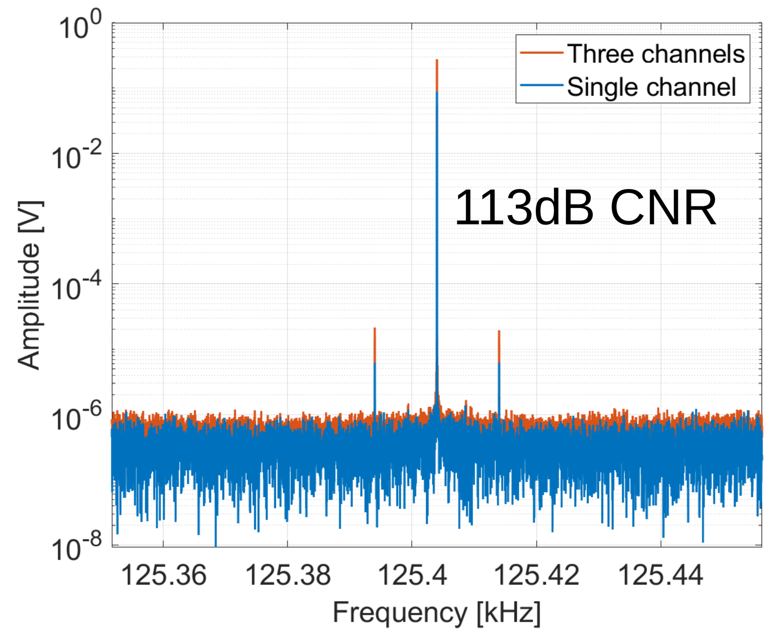
Miniaturized ΔE-effect sensors with a standard deviation of f_r<0.2% [A4-6]



Signal-noise model for sensor arrays [A4-4]



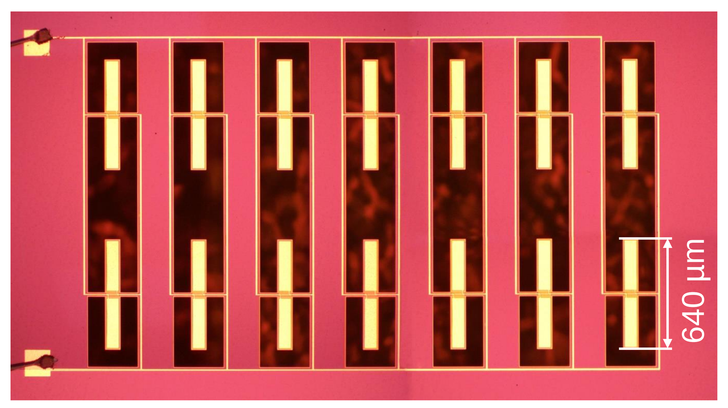
ASIC for excitation and signal amplification [A4-10]

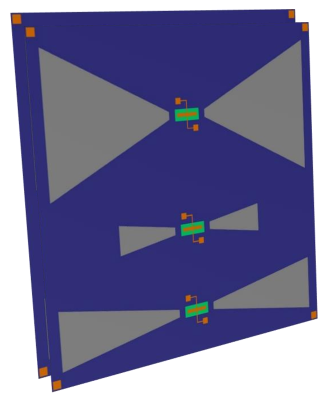


Work Plan for Third Funding Period

WP1: Multiscale sensor and matrix modeling

- Expand existing single sensor models to sensor matrices
- Statistical analysis
- Data-driven modeling





WP2: Vector-enable sensor arrays and characterization

- Explore use of different array configurations
- Introduce flux guides/concentrators
- Improve LOD, optimize spatial and angular resolution

WP3: Sensor interface electronics

- Low-power integrated system matched to the sensor arrays
- Crystal-referenced frequency-tunable on-chip oscillators
- Multi-channel low-noise amplification, demodulation, filtering, analog-to-digital conversion

WP4: Electronic system for wireless sensing

- Wireless data transmission
- Power supply with batteries or RF-harvested power

WP5: Realization of 2D matrices and 3D sensing cubes

- Fully self-contained sensing units
- Wireless detection of magnetic fields in 3D
- Untethered sensing towards application in medical projects

Prospect:

We will show a structured path for future sensor optimization to specific application scenarios for individual sensors as well as multi-sensor arrangements. The sensor concepts with integrated electronics will enable the ubiquitous and simple deployment of magnetic sensors applicable to a diverse set of measurement problems.

		2024		2025				2026				2027				2028	
		3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
WP 1	Multiscale modeling																
WP 2	Vector enabled arrays																
WP 3	Interface electronics																
WP 4	Wireless sensing																
WP 5	Sensing cubes																

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Collaborations

A1: Provides expertise on advanced magnetic multilayers and fluxgates.
A6: Improvement of process parameters in FeCoSiB deposition.
A8: Joint analysis of time-dependent behavior of ΔE-effect sensors.
A10: Magnetic characterization and modeling support of magnetic noise.
B1: Exchange on electronic circuit concepts for sensor readout.
B2, B9, B10, B11 (N): Provision of sensor samples for research in biomedical measurement and signal processing applications.
Z1: Support with MEMS post-processing.
Z2: Exchange of information and samples for improvement in sensor electronics.

Participation in focus groups

F1: Magnetic Layers
F2: Modelling
F3: Comparison of Sensor Concepts
F5: Concepts based on ΔE-effect

Funds Requested

2 Doctoral researchers, consumables: 68.5 k€

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