Z1

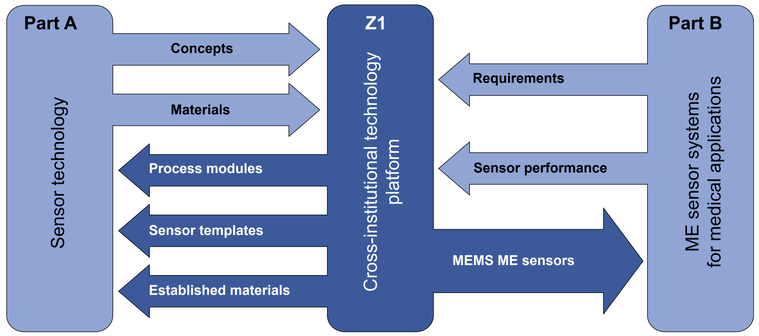
MEMS Magnetoelectric Sensor Fabrication

Lisa Hanke, Hanna Lewitz, Marc Alexander Nowak, Dirk Meyners (PI), Björn Gojdka (PI)

biomagnetic sensing SFB 1261

Motivation and Objectives

Microfabrication of magnetoelectric sensors and partially processed substrates for the CRC's scientific work program

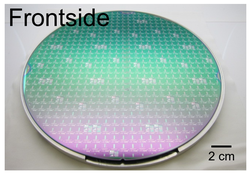


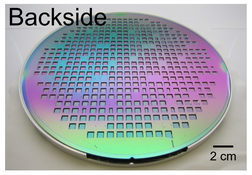
Main objectives:

Z1 cares for the demands of the technology-oriented **A** projects and the application-related **B** projects. Outsourcing of established manufacturing frees up scientific resources of the **A** and **B** projects. The quality of manufacture (reliability and yield) is increased thanks to dedicated experts and processes. [Z1-1]

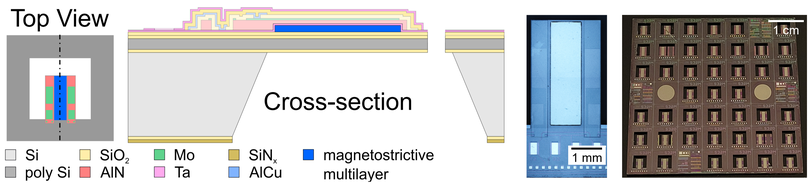
Results of the Second Funding Period

Bulk-micromachined ME sensors





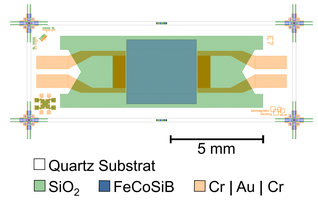
Partially processed BMM ME sensor wafer and released cantilever sensors for projects **B1**, **B2** and **B9**



Characteristics of BMM ME sensors

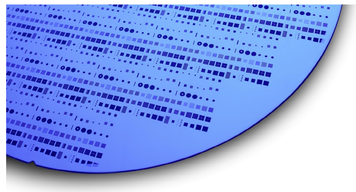
	Resonance [Hz]	Bandwidth [Hz]	Q factor	Sensitivity [V/T]	Noise [nV/Hz$^{1/2}$]	LOD [pT/Hz$^{1/2}$]
Sensor A4	7858	24	262	354	19	52
Sensor C7	7845	28	218	543	57	104
Sensor E1	7691	10	549	1007	74	73
Average (12 sensors)	7817	34	272	482	56	158
Std.Dev. (12 sensors)	67	22	163	288	19	87

Quartz-based bulk SAW sensors



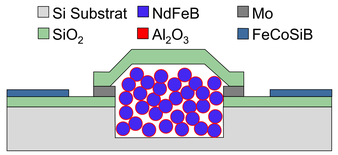
- New SAW sensor layout
- Complete flow for quartz-based bulk SAW sensors on 4-inch substrates integrated into the technology platform
- Sensors fabrication for **A1** and **A9** [Z1-3, Z1-4]

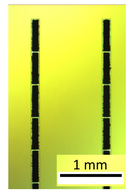
Wafer-level integrated NdFeB micromagnets



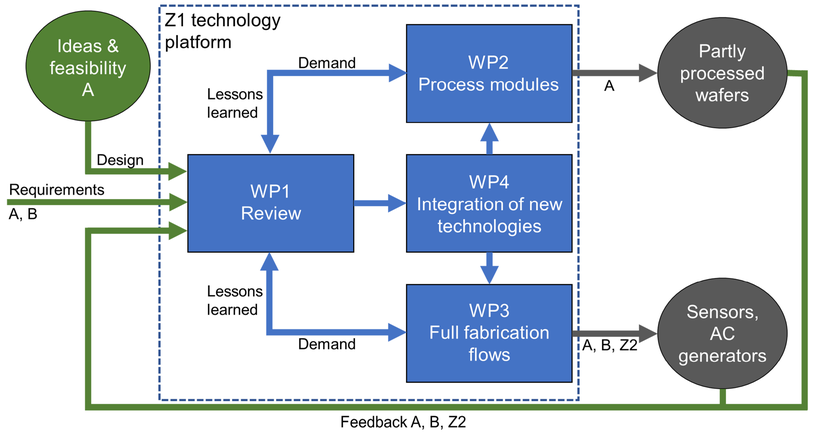
- New process module: wafer-level integration of powder-based micro-magnets
- Integration to the technology platform
- Fabrication process offers unique microfabrication capabilities [Z1-5, Z1-6]

- Integrated NdFeB permanent magnets provided to **A1** for biasing of FeCoSiB layers





Work Plan for Third Funding Period



WP1 Review of the technology platform

- Integration of new findings and demand from **A** and **B** projects
- Feedback intake for continuous improvement of manufacturing quality

WP2 Process modules for the fabrication of ME sensors

- Execution of process modules for **A** and **B** projects; provisioning of partly processed wafers
- Establishment and testing of new process modules [Z1-7, Z1-8]

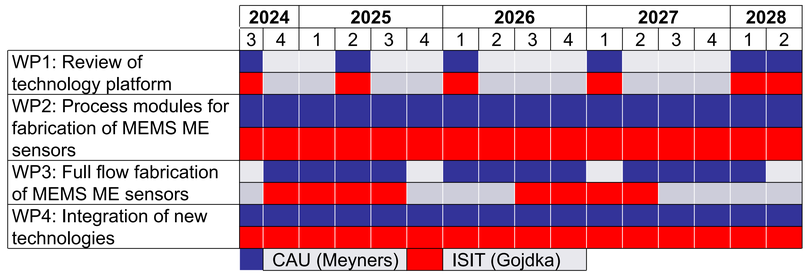
WP3 Full flow fabrication of MEMS ME sensors

Execution of complete manufacturing flows for ME sensor fabrication

Fabrication flow	Wafer-cut	Bulk-micromachined	Bulk SAW
Distinct features	Fast processing [Z1-9]	Miniaturization	Broad bandwidth
Application fields	Materials research & new sensor concepts, converse ME sensors, noise and transfer function modelling	Resonant sensors, ΔE-effect sensors, movement analysis, 3D sensors	Magnetic nanoparticle detection
Planned cycles	Continuous	2	3
Sensors / wafer	32	385	68

WP4 Integration of new technologies

- Integration of new technologies either in process modules or full fabrication flows
- Provision of MEMS magnetic AC flux sources
- Advancement of frequency tuning of MEMS ME sensors [Z1-10]



Collaborations

A1: New magnetic multilayers and powder-based micromagnets
A2: Functional layers for sensors
A4: ΔE-effect sensor fabrication
A6: Advanced characterization
A7: Miniaturization and fabrication of converse ME effect sensors
A9: Processing of SAW wafers
A10: ME sensor structures for magnetic noise modeling

B1: Sensor noise performance
B2: Sensors for digital signal processing
B9: Resonant ME sensors for movement analysis
B10: ME sensors for MCG
B11(N): ME sensors and AC flux sources
B12(N): SAW sensors for magnetic nanoparticle detection
B13(N): Resonant ME sensors
Z2: Assembly and characterization

Participation in Focus Groups
F1: Magnetic layers, F4: ME sensors, F5: Concepts based on ΔE effect

Funds Requested

CAU: 1 Postdoctoral researcher, consumables: 40.5 k€
ISIT: 1 Postdoctoral researcher, consumables: 47.3 k€

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[Z1-2] Spetzler, B., Bald, C., Durdaut, P., Reermann, J., Kirchhof, C., Teplyuk, A., **Meyners, D.**, Quandt, E., Höft, M., Schmidt, G., & Faupel, F. (2021). *Sci Rep*, *11*, 5269. – **A4, B1, B2, Z1**

[Z1-3] Schell, V., Spetzler, E., Wolff, N., Bumke, L., Kienle, L., McCord, J., Quandt, E., & **Meyners, D**. (2023). *Scientific reports*, *13*, 8446. – **A6, A9, A10, Z1**

[Z1-4] Schell, V., Müller, C., Durdaut, P., Kittmann, A., Thormählen, L., Lofink, F., **Meyners, D.**, Höft, M., McCord, J., & Quandt, E. (2020). *Appl. Phys. Lett.*, *116*. – **A1, A9, A10, B1, Z1**

[Z1-5] Lisec, T., Behrmann, O., & **Gojdka, B.** (2022). *Micromachines*, *13*(3), 398. – **Z1**

[Z1-6] Bodduluri, M. T., **Gojdka, B.**, Wolff, N., Kienle, L., Lisec, T., & Lofink, F. (2022). *Micromachines*, *13*. – **A6, Z1**

[Z1-7] Bodduluri, M. T., Dankwort, T., Lisec, T., Grünzig, S., Khare, A., Ahmed, M., & **Gojdka, B.** (2022). *Micromachines*, *13*. – **A6, Z1**

[Z1-8] Schmitt, P., **Gojdka, B.**, Lisec, T., Kroll, M., & Hoffmann, M. (2023). *IEEE Sensors Letters*, *7*(9), 1–4. – **Z1**

[Z1-9] Özden, M.-Ö., Teplyuk, A., Gümüs, Ö., **Meyners, D.**, Höft, M., & Gerken, M. (2020). *AIP Advances*, *10*, 025132.. – **A8, Z1**

[Z1-10] Su, J., Niekiel, F., Fichtner, S., Kirchhof, C., **Meyners, D.**, Quandt, E., Wagner, B., & Lofink, F. (2020). *J. Micromech. Microeng.*, *30*, 75009. – **Z1**