

Integrated Micromagnets for Microelectronics and MEMS

Wafer-level integrated NdFeB micromagnets in 200 mm silicon wafer

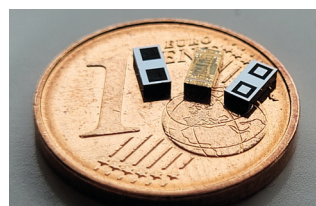
Magnets play a crucial role in numerous microelectronic and MEMS devices. Fraunhofer ISIT's PowderMEMS® process enables the integration of three-dimensional micromagnets on wafer level. Precise custom magnet geometries and placement are combined with thicknesses up to several hundred micrometers. The low process temperature below 100 °C allows integration in pre-processed device wafers (e.g. CMOS). In this way, microelectronic components can be equipped with highly precise local magnetic fields, for example for back-biased magnetic field sensors. PowderMEMS® micromagnets can be post-processed with standard back-end-of-line processes allowing for the realization of complex devices.

Technology¹

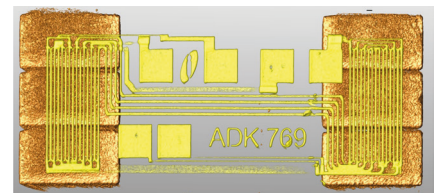
The PowderMEMS® process is based on the agglomeration of microfine powders by atomic layer deposition (ALD). In the first step, microcavities are etched into the substrate. Subsequently, the cavities are filled with dry microfine magnetic powder. The loose particle structure is then bonded by atomic layer deposition at low temperature below 100 °C.

Examples of applications

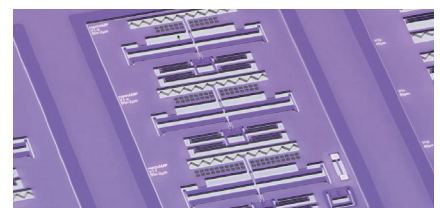
- Magnetic field sensors, e.g. back-bias², AMR³, TMR, NV⁴
- Quantum hardware, local fields and gradients for NV⁴ and ion-based architectures
- Magnetic MEMS, e.g. SOI⁵, contactless MEMS energy harvesting⁶



Back-biased Hall-sensors with substrate-integrated NdFeB magnets



CT scan of commercial AMR sensor (ADK769, Sensitec) with integrated magnetic in-plane bias



SOI MEMS sensor with integrated NdFeB micromagnets (courtesy RUBIP. Schmitt)

Technical specifications

Applicable Materials	NdFeB; SmCo and soft magnets ⁷ in development
Typ. magnet height within the substrate	30 µm ... 600 µm
Typ. magnet lateral dimensions	30 µm ... 2000 µm
Typ. remanence Br (NdFeB)	330 mT...550 mT, depending on powder
Typ. coercivity Hc (NdFeB)	770 kA/m
Operation temperature (NdFeB)	5 K ... 420 K / -260 °C ... 150 °C
Substrates	130 °C

Our services:

- Development of microelectronics and MEMS with custom micromagnetic structures
- Concept, design, manufacturing, and characterization
- Integration of micromagnets in pre-processed substrates
- Pilot production in 200 mm MEMS fab
- Technology transfer for high-volume production

¹ <https://doi.org/10.3390/mi13030398>

² <https://doi.org/10.1109/MEMS49605.2023.10052184>

³ <https://doi.org/10.1109/JSEN.2025.3609635>

⁴ <https://doi.org/10.1016/j.mne.2025.100316>

⁵ <https://doi.org/10.1109/LSENS.2023.3308125>

⁶ <https://doi.org/10.3390/mi13060863>

⁷ <https://doi.org/10.1109/APEC39645.2020.9124474>

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MEMS R&D at Fraunhofer ISIT

Professional MEMS production line

- Development and production: 8" / 200 mm wafer technologies (silicon and glass)
- ISO 5 BEOL cleanroom
- Critical Dimension: 0.35 μm
- Installed capacity: 800 wafers per month
- Chemical-mechanical polishing (CMP) facility
- Wafer grinding and dicing facility

PowderMEMS® production line

- Dedicated atomic layer deposition (ALD) tool for 8" / 200 mm wafers
- Custom tooling for automated filling of wafers with dry powders
- Optical and magneto-optical inspection for characterization and quality control
- Custom tooling for magnetization of 8" / 200 mm wafers

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