MA 49: Magnetic Imaging, Information Technology, and Sensors

Time: Thursday 15:00–17:15 Location: POT/0112

MA 49.1 Thu 15:00 POT/0112

Scalable magnetoreceptive e-skin for high-resolution interaction towards undisturbed extended reality — •Pavlo Makushko[1], Jin Ge[1], Gilbert Santiago Cañón Bermúdez[1], Oleksii Volkov[1,5], Yevhen Zabila[1], Stanislav Avdoshenko[2], Rico Illing[1], Leonid Ionov[3], Martin Kaltenbrunner[4], Jürgen Fassbender[1], Rui Xu[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Dresden, Germany — [2]Leibniz Institute for Solid State and Materials Research Dresden, Dresden,Germany — [3]University of Bayreuth, Bayreuth, Germany — [4]Johannes Kepler University, Linz, Austria — [5]Goethe-Universität Frankfurt, Frankfurt am Main, Germany

Electronic skins seek to go beyond the natural human perception, e.g., by providing magnetoperception to detect magnetic fields. However, realizing magnetoreceptive e-skin with spatially continuous sensing over extended areas is challenging due to escalating circuit complexity and power consumption with increasing sensing resolution or interactive area. Here, by incorporating the GMR effect and electrical resistance tomography, we achieve continuous sensing of magnetic trigger across an area up to $120 \times 120\,\mathrm{mm}^2$ with a sensing resolution of better than 1 mm [1]. A simplified circuit design enables optically transparent, mechanically compliant, and vapor/liquid permeable devices, that can be conveniently applied onto any surface including human skin. These achievements pave the way to numerous applications, including undisturbed recognition of fine-grained gesture touchless interaction. [1] P. Makushko et al., Nat Commun 16, 1647 (2025).

MA 49.2 Thu 15:15 POT/0112

Probing the magnetic order in a ferromagnetic monolayer — •Paritosh Karnatak[1], Andriani Vervelaki[1], Katharina Kress[1], Boris Gross[1], Daniel Jetter[1], Menghan Liao[2,3], Ritadip Bharati[2,3], Fengrui Yao[2,3], Ignacio Gutierrez[2,3], Kenji Watanabe[4], Takashi Taniguchi[5], Alberto Morpurgo[2,3], and Martino Poggio[1,6] — [1]Department of Physics, University of Basel, Basel, Switzerland — [2]Department of Quantum Matter Physics, University of Geneva, Geneva, Switzerland — [3]Group of Applied Physics, University of Geneva, Geneva, Switzerland — [4]Research Center for Functional Materials, National Institute for Material Science, 1-1 Namiki, Tsukuba 305-0044, Japan — [5]International Center for Materials Nanoarchitectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan — [6]Swiss Nanoscience Institute, University of Basel, Basel, Switzerland

Understanding magnetism in two-dimensional (2D) van der Waals (vdW) magnets requires nanoscale local probes. Scanning SQUID microscopy (SSM), with ∼100 nm resolution, enables direct imaging of magnetic structures in mono- and few-layer materials. Using SSM, we investigate the magnetic behavior of $CrPS_4$, a weakly anisotropic vdW interlayer antiferromagnet. Monolayer $CrPS_4$ shows no remanence and a zero coercive field, unlike thicker odd layers that exhibit 20-50 mT coercivity and nearly 100% remanence.

These layer-dependent studies reveal the role of interlayer coupling and dimensionality on magnetic responses. Our findings provide insights into mechanisms driving long-range magnetic order in 2D.

MA 49.3 Thu 15:30 POT/0112

SQUID-on-lever scanning probe for magnetic imaging with sub-100-nm spatial resolution — Timur Weber[2], •Daniel Jetter[1], Martino Pogio[1], and Dieter Kölle[2] — [1]Department of Physics, University of Basel, 4056 Basel, CH — [2]Physikalisches Institut, University of Tübingen, 72076 Tübingen, Germany

Scanning superconducting quantum interference device (SQUID) microscopy is a magnetic imaging technique combining high field sensitivity with nanometer-scale spatial resolution. We demonstrate a scanning probe that combines the magnetic and thermal imaging with the tip-sample distance control and topographic contrast of a non-contact atomic force microscope. We pattern the nanometer-scale SQUID, including its weak-link Josephson junctions, via neon or helium focused ion beam milling on a niobium coated cantilever. These SQUID-on-lever probes overcome many of the limitations of existing devices, achieving spatial resolution better than 100 nm, magnetic flux sensitivity of $0.3\ \mu\Phi_0/\sqrt{\mathrm{Hz}}$, operation in magnetic fields up to about 0.5 T and the incorporation of a third Josephson junction for shifting its phase. Its advanced functionality, high spatial resolution, and the ease of use of a cantilever-based scanning probe, extends the applicability of scanning SQUID microscopy to a wide range of magnetic, superconducting, and quantum Hall systems. We demonstrate magnetic imaging of skyrmions at the surface of bulk Cu2OSeO3. Analysis of the SQUID's point spread function yields a full-width-half-maximum of 71 nm that allows to image modulated magnetization patterns with a period of 65 nm.

MA 49.4 Thu 15:45 POT/0112

Magneto-Mechanical Resonator with Stimulus-Responsive Hydrogel for pH Sensing — •Nora Timm[1], Jonas Faltinath[2,3], Bruno Kluwe[1], Jonas Schumacher[1], Pascal Stagge[1], and Tobias Knopp[1,2,3] — [1]Fraunhofer Research Institution for Individualized and Cell-based Medical Engineering IMTE, Lübeck, Germany — [2]Section for Biomedical Imaging, University Medical Center Hamburg-Eppendorf, Hamburg, Germany — [3]Institute for Biomedical Imaging, Hamburg University of Technology, Hamburg, Germany

Magneto-mechanical resonators (MMRs) offer a promising platform for passive and wireless sensing. We present a novel chemical sensor by integrating a miniaturized MMR (2 mm × 2 mm × 7 mm) with a pH-responsive poly(2-hydroxyethyl methacrylate) (pHEMA) hydrogel functionalized with acrylic acid. In our implementation, the stimulus-responsive hydrogel modulates the distance between two permanent magnets through reversible volumetric changes in response to pH variations. One magnet serves as the stator and the other as the rotor of the MMR that is excited into torsional oscillations by external magnetic fields. Since the resonance frequency depends on magnet separation, frequency analysis of the inductively detected signal enables pH sensing. We demonstrate the sensor's response to pH variations in the range of pH 5-7 with observable shifts in resonance frequency of more than 40 Hz, which corresponds to a relative shift of more than 12 %. This proof-of-concept establishes hydrogel-integrated MMR sensors as a viable approach for wireless chemical sensing.

MA 49.5 Thu 16:00 POT/0112

Deep learning enabled wearable magnetoelectronics — •Guannan Mu, Rui Xu, Proloy T. Das, Jan Schmidtpeter, Lin Guo, Oleksandr Pylypovskyi, Andreas Knüpfer, Rico Illing, Olha Bezsmertna, and Denys Makarov — Helmholtz-Zentrum Dresden-Rossendorf e.V., 01328 Dresden, Germany

A wide variety of magnetic field sensors is already integrated into human-machine interfaces in wearable electronics [1,2]. However, the currently available interfaces are limited in the number of recognizable gestures and operation distance. To overcome these limitations, we integrate deep learning into two magnetic interaction platforms. First, we employ a flexible magnetoresistive sensor for user-definable temporal multipattern classification. Furthermore, we realize a compact LSTM-enabled wearable magnetic-interaction system integrated into a wrist-worn platform that incorporates a planar Hall magnetoresistive sensor, enabling a single sensor to recognize multiple predefined gestures and achieving a high classification accuracy of 99.4 % at a long range interaction distance of 12 cm, highlighting the potential of deep learning-enhanced magnetic sensing to expand functionality and enable long-range magnetic interaction recognition in smart wearable interfaces. [1] R. Xu et al., ACS Nano 19, 21891 (2025) [2] O. Bezsmertna et al., Adv. Funct. Mater. 2502947 (2025)

MA 49.6 Thu 16:15 POT/0112

Eco-sustainable printed magnetoresistive sensors — •Lin Guo, Xiaotao Wang, Proloy Taran Das, Yevhen Zabila, Ihor Veremchuk, Rui Xu, and Denys Makarov — Helmholtz-Zentrum Dresden-Rossendorf e.V., 01328 Dresden, Germany

Magnetoresistive sensors (MR), capable of non-contact detection of magnetic fields and consequently relative motion, have been extensively used across a broad spectrum of applications[1].Meanwhile, the massive deployment of magnetoresistive sensor arise the sustainability concerns from two aspects: 1. Carbon footprint in fabrication. 2. Electronics waste issue at the end of their lifetime.

Here, we propose the printed eco-sustainable magnetoresistance sensors. First, the recyclable printed MR sensors is developed based on a polyepichlorohydrin binder[2]. The hazardous MR ([Co/Cu]50) fillers are realized a close loop recycle once after the sensor lifetime. Further, we develop a healable and recyclable printed MR sensor via a full biomaterial gelatin-choline-citric acid ionogel. The additional healable capability extends the service time of the printed MR sensors and the full biomaterial binder decreased the carbon footprint. Finally, we developed a fully green printed magnetoresistance with Fe@Fe3O4 core-shell particles as functional filler, carboxymethyl cellulose as matrix binder, and water as solvents. Given that the skill-fully engineered magnetic structure and spin dependent transport, the printed sensors exhibit the remarkable low field magnetoresistance and sensitivity.

[1]Guo, L. et al., Chin. J. Struct. Chem. 44, 100428 (2025).
[2]Wang, X., Guo L. et al., J. Mater. Chem. A. 12, 24906 (2024).

MA 49.7 Thu 16:30 POT/0112

Mechanically Flexible High-Resolution Planar-Hall Effect Sensors — •Proloy Taran Das, Jan Schmidtpeter, Pavlo Makushko, Yevhen Zabila, Conrad Schubert, and Denys Makarov — Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany

Planar Hall effect (PHE) magnetic field sensors are attractive for applications requiring sub-nanoTesla resolution and vector field sensing [1,2]. In this presentation, we will discuss a comparative investigation of rigid and flexible PHE devices, linking their thin-film design and substrate mechanics to performance in sensitivity, linearity, and low-frequency noise. We show that flexible PHE sensors [3], fabricated as bi- and tri-layer elements on polymer substrates, maintain linear response under bending and achieve a magnetic field resolution to a few nT/*Hz at 10 Hz. The performance, rivalling that of rigid silicon-based references, is attained through careful tuning of unidirectional and uniaxial anisotropy through exchange bias, shape and growth effects and a synchronous demodulation readout. The results underscore the potential of PHE sensors for high-resolution biomagnetic sensing and robotics.

References: 1.Proloy T. Das et al. IEEE Trans. Magn. 60(9), 1-4 (2024) 2.*J. Schmidtpeter, Proloy T. Das et al. IEEE Magn. Lett. 15, 4100205 (2024) 3.*H. Nhalil et al. Appl. Phys. Lett. 123, 024102(2023)

MA 49.8 Thu 16:45 POT/0112

Probing nuclear spin dynamics in a single-atom magnet using Landau-Zener transitions — •Seunghyeok Jang[1,4], Valeria Sheina[1,3], Luciano Collazo[1,3], Georg A. Traeger[5], Denis Jankovic[1,3], Alexina Ollier[1,3], Muskan Sande[2,3], Sejong Kahng[4], Andreas Heinrich[2,3], and Won-jun Jang[1,3] — [1]Center for Quantum Nanoscience, Institute for Basic Science (IBS) — [2]Departure of Physics, Ewha Woman University — [3]Ewha Woman University — [4]Departure of Physics, Korea University — [5]Physik, Georg-August-Universitat Gottingen

Single-atom magnets provide a unique platform to probe quantum dynamics driven by hyperfine interactions. Holmium atoms on MgO thin films constitute a model system with exceptionally long-lived electronic states and well-resolved avoided level crossings, enabling electron-spin inversion via Landau-Zener (LZ) tunneling. Here, using spin-polarized scanning tunneling microscopy, we perform single-shot measurements of LZ tunneling events on 2-monolayer (ML) MgO at millikelvin temperatures, observing nuclear-spin polarization and resolving a ~10 peV gap at the avoided level crossing. We further measure the nuclear-spin lifetimes on both 2 ML and 3 ML MgO by applying LZ transitions twice in a pump-probe scheme. On 3 ML MgO, the lifetime reaches several hundred seconds, representing an enhancement of roughly two orders of magnitude compared with 2 ML. The exceptionally long nuclear-spin lifetime highlights single Ho atoms on MgO as a promising platform for quantum information processing based on coupled electron-nuclear spin states.

MA 49.9 Thu 17:00 POT/0112

Sensing Electric Currents in an a-IGZO TFT-Based Circuit Using a Quantum Diamond Microscope — •Pralekh Dubey[1], Mayana Yousuf Ali Khan[2], Lakshmi Madhuri P[3], Ashutosh Kumar Tripathi[3], Phani Kumar Peddibhotla[1], and Pydi Ganga Bahubalindruni[2] — [1]Department of Physics, Indian Institute of Science Education and Research, Bhopal — [2]Department of Electrical Engineering and Computer Science, Indian Institute of Science Education and Research, Bhopal — [3]National Centre for Flexible Electronics, Indian Institute of Technology, Kanpur

Quantum diamond microscopy (QDM), based on nitrogen-vacancy centers in diamond, provides a new approach for non-invasive magnetic imaging and diagnostics of electronic circuits under ambient conditions. By detecting magnetic fields generated by on-chip currents, QDM can probe device regions inaccessible to conventional electrical methods. It enables reconstruction of current density maps with sub-micron spatial resolution and sensitivity down to sub-microampere currents. Here, we employ a home-built QDM to map current flow in amorphous indium-gallium-zinc oxide (a-IGZO) thin-film transistor (TFT) circuits, a key technology for flexible and transparent electronics. As a demonstration, we map magnetic fields produced by current flowing through an a-IGZO TFT-based current mirror circuit. The corresponding current density was reconstructed, enabling direct visualization of current pathways. This study establishes QDM as a novel and powerful diagnostic tool for evaluating oxide-semiconductor circuits and emerging technologies.