INTERMAG 2023
Best Student Presentation Award Finalist & Best 2023 Lightning Talk Award

Nico Daniel BUDAI, D2, Otani Laboratory

The INTERMAG is a leading international conference encompassing all aspects of fundamental and applied magnetism. Scientists and engineers from various fields worldwide are participating and contributing to the technical sessions. The program includes oral and poster presentations, invited talks and symposia, tutorial sessions, and exhibits. This year, the conference was held from May 15 to May 19, 2023, in Sendai, famously known as the "City of Green", boasting a captivating natural environment, delightful cuisine, and distinctive hot springs. The conference is jointly sponsored by the IEEE Magnetics Society and the Magnetics Society of Japan.

The IEEE Magnetics Society established an award to promote students in research and recognize excellence in graduate studies in the field of magnetism, known as the Best Student Presentation Award, in which I participated.

The Lightning Talk is a new format organized by the IEEE Magnetics Society Young Professionals. It falls under the category of 'Special Sessions'. The idea behind it is to present your research understandably to an audience outside of your field within three minutes. The talks are given by young professionals in magnetism (from Postdocs to Asst. Professors and industry), followed by audience feedback and a panel discussion.

It was my first time joining an international conference and giving my first oral presentation; consequently, I was nervous about it. However, being chosen as one of the 'Best Student Presentation Finalists' was a great honor and filled me with pleasant memories of my first-ever oral presentation. It motivated my research and made me look forward to future conferences and presentations!

The Young Professionals Lightning Talk is a unique format where the presenting skill, instead of the content of the research, is in the foreground. I understandably conveyed my research to the audience, which granted me the 'Best 2023 Lightning Talk Award'. I am pleased about this and immensely enjoyed this different kind of format.

Figure 1: Me (Nico Budai) holding the awarded certificates at ISSP.

In the following, I want to give a brief introduction to my study.

We have recently developed a magnetic imaging technique based on atomic force microscopy (AFM) and the anomalous Nernst effect (ANE). The sample to be investigated is heated by a parallel wire, which raises its temperature. If the AFM-tip touches the surface of the heated sample, a local vertical temperature gradient, ∇T_z, is induced (the AFM-tip works here as a heat sink) below the tip-contact area. Due to the magnetization dependence of the anomalous Nernst effect, given by

$$\boldsymbol{E}_{ANE} = S_{ANE} \cdot (\boldsymbol{m} \times \nabla T),$$

and the locally induced temperature gradient, the magnetization direction (or anomalous Nernst effect) of the touched point on the sample surface can be detected accurately. Figure 2(a) shows the schematics of the technique.

We applied our method to the Weyl ferromagnet Co_2MnGa, famous for exhibiting a very high anomalous Nernst effect among metals [1]. In Figure 2(b), the topographical image of our device, including the heating wire, can be seen. The sample itself is indicated with a white box.

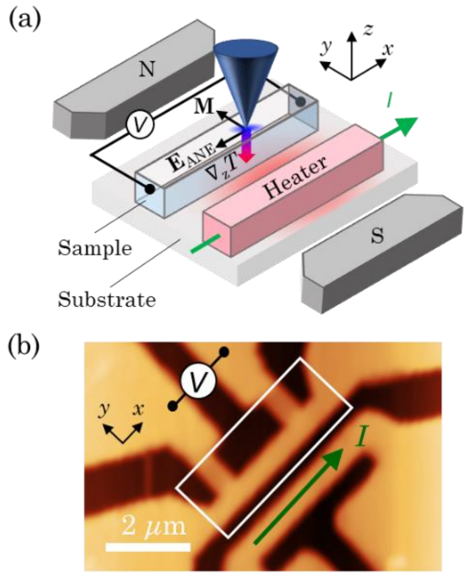

Figure 2: (a) Schematics of the proposed magnetic imaging technique. (b) Topographical image of the sample obtained by standard AFM measurement.

We can scan under different external magnetic fields, which allows us to investigate the change in the sample's magnetization during this process. As indicated in Figure 3, a clear change in magnetic contrast from +134 mT to -134 mT can be seen. Here, red means a positive measured voltage, and blue represents a negative one, which resembles a positive and negative magnetic field. At -5 mT, even a clear domain wall (transition from red to white to red in the middle of the wire) can be determined [2].

Our technique provides a sub-100 nm spatial resolution and does not rely on net magnetization, making it a promising candidate in materials science. Especially for non-collinear antiferromagnets such as Mn_3Sn, this magnetic imaging technique is applicable, enabling a way to determine their magnetic properties easily.

At this point I want to thank all the co-authors who contributed to my work, without them I would not have been able to receive the awards nor develop the magnetic imaging method. Special thanks to Hironari Isshiki, who is my technical supervisor and assistant professor, and Professor Yoshichika Otani, as my academic supervisor, for the huge support throughout the work and the preparation for the conference. I am also very thankful for Ryota Uesugi's, Zheng Zhu's, Tomoya Higo's and Professor Satoru Nakatsuji's support in the sample fabrication and the very valuable discussions.

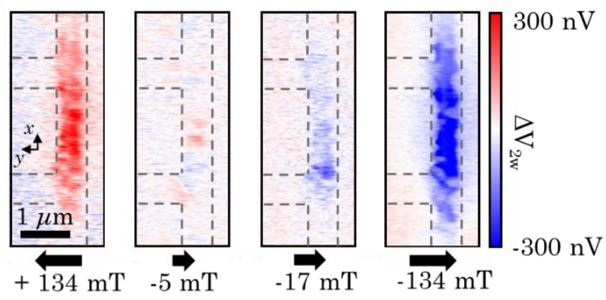

Figure 3: Results of the magnetic imaging on Co_2MnGa under different external magnetic fields.

References

[1] A. Sakai et al., *Nature Physics* **14**, 1119–1124 (2018)
[2] **N. Budai** et al., *Appl. Phys. Lett.* **122**, 102401 (2023)