fit4nano

Newsletter # 2 - May 2023

CONTENT

www.fit4nano.eu

Editorial

Spring greetings to all FIT4NANO members and enthusiasts! In this issue, we report on the very positive evaluation the FIT4NANO project received in the COST mid-term review. In February, we held a nice role model webinar by three rellevant membres of the CA. If you missed it, don't worry! Videos of the event will be available shortly. These generous speakers are always eager to providing young students and fellow researchers advice on career development. Feel free to contact me for any requests regarding that.

Very importantly, the organization of the 3rd FIT4NANO workshop is coming along nicely. It will be held in July in the beautiful and vibrant city of Lisbon, Portugal. Our chairperson Dr Catarina Pinto Reis has set an unmissable social event for all in person participants. Surely, you cannot miss this, but specially the abstract submission deadline!

Please enjoy the Newsletter 2 contents, and make sure you check your agenda for actively contributing to the coming activities within FIT4NANO.

Gemma Rius, Institute of Microelectronics of Barcelona (IMB-CNM-CSIC)

fit4nano Project news

Report from Gregor Hlawacek, Action Chair of FIT4NANO

In our latest update, we are pleased to report that after completing two grant periods and reaching halfway through the third, we have received positive feedback from the Action Rapporteur. He commended our progress and the results achieved thus far, especially our successful growth in size and inclusiveness, with 31 COST members and 1 COST associated member, as well as several IPC joining the Action. The fact that we have a good representation of female researchers and YRI in leadership positions was also noted. However, we have been encouraged to continue expanding and being inclusive.

We are excited to announce that the roadmap is nearing publication, with final proofreading currently in progress. This document will be a major asset to the Action and help us achieve our objectives, tasks, and deliverables. Once finished, it will be available in ArXiV and sent for review to an appropriate journal.

WG2 recently hosted a successful webinar on software development in the context of FIB processing, and a short report on this is included below. We are finalizing plans for similar workshops for the other WGs, so keep an eye out for more interesting webinars after the summer break. The dates for the working group meetings will be announced on the website shortly.

As a reminder, there are still funding opportunities available within our COST Action, including ITC Conference grants and Virtual Mobility grants. While the allocated budget for STSMs has been used up, we look forward to receiving great reports and excellent papers from those collaborations. We encourage you to visit our website and review the information in this newsletter for further details on funding opportunities.

Webinars

FIT4NANO hosted two webinars in the beginning of GP3 – around 20 Action members signed up for a webinar in December 2022 on Short-Term Scientific Missions – how to apply for one and what to expect.

At the end of February 2023, Katja Höflich (HZB, Germany), Anne Delobbe (Orsay Physics, France), and Gregor Hlawacek (HZDR, Germany) invited interested members of the public as well as Action members to a Role Model Webinar, where the three talked about their unconventional career paths which brought them to leading positions in academia as well as in industry. This webinar is part of the goals of Grant Period 3 to generate role model materials meant to inspire and motivate. Recordings will be made available on the website shortly.

WG2 meeting in Dresden

The WG2 meeting discussing the progress in mostly BCA based simulation codes for FIB based milling applications took place on 28 March 2023 at HZDR, Germany. Developments of user interfaces suitable for accepting input from experimental researchers and providing output in a format suitable for the usage in FIB instruments were discussed.

The meeting was introduced by guest speaker Richard Wilhelm from TU Wien who, together with two of his students, presented a new graphical user interface (GUI) for SDTrimSP and TRIDYN. This work paves the way for a wider use of these codes in the post-TRIM era. They also demonstrated the extensibility of their GUI to other BCA codes. The presentation was followed by a talk by Hans Hofsäss on his SDTrimSP fork, IMINTDYN, emphasizing extensions for very low and high energies. Wolfhard Möller continued with a study of scan strategies for milling circular holes, using his TRI3DYN code. Gerhard Hobler discussed options for beam profile modeling and presented the GUI concept for his BCA code IMSIL. The afternoon closed with a presentation by Flyura Djurabekova, highlighting a GUI for the PARCAS molecular dynamics (MD) code along with some recent MD results.

Lively discussions developed among the in-person participants of the meeting. In addition, the meeting was well received by ~30 online participants. The organizer hopes to have demonstrated the many options in a post-TRIM era.

fit4nano Project news

Eligibility

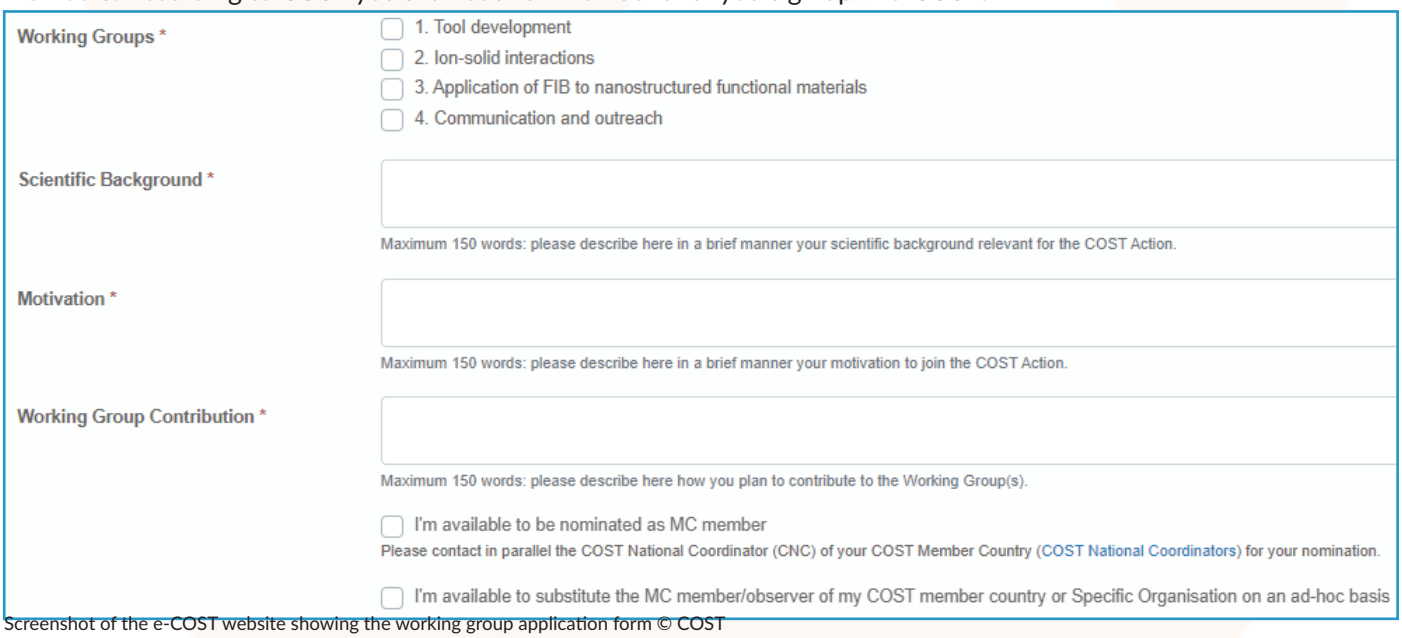
COST has made a few changes to their eligibility rules. Since 2 March, participants affiliated with Belarus are no longer able to participate in COST actions.

Armenia became the 41st Full Member of COST in November and can now fully participate in COST actions. If you know of any researchers from Armenia that would be interested in our action, please let them know!

FIT4NANO Membership - Become a member and check your membership status

Read the memorandum of understanding, our project description, or visit our website. Then, apply to become a member of at least one of the working groups here: https://e-services.cost.eu/action/CA19140/working-groups/apply

Do you want to check if you are already a member? All members are listed on the COST website:
https://www.cost.eu/actions/CA19140/#tabs+Name:Working%20Groups%20and%20Membership
If you don't show up here, you are not an official FIT4NANO member!
Why is it so important that you all sign up? Part of the budget allocated to us by COST for each Grant Period is based on the number of COST countries involved in the action, but the budget is also determined by the actual number of members. According to COST you are not a full member until you sign up in e-COST!



Screenshot of the e-COST website showing the working group application form © COST

FIT4NANO acknowledgment in publications

Official acknowledgment: *This article/publication is based upon work from COST Action FIT4NANO CA19140, supported by COST (European Cooperation in Science and Technology). https://www.cost.eu/*

If your work is a result from an STSM: *Financial support through a short term scientific mission funded by the COST Action CA19140 is acknowledged. http://www.fit4nano.eu/*

All others: *The authors are (partly) members of the COST Action FIT4NANO CA19140. http://www.fit4nano.eu/*

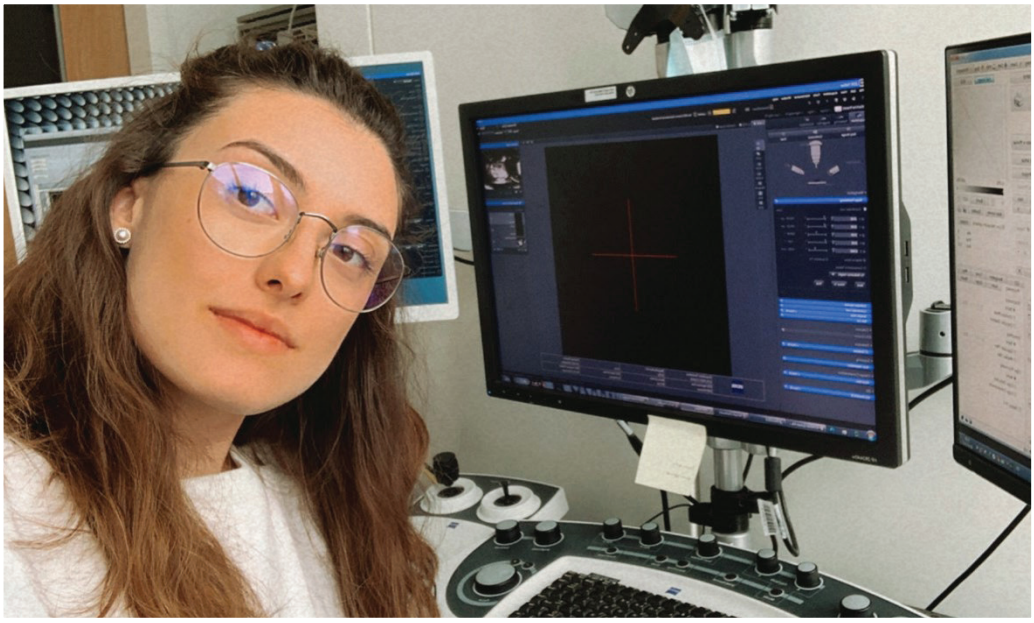
Please use the first one for all publications that are a result of a collaboration between two or more international FIT4NANO partners. Should you also have received financial support from us, please add the second (both statements are required).

fit4nano STSM & other grants

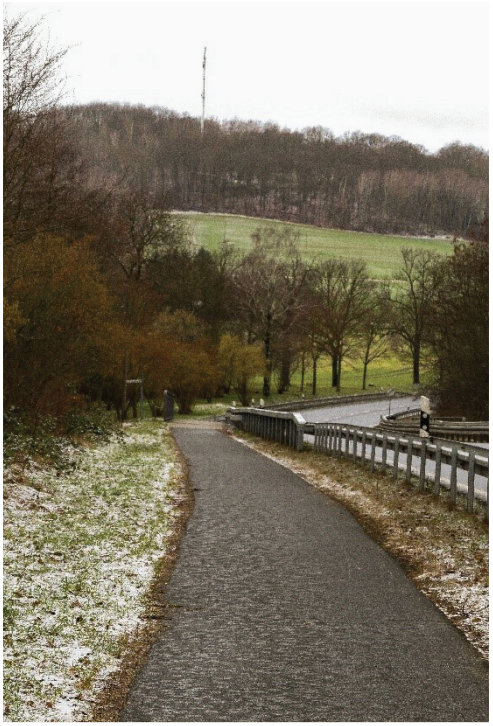
STSM in Dresden (HZDR) by Alba Arroyo-Fructuoso

from Institute of molecular Science (ICMol), Spain. February 2023

During the first two weeks of February, I was able to visit the Institute of Ion Beam Physics and Materials Research at the Helmholtz-Zentrum Dresden Rossendorf in Dresden, Germany, thanks to an STSM grant. My main goal was to use the Helium Ion Microscope to create W-C nanostructures, but unfortunately, that was not possible due to a malfunction. However, I got involved in other projects underway in Gregor Hlawacek's group, such as studies of direct transmission detectors using a Helium Microscope (ZEISS) with different samples. I also learned through self-reading of the Orion Helium Ion Microscope advanced software manual and designed different nanostructures using the NanoPatterning and Visualization Engine (NPVE) by modifying dimensional parameters with different growth strategies. Additionally, I learned how to use the Kleindiek nanomanipulator on an SEM/Ga+ FIB, which allowed me to control the nanomanipulator and operate close to the sample.



Copyright: all photos by A. Arroyo-Fructuoso



In addition to scientific learning, I was lucky enough to visit the beautiful city of Dresden and walk through its streets. As a nature lover, I also enjoyed the opportunity to hike in the rural areas near the Helmholtz-Zentrum Dresden Rossendorf. I loved being able to experience the combination of city and country in one place without having to travel far, and the cold did not manage to ruin the beauty of the landscapes around Dresden.

My experience taught me that the STSM encourages scientific collaboration between different research groups and generates personal and professional learning by providing new situations and experiences for the person doing the stay. Finally, I thank Gregor Hlawacek, Nico Klinger, and Svenja Lohmann for their kindness during my visit.

fit4nano STSM & other grants

STSM Report by Alix Tatiana Escalante Quiceno *INMA, Spain - March'23*

Copyright of the photos: Alix Tatiana Escalante Quiceno

My stay was in the Institute of Ion Beam Physics and Materials Research located at the Helmholtz Zentrum Dresden Rossendorf (HZDR), 15 km from the city of Dresden, Germany.

I chose this institute due to the expertise of the group in the field of ion irradiations and the equipment available in the facilities of the centre. My goal was to reduce the diameter of MFM tips fabricated by FEBID, using localized or broad irradiation with He+ ions, as well as to analyse the magnetic change in the NdCo5/Ni80Fe20 samples resulting from the localized ion irradiation.

One of the biggest challenges during the stay was to restructure the project, because the equipment that would be used for the irradiations was not working properly. After discussions with the host, Dr. Gregor Hlawacek, we decided to focus only on the second part of the initial objective. Therefore, during my stay I was able to irradiate my sample with three different ions, gallium, helium and cobalt. I have to say, that in the centre there is a wide range of possibilities in terms of ion irradiation.

My biggest success during the stay was the possibility to irradiate my sample with the different ions, which allowed me to have a lot of very interesting results that open up a range of possibilities for study. My biggest failure was not being able to perform the initially planned experiments, however, the situation was handled quite well.

The next steps will be to study in more depth the irradiations performed during the stay and hopefully, when the equipment is repaired, we will talk about a collaboration to carry out the initially planned objective.

Regarding the city, I loved the experience, it has very good bus and tram connections, although I faced two days of transport strike. I took advantage of my stay as I booked accommodation in the city of Dresden. I had to travel almost an hour by bus to go to the institute, but I took advantage of the evenings and weekends to visit the city.

I took a city tour in Spanish, which is great as there are tours in many languages, including Spanish, English, French and of course German. The tour is worthwhile as the city has a lot of history and is quite beautiful to walk around. I also visited many museums, for this there is a ticket that costs 25 euros, it is valid for 2 days and you can visit a long list of museums, among them the porcelain museum, the mathematics museum, the Zwinger museum and the Gemäldegalerie Alte Meister, which is where the Sistine Madonna is located. I consider the stay a very enriching experience both culturally and scientifically.

fit4nano publications

Sputter yields of surfaces with nanoscale textures: Analytical results and Monte Carlo simulations

R. Mark Bradley, Gerhard Hobler

We find the spatially averaged sputter yield $\bar{Y}$ analytically for non-planar surfaces that have slowly varying surface heights h=h(x,y). To begin, nonlocal effects like redeposition of sputtered material and secondary sputtering are neglected. We show that the leading order corrections to $\bar{Y}$ are proportional to the spatial averages of $(\partial h/\partial x)^2$ and $(\partial h/\partial y)^2$. The constants of proportionality can be written in terms of the first and second derivatives of the sputter yield of a flat surface with respect to the ion incidence angle θ. For a range of θ values, $\bar{Y}$ is a decreasing function of the amplitude of the surface texture. We also determine how the contribution of redeposition to $\bar{Y}$ depends on the amplitude and characteristic lateral length scale of the surface morphology. As a test of our theory and to quantify the roles of redeposition and secondary sputtering, we performed Monte Carlo simulations of sputtering from Si targets with sinusoidal surfaces by 1 keV Ar^+ ions. The theory agrees remarkably well with our Monte Carlo simulations. Our simulations also lead to the notable result that atoms that are sputtered and then strike the surface can themselves cause significant sputtering.

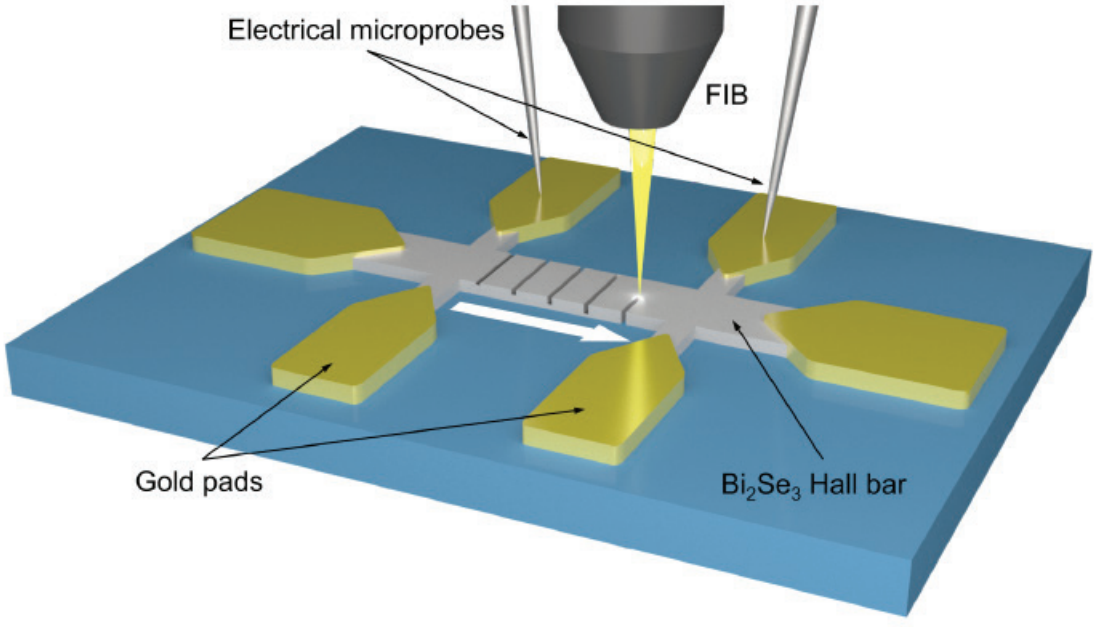
Published in Journal of Applied Physics 133, 065303 (2023) DOI: https://doi.org/10.1063/5.0137324

Ion-induced lateral damage in the Focused Ion Beam patterning of topological insulator Bi_2Se_3 thin films

R. Gracia-Abad, S. Sangiao, S. Kumar Chaluvadi, P. Orgiani, J. M. De Teresa

Focused Ion Beam patterning has become a widely applied technique in the last few decades in the micro- and nanofabrication of quantum materials, representing an important advantage in terms of resolution and versatility. However, ion irradiation can trigger undesired effects on the target material, most of them related to the damage created by the impinging ions that can severely affect the crystallinity of the sample, compromising the application of Focused Ion Beam to the fabrication of micro- and nanosized systems. We focus here on the case of Bi_2Se_3, a topological material whose unique properties rely on its crystallinity. In order to study the effects of ion irradiation on the structure of Bi_2Se_3, we irradiated with Ga^+ ions the full width of Hall-bar devices made from thin films of this material, with the purpose of inducing changes in the electrical resistance and characterizing the damage created during the process.

The results indicate that a relatively high ion dose is necessary to introduce significant changes in the conduction. This ion dose creates medium-range lateral damage in the structure, manifested through the formation of an amorphous region that can extend laterally up to few hundreds of nanometers beyond the irradiated area. This amorphous material is no longer expected to behave as intrinsic Bi_2Se_3, indicating a spatial limitation for the devices fabricated through this technique.



Published in Materials 16 2244 (2023) DOI: https://doi.org/10.3390/ma16062244

fit4nano publications

Focused He^+-ion beam irradiation enables the creation of ultradense nanostructures in copper-oxide superconductors

Bernd Aichner, L. Backmeister, M. Karrer, K. Wurster, R. Kleiner, E. Goldobin, D. Koelle and Wolfgang Lang

Nanopatterning of the copper-oxide high-Tc superconductors (HTS) is challenging due to their complex atomic structure and susceptibility to environmental influences. The severe constraints on conventional lithographic techniques can be overcome by leaving the material's crystallographic framework intact and tailoring the superconducting properties by introducing controlled point defects.

To this end, the focused beam of a helium ion microscope (He-FIB) can be used to fabricate narrowly spaced columnar defects in thin films of HTS. Inside these columns, the critical temperature Tc is reduced or entirely suppressed due to pair-breaking by numerous point defects. Such modulation of Tc can be used to anchor Abrikosov vortices, each of which carries one flux quantum. We apply the He-FIB technology to investigate the various topological phases of vortices in the most important HTS, thin films of the compound $YBa_2Cu_3O_{7-\delta}$ (YBCO).

When a magnetic field is applied to a superconductor, many different thermodynamic vortex phases can form, depending not only on the specific defect topography, but also on the magnitude of the magnetic field, its orientation with respect to the main crystallographic axes, and the temperature. HTS phase diagrams are extremely rich, encompassing the long-range-ordered vortex crystal in very clean superconductors and the vortex Mott insulator in a superconductor with periodic defects. When a sufficiently high density of uncorrelated defects is present, the vortex glass (zero-dimensional defects) or the Bose glass (one-dimensional defects) is formed.

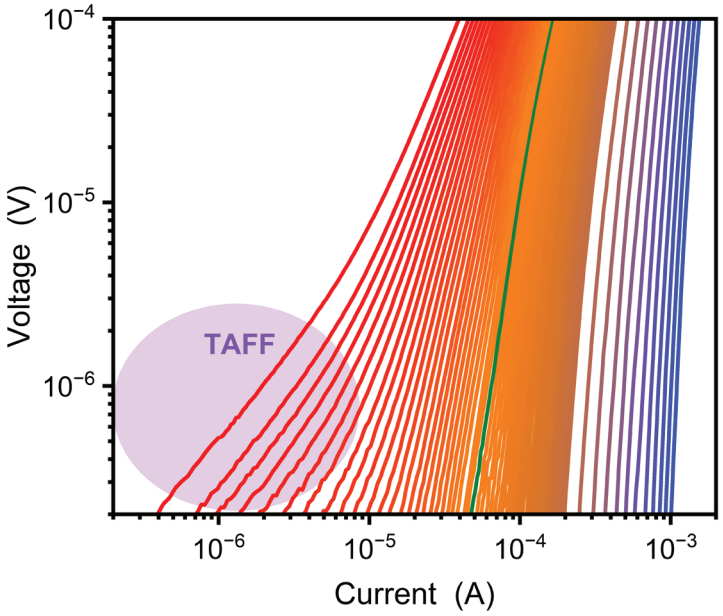


Figure: Voltage-current isotherms from 66K (red) to 30K (blue) of a YBCO film with a 30-nm-spaced hexagonal defect array. The applied magnetic field of 2.65 T corresponds to the matching field, where each defect is occupied by one flux quantum. The green line accentuates the isotherm at 59.5 K. At this temperature, the glass transition separates between the thermally-assisted flux flow (TAFF) region with a finite resistance and the "true" superconducting state with zero resistance © B. Aichner et al.

In this publication we report on a novel topological phase, the ordered Bose glass of Abrikosov vortices. It can emerge from a vortex Mott insulator when thermal energy and disorder weaken the vortex correlations. The ordered Bose glass has distinct properties such as pronounced commensurability effects of the melting temperature in an applied magnetic field and the critical scaling of voltage-current isotherms around the second-order glass transition. Angle-dependent magnetoresistance measurements in constant Lorentz force geometry reveal a substantial increase in anisotropy after patterning when the density of vortices matches that of the columnar defects. Then, only the magnetic-field component parallel to the columnar defects dominates vortex pinning, revealing its one-dimensional nature. All of these findings support the concept of an ordered Bose glass phase and, moreover, demonstrate the benefits of He-FIB for nanoscale modification of HTS.

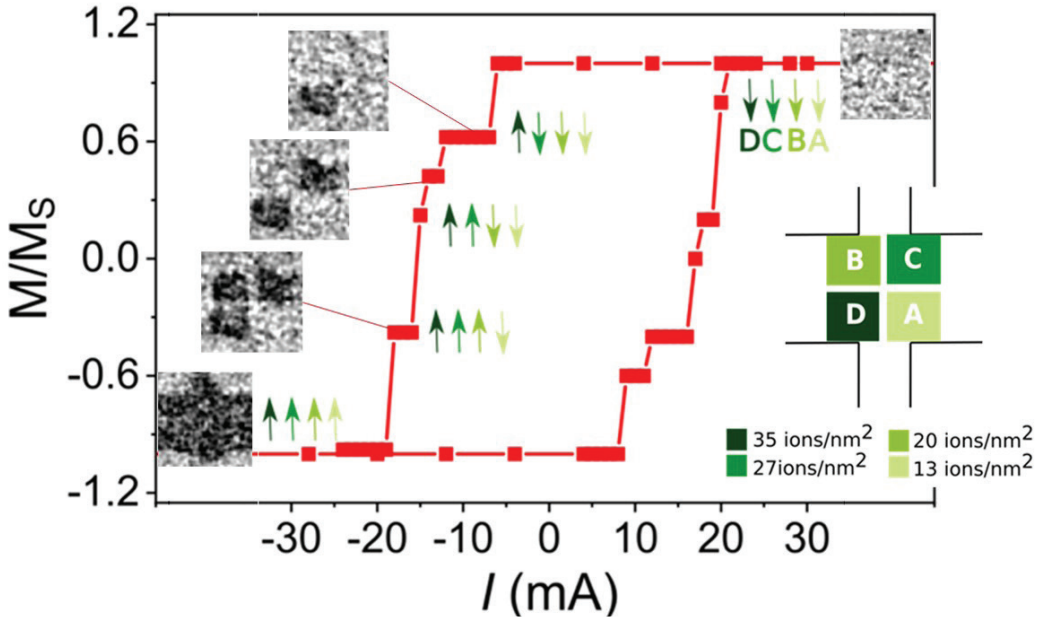
The publication "Angle-dependent Magnetoresistance of an Ordered Bose Glass of Vortices in $YBa_2Cu_3O_{7-\delta}$ Thin Films with a Periodic Pinning Lattice" was published in Condensed Matter. 2023; 8(2):32. and is available at https://doi.org/10.3390/condmat8020032

fit4nano publications

Deterministic multi-level spin orbit torque switching using focused He+ ion beam irradiation

Jinu Kurian, A. Joseph, S. Cherifi-Hertel, C. Fowley, G. Hlawacek, P. Dunne, M. Romeo, G. Atcheson, J. M. D. Coey, and Bernard Doudin

He⁺ ion irradiation is used to pattern multiple areas of Pt/Co/W films with different irradiation doses in Hall bars. The resulting perpendicular magnetic anisotropy landscape enables selective multilevel current-induced switching with full deterministic control of the position and order of the individual switching elements. Key pattern design parameters are specified, opening a way to scalable multi-level switching devices.



Published in Appl. Phys. Lett. 122, 032402 (2023). Available at https://doi.org/10.1063/5.0131188

Open Access costs covered by COST

This publication received funding from FIT4NANO for open access funding. Every Grant Period, we reserve a small sum to fund open access publications by FIT4NANO members. COST strongly recommends Open Access "for any reproducible products to which Action activities have contributed materially (for example, a publication resulting from an STSM or a workshop)"

(see Annex 3 of the annotated rules, especially A3-3.1 at https://www.cost.eu/uploads/2022/12/COST-094-21-Annotated-Rules-for-COST-Actions-Level-C-V1.3.pdf)
Eligible expenses are the open access fees for scientific publications as well as expenses for proof reading, editing, translation, and layout.

The conditions are that the publication is
- published in the same grant period (proof of delivery is required; our grant periods run from 1 November to 31 October)
- the result of the work of FIT4NANO
- is authored by action participants
  - from at least 3 different COST members or
  - Action participants from at least 2 different COST members and 1 NNC, or
  - from at least 2 different COST Members if the publication is resulting from an STSM funded by FIT4NANO

Please contact Astrid Berens (a.berens@hzdr.de) in case of any questions.

The new budget for GP4 is drafted in November. If you plan on publishing open access next year, please contact us so we can discuss it and take your publication under consideration for the next budget.

fit4nano workshop

3rd FIT4NANO Workshop from 17 - 19 July 2023 in Lisbon

Join us for 2 1/2 packed days full of presentations and working group meetings and share your research with us! The workshop will officially start around noon on the 17th of July and will end in the late afternoon on the 19th. Registration and abstract submission for the 3rd FIT4NANO workshop is open at
https://events.hifis.net/event/585

Abstract submission deadline as well as the deadline to apply for a FIT4NANO travel grant is on 10 May 2023.

As in the previous years, workshop participation is free of charge. We will try our best to offer participants with accecpted contributions (oral or poster presentations) a travel grant, which includes a daily allowance as well as travel expenses.

Important Dates

Abstract submission deadline: 10 May 2023
Deadline to apply for a travel grant: 10 May 2023
Communication of abstract acceptance: 19 May 2023
Registration deadline: 15 June 2023

Confirmed Invited speakers

Associate Professor **Peter Hosemann**
Nuclear Materials Group, UC Berkeley, USA
Helium bubbles in reactor applications and mechnical testing

Professor **Karen Kavanagh**
Kavanagh Lab – Simon Fraser University, Canada
Negative ion HIM

Dr **Ulrich Mantz**
Raith GmbH, Germany
FIB for microelectronics: instrument developments and applications

Dr **Carla Perez Martinez**
London Centre for Nanotechnology Research Groups , University College London, UK
Ionic Liquid ion sources

Dr **Daniela da Silva Nunes Gomes**
CENIMAT/i3N/Materials Science and Engineering Department of FCT/UNL, Portugal
FIB and applications in health science

Praça do Comércio © A. Berens

If you have questions, comments, or input for the next newsletter, please send an e-mail to Astrid at a.berens@hzdr.de

Newsletter design by Astrid Berens. Title page design adapted from www.stockindesign.com

Funded by the European Union

Funded by the European Union. This newsletter is based upon work from COST Action FIT4NANO - CA19140, supported by COST (European Cooperation in Science and Technology).