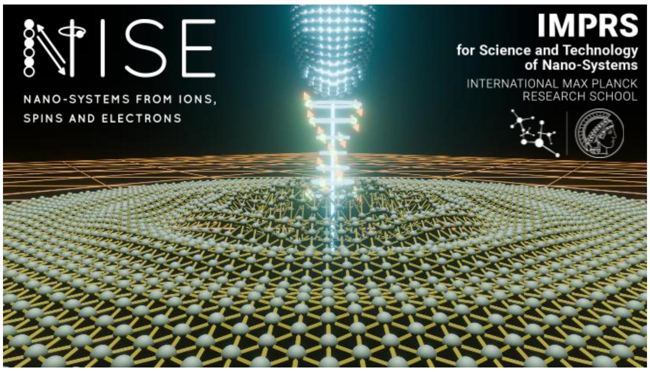
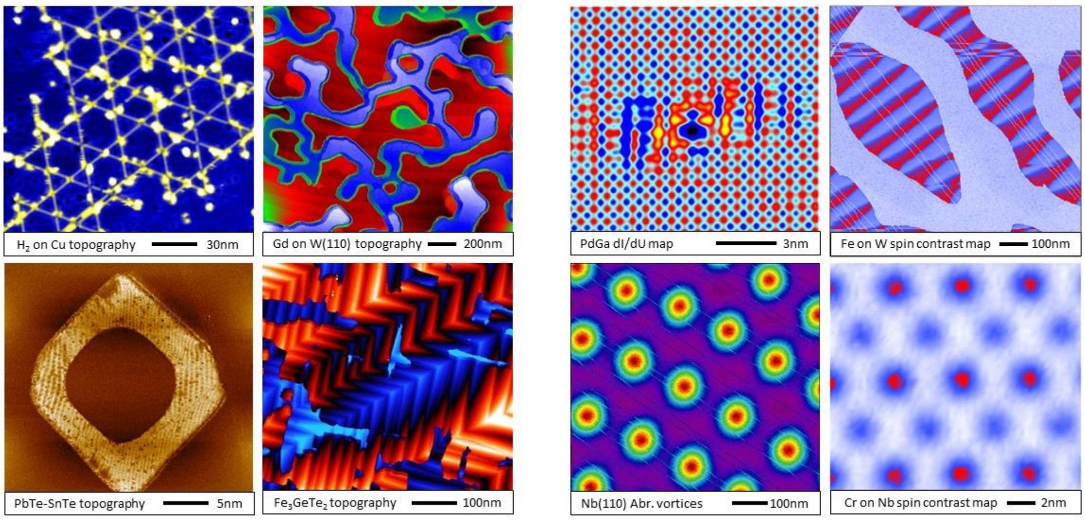
Low-temperature SPM Lab at the Max Planck Institute of Microstructure Physics - Department Nanosystems from Ions, Spins and Electrons (NISE)



The LTSPM lab/group is currently looking for motivated PhD students / postdocs to reinforce our team of low-temperature scanning probe specialists, investigating atomically designed and crafted quantum materials for next-generation technology created with in-house facilities.

Local probe instruments like the scanning tunneling microscope (STM) or the atomic force microscope (AFM) are surface characterization methods with ultimate space resolution. Working in a low-temperature setup they unfold a great arsenal of analysis methods by enabling high-resolution local spectroscopy under ultra-stable conditions. The following pictures show some examples of STM real space imaging of sample areas ranging from a few nanometers to several 100 nm scales.



Current status of the lab

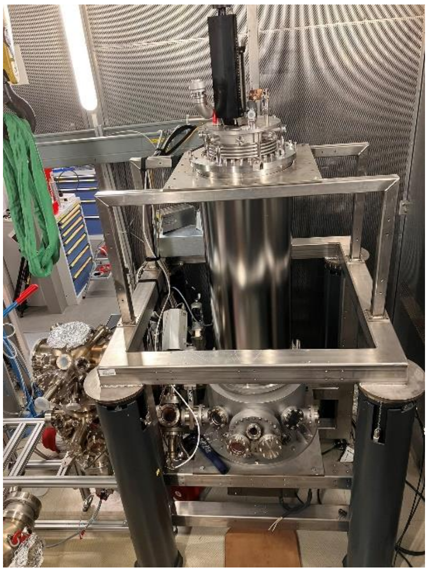
Our laboratory stands on exceptionally low-noise concrete foundation, the microscope systems are additionally separated from the surrounding floor and housed in acoustic shields to minimize environmental influences. The institutes liquid helium network is well connected and recovers evaporated helium to send it back to a large liquefier to ensure cryogenic supply. Further, the institutes portable vacuum suitcases enable us to measure samples grown by our MBE experts next door.
The two currently running systems (^{3}He-STM and MFM) will soon be extended to four low temperature scanning probe microscopes.

In our ^{3}He-STM system we achieved all of our recent results (see publication list for reference). It reaches a temperature of 500mK and is equipped with a 6-1-1 Tesla superconducting vector magnet.
Here we readily conduct

- atomic-scale imaging,
- local density of states spectroscopy with sub-meV resolution,
- >24h full spectroscopy grids,
- quasiparticle interference derived momentum-space imaging,
- in-situ atom deposition,
- atomic manipulation,
- tip functionalization for superconducting or magnetic tips facilitating spin contrast maps and Josephson spectroscopy.

Our low-temperature performance will soon reach new horizons with the already ordered UNISOKU USM 1600 ultra-low temperature SPM system. The dilution fridge cryostat allows continuous measurement below 50mK, it is equipped with additional RF lines for high frequency experiments, a 9-2-2T vector magnet and ready for qplus© AFM. The ultra-low temperature makes it the ideal tool to study superconducting phenomena including triplet superconductivity and magnet-superconductor quantum interfaces via e.g. Josephson STM.

We are currently setting up a home-built LTSTM system with 1.5K base temperature and a unique 12T external magnetic field along any sample direction. It will be our most flexible system for custom-built low-temperature SPM experiments. There is an additional variable temperature STM connected to its preparation chamber allowing for quick checks of sample morphologies in order to enhance productivity and growth optimization.



Working in the LTSPM lab

Scanning probe microscopy is an extremely powerful surface characterization method, however, it is technically challenging. Working with these systems will grant you expertise with ultra-high vacuum and ultra-low temperature, deep technical understanding on femto-scale current detection including means to reduce noise sources to a minimum. It requires the readiness to yield a wrench and to manipulate samples in vacuum with a steady hand on the wobblestick.
On the scientific side, it proves very rewarding, provided a little patience, due to the variety of information one might extract from a material surface with unique real space resolution.

Research prospects

Every microscope system is directly connected to a preparation chamber where we can do Ar sputtering, annealing and even some basic MBE.
However, the big advantage of working at Max Planck in Halle is the opportunity to have immediate contact to many scientists that focus on synthesizing new atomically engineered materials with potential application in spintronics, large and efficient data storage technology or quantum computing. In order to achieve that, we interface magnetism and superconductivity at the quantum level looking for unconventional superconductors like triplet and topological superconductors or high-T_C superconductors. We are investigating epitaxial thin films, 2D materials, heterostructures, Van-der-Waals layered crystals, cleaved single crystals, MBE grown nano-islands and STM tip assembled nanostructures.

Requirements

For the PhD position: MSc degree (or equivalent, e.g. 4 years Bachelors) in physics, materials science, or related fields, including a final thesis project. For postdocs a PhD in physics, materials science, or related fields is a requirement. Candidates with prior experience of SPM, thin-film growth, or 2D materials will be preferred.

Employer

The Max Planck Society is Germany's premier research organization dedicated to basic research and to supporting and developing early career scientists. It offers an excellent infrastructure and a very international environment that enables research at the highest level. The Max Planck Society seeks to increase the number of women in those areas where they are underrepresented and therefore explicitly encourages women to apply.

We offer

- Access to state-of-the-art facilities;
- An open and engaging working environment addressing some of the most impactful problems in the field with the freedom to contribute your ideas to solve high-impact problems;
- Schedule flexibility;
- Remuneration amounting to 65% EG13 TVöD-Bund (PhD) / 100% EG13 TVöD-Bund (Postdoc).

All necessary training will be carried out after admission. The starting date is flexible.

Your application

- For applications and any other questions, please email michael.strauch@mpi-halle.mpg.de with reference to **job code LTSPM-2024** including CV, motivation letter, and two academic reference letters **before 31.05.2024**.
- The Max Planck Institute of Microstructure Physics gives priority to applications from severely disabled candidates with equivalent qualifications.
- For more information, please visit https://www.mpi-halle.mpg.de/.

List of recent publications

- Sessi et al., *Handedness-dependent quasiparticle interference in the two enantiomers of the topological chiral semimetal PdGa.*
  Nature communications **11**, 3507 (2020)
  https://doi.org/10.1038/s41467-020-17261-x
- Zhang et al., *Competing Energy Scales in Topological Superconducting Heterostructures.*
  Nano Letters **21**, 2758-2765, (2021).
  https://doi.org/10.1021/acs.nanolett.0c04648
- Chang et al., *Vortex-Oriented Ferroelectric Domains in SnTe/PbTe Monolayer Lateral Heterostructures.*
  Advanced Materials, **33**, 2102267 (2021).
  https://doi.org/10.1002/adma.202102267
- Küster et al., *Correlating Josephson supercurrents and Shiba states in quantum spins unconventionally coupled to superconductors.*
  Nature communications **12**, 1108 (2021).
  https://doi.org/10.1038/s41467-021-21347-5
- Küster et al., *Long range and highly tunable interaction between local spins coupled to a superconducting condensate.*
  Nature communications **12**, 6722 (2021).
  https://doi.org/10.1038/s41467-021-26802-x
- Brinker et al., *Anomalous excitations of atomically crafted quantum magnets. Science advances **8**, eabi7291 (2022).*
  DOI:10.1126/sciadv.abi7291
- Küster et al., *Non-Majorana modes in diluted spin chains proximitized to a superconductor.*
  Proceedings of the National Academy of Sciences **119**, e2210589119 (2022).
  https://doi.org/10.1073/pnas.2210589119
- Soldini et al., *Two-dimensional Shiba lattices as a possible platform for crystalline topological superconductivity.*
  Nature Physics **19**, 1848–1854 (2023).
  https://doi.org/10.1038/s41567-023-02104-5
- Wagner et al., *Designer-Supraleiter nehmen Form an.*
  Physik unserer Zeit (2024)
  https://doi.org/10.1002/piuz.202401701