Quantum sensing

to enable new energy efficient memory devices

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Qnami – the quantum wave

A pioneer and leader of the quantum revolution

2017: Creation of Qnami
NCCR QSIT Innovation Award

2018: First quantum sensor sold

2019: First quantum microscope sold

2020: Partnership Horiba
Nobel Laureate Prof. A. Fert becomes customer
Fraunhofer becomes a customer

2021: Partnership IMEC
EIC Accelerator grant (2.5M EUR)

2022: Team reaches 20 people

2023: First Turnkey SNVM for LT will be delivered

Location: Basel, Switzerland
Team size: 20
Patents: 7
Quantum experience: 100 years
Funds raised (Equity & grants): $ 11M+

Strategic partnerships:

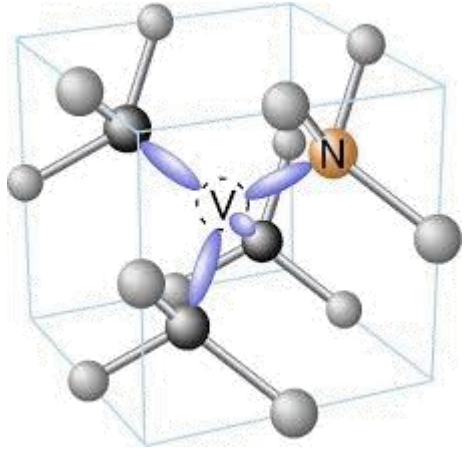
UNI BASEL
elementsix a De Beers Group Company
imec
HARVARD
cnrs
Fraunhofer
HORIBA Scientific
PAUL SCHERRER INSTITUT PSI

qnami

Qnami technology: NV center in diamond

Nitrogen Vacancy Center in Diamond

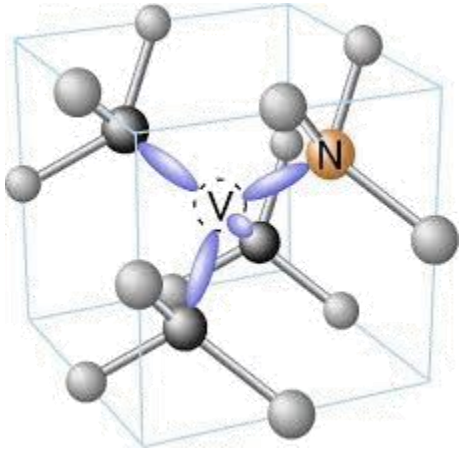
Trapping electron from the CB,
→ negatively charged NV-

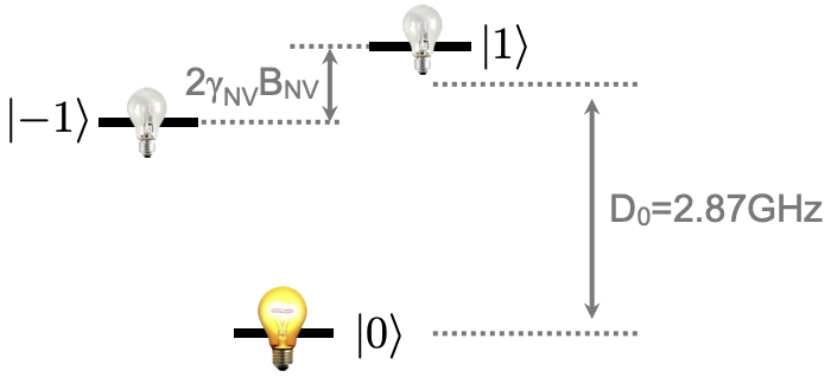


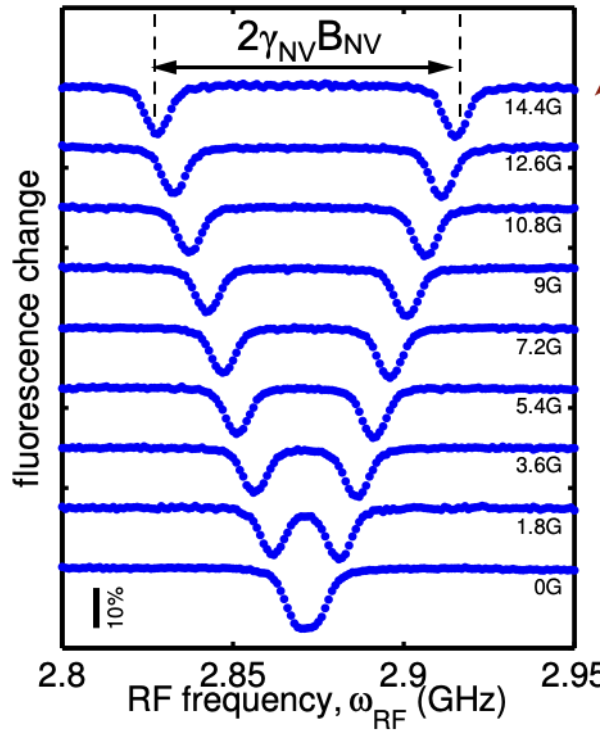
- ✓ Quantum sensors
- ✓ Scalable fabrication

Qnami technology: NV center in diamond

The NV center in diamond: an atomic compass with ultra-high sensitivity







Atomic size provides
ultimate spatial resolution

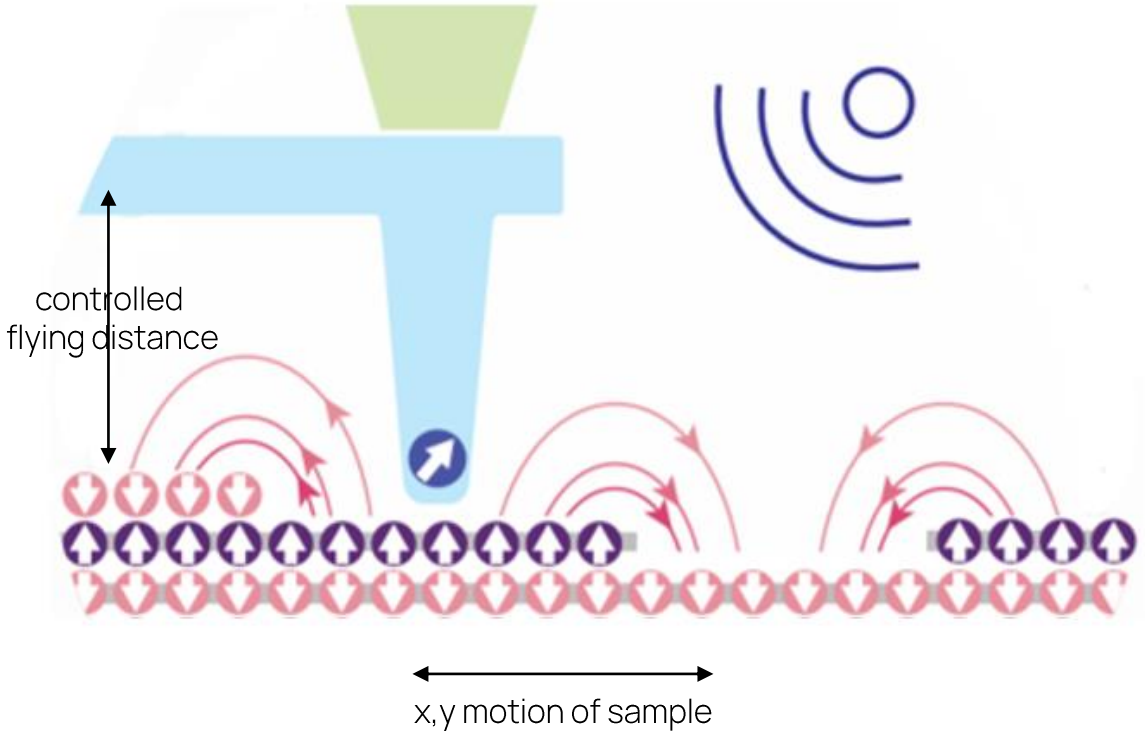
Quantum system provide
ultra high sensitivity

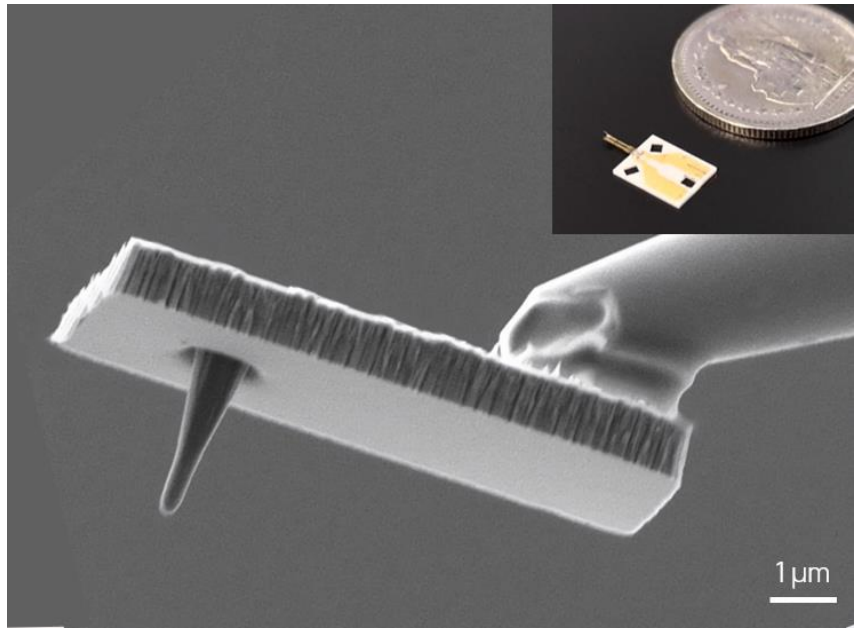
Fundamental constants provides
reliable analytics

High resolution magnetic imaging

Principle of Scanning NV microscopy

Combination of ODMR spectroscopy and non-contact Scanning Probe Microscopy





The Quantilever, Tuning fork based full diamond SPM probe, contains a single defect

Qnami Quantilever™ and ProteusQ™

The first commercial NV probes and scanning NV microscope

01

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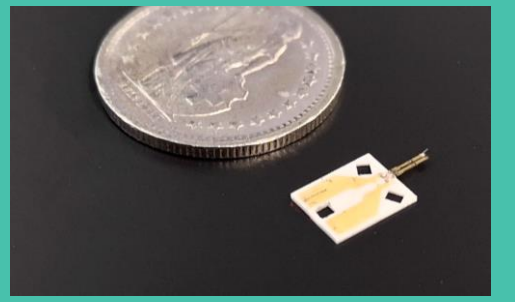
Quantilever™



Quantum sensor made with NV centres for custom scanning NV microscopy applications

02

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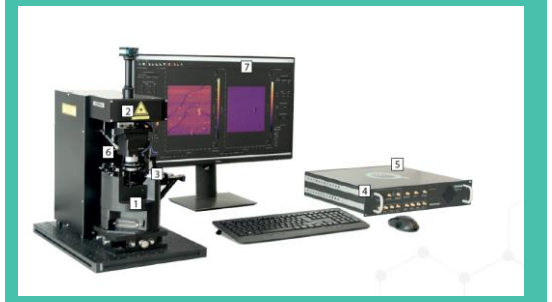
Qnami ProteusQ™



The first scanning NV microscope for the analysis of magnetic materials at the atomic scale

03

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App Lab

A pilot lab offering quantum microscopy services

04

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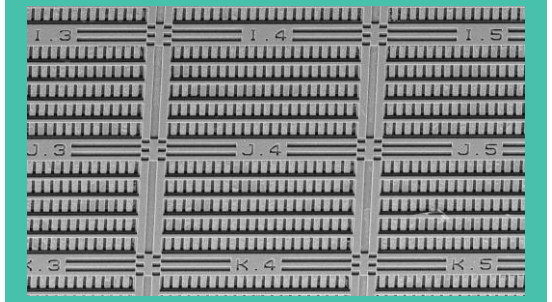
Quantum Foundry



Foundry services for diamond materials and quantum applications

Quantum metrology already used in research

Qnami customers at the cutting edge of science

PHYSICAL REVIEW APPLIED **13,** 044079 (2020)

Editors' Suggestion

Room-Temperature Skyrmions at Zero Field in Exchange-Biased Ultrathin Films

K. Gaurav Rana,[1] A. Finco,[2] F. Fabre,[2] S. Chouaieb,[2] A. Haykal,[2] L. D. Buda-Prejbeanu,[1] O. Fruchart,[1] S. Le Denmat,[3] P. David,[3] M. Belmeguenai,[4] T. Denneulin,[5] R. E. Dunin-Borkowski,[5] G. Gaudin,[1] V. Jacques,[2,*] and O. Boulle[1,†]

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Forschungszentrum Jülich, 52425 Jülich, G

(Received 24 January 2020; accepted 30 March 2020; p

We demonstrate that magnetic skyrmions with a mean diameter arou
temperature and zero external magnetic field in an exchange-biased P
stack. This is achieved through an advanced optimization of the mul
to balance the different magnetic energies controlling the skyrmion siz
is performed both with magnetic force microscopy and scanning nit
latter providing unambiguous measurements at zero external magneti
that exchange bias provides an immunity of the skyrmion spin textu
field perturbations, in the tens-of-millitesla range, which is an impor
as memory devices. These results establish exchange-biased multilay
toward the effective realization of memory and logic devices based on

nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-020-15501-8 OPEN

Check for updates

Antiferromagnetic textures in $BiFeO_3$ controlled by strain and electric field

A. Haykal[1,9], J. Fischer[2,9], W. Akhtar[1,8], J.-Y. Chauleau[3], D. Sando[4], A. Finco[1], F. Godel[2], Y. A. Birkhölzer[5], C. Carrétéro[2], N. Jaouen[6], M. Bibes[2], M. Viret[3], S. Fusil[2,7✉], V. Jacques[1] & V. Garcia[2]

NANO LETTERS

pubs.acs.org/NanoLett

Letter

Probing Magnetic Defects in Ultra-Scaled Nanowires with Optically Detected Spin Resonance in Nitrogen-Vacancy Center in Diamond

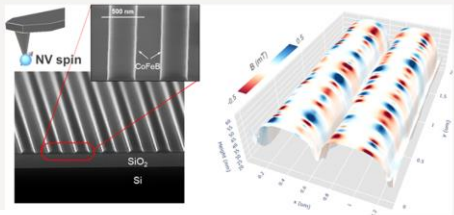
elano,* Hai Zhong, Florin Ciubotaru, Laurentiu Stoleriu, Alexander Stark, Peter Rickhaus, ro de Oliveira, Mathieu Munsch, Paola Favia, Maxim Korytov, Patricia Van Marcke, letinsky, Christoph Adelmann, and Paul van der Heide

https://doi.org/10.1021/acs.nanolett.1c03723

Read Online

Metrics & More | Article Recommendations | Supporting Information

Magnetic nanowires (NWs) are essential building ntronics devices as they offer tunable magnetic l anisotropy through their geometry. While the compositional control of NWs have seen major considerable challenges remain for the character- al magnetic features at the nanoscale. Here, we onperturbative field distribution mapping in ultra- ic nanowires with diameters down to 6 nm by gen-vacancy magnetometry. This enables localized, sive magnetic imaging with sensitivity down to 3 μT



nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-021-22239-4 OPEN

Check for updates

Magnetic domains and domain wall pinning in atomically thin $CrBr_3$ revealed by nanoscale imaging

Qi-Chao Sun[1,8✉], Tiancheng Song[2,8], Eric Anderson[2], Andreas Brunner[1], Johannes Förster[3], Tetyana Shalomayeva[1], Takashi Taniguchi[4], Kenji Watanabe[4], Joachim Gräfe[3], Rainer Stöhr[1,5✉]

nature materials

LETTERS

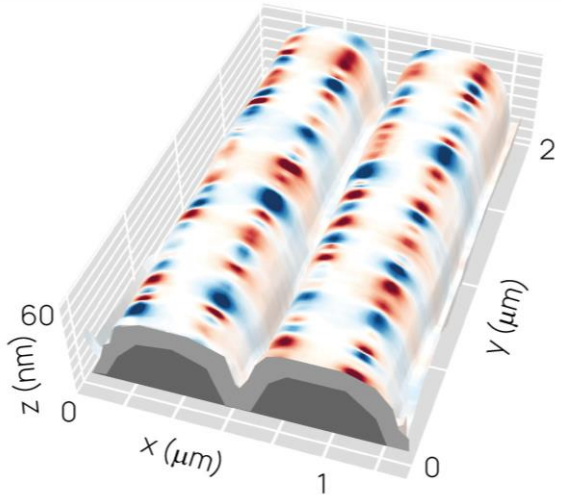
https://doi.org/10.1038/s41563-019-0516-z

Electric and antiferromagnetic chiral textures at multiferroic domain walls

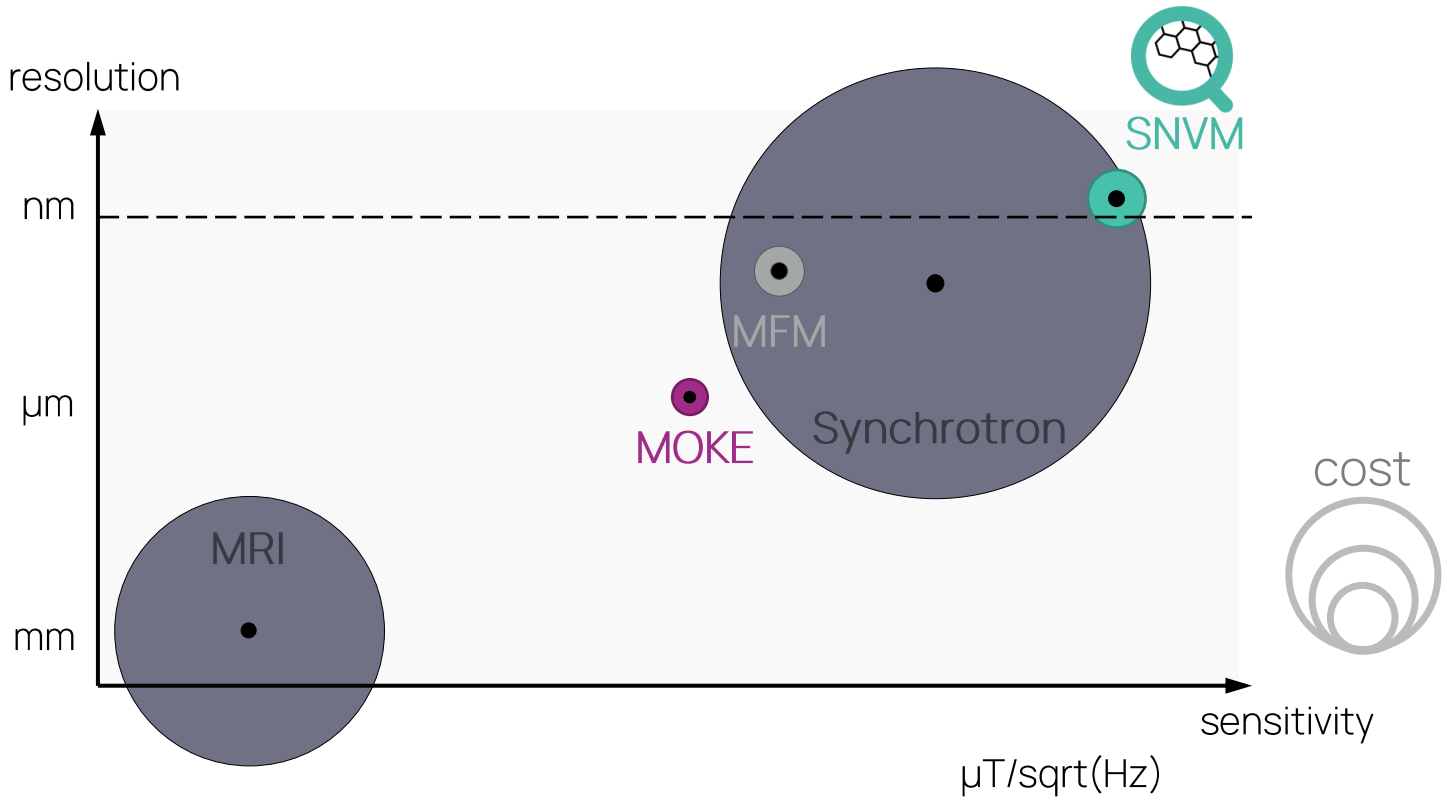
J.-Y. Chauleau[1,2], T. Chirac[1], S. Fusil[3,4], V. Garcia[3], W. Akhtar[5], J. Tranchida[6,9], P. Thibaudeau[6], I. Gross[5], C. Blouzon[1], A. Finco[5], M. Bibes[3], B. Dkhil[7], D. D. Khalyavin[8], P. Manuel[8], V. Jacques[5], N. Jaouen[2] and M. Viret[1*]

SNVM: Ideal quantum sensing

Relevance of measurements



- Unexpected magnetic inhomogeneity of nanowire
- Potential DW pinning sites
- Reduce inhomogeneities for more efficient RTM operation



Celano, U., … P. Rickhaus,… Paul von der Heide, Nano Lett. 2021, 21, 24, 10409−10415

MRAM

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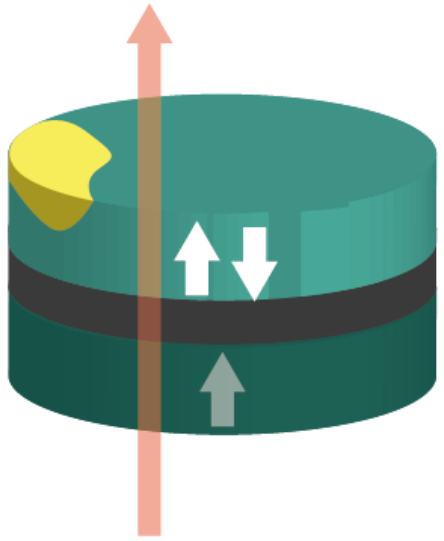
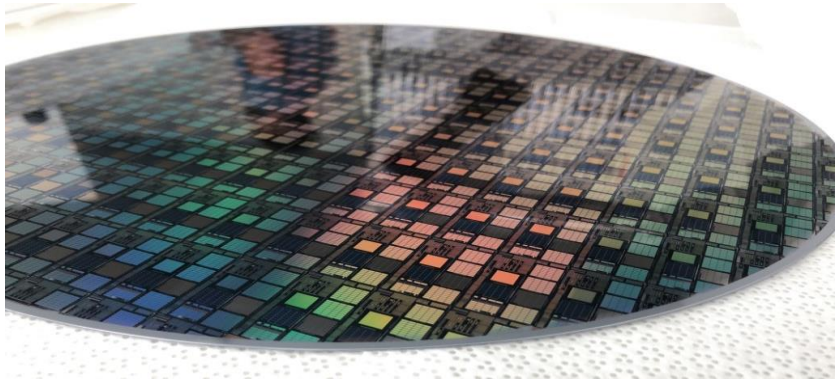
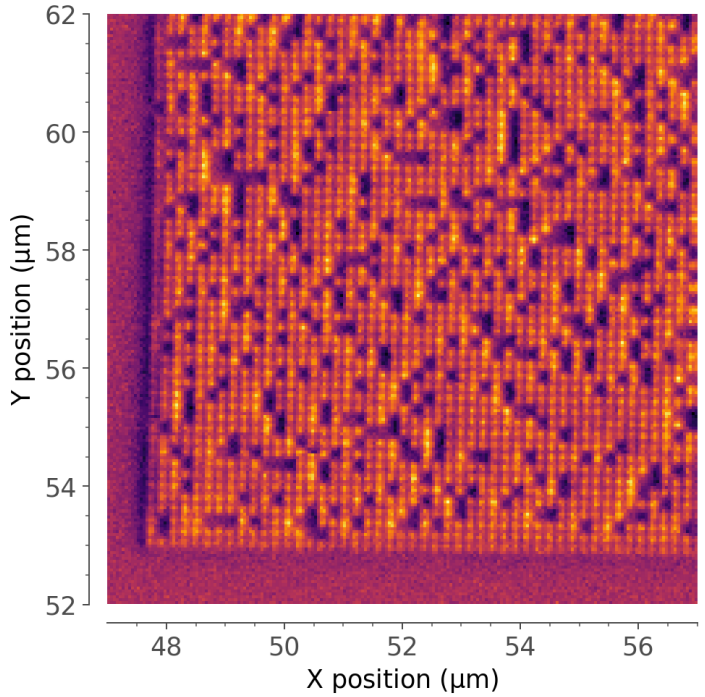
Characterize magneticswitching behavior without the need of electrical contact

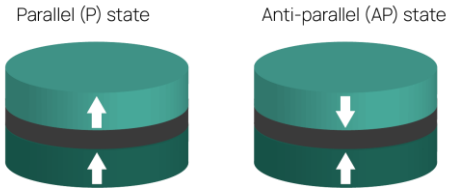


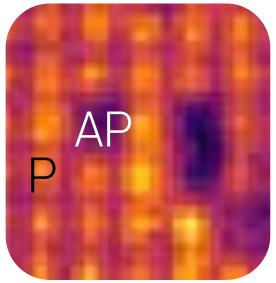
Application to embedded MRAM

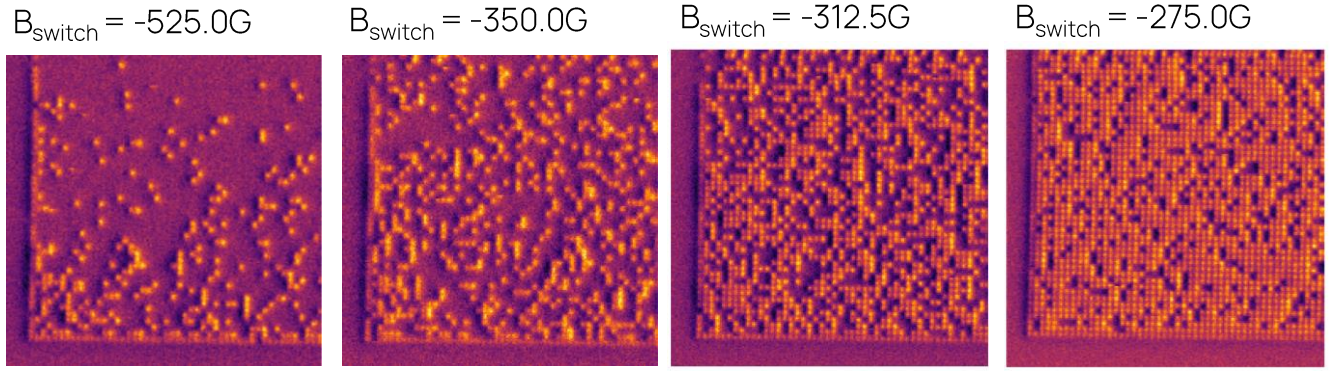
- Manufacturing via multistep process
- Metrology well defined for dimensional properties and layer thickness
  BUT not magnetic properties
- Typically, only possible to measure contacted bits







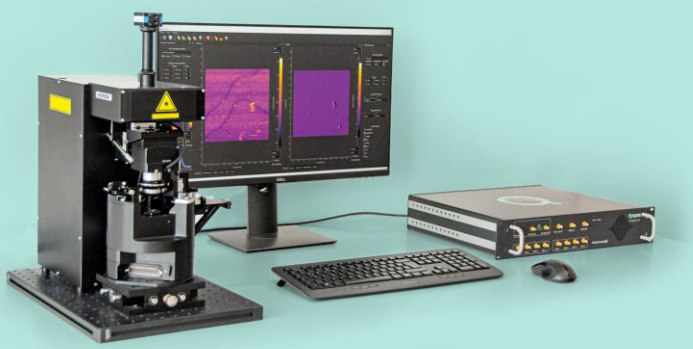




Summary and Outlook

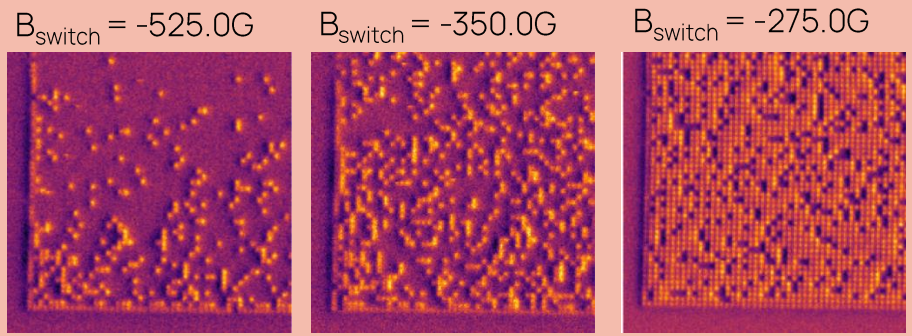
On the technology

- NVs can be used as quantum sensor with high sensitivity and resolution at RT to measure magnetic field
- SNVM moved beyond the lab and that there are turn-key instruments available
- Extending measurement capabilities beyond current limits



SNVM for Memory Devices

- Extending the tools set for process metrology
- Sensitivity and resolution at RT allow to noninvasive measurement of individual bits
- Integration into manufacturing process to correlate defects to critical process step



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qnami

the quantum wave

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