Qnami

the quantum wave

Advancing research and materials science with quantum metrolog

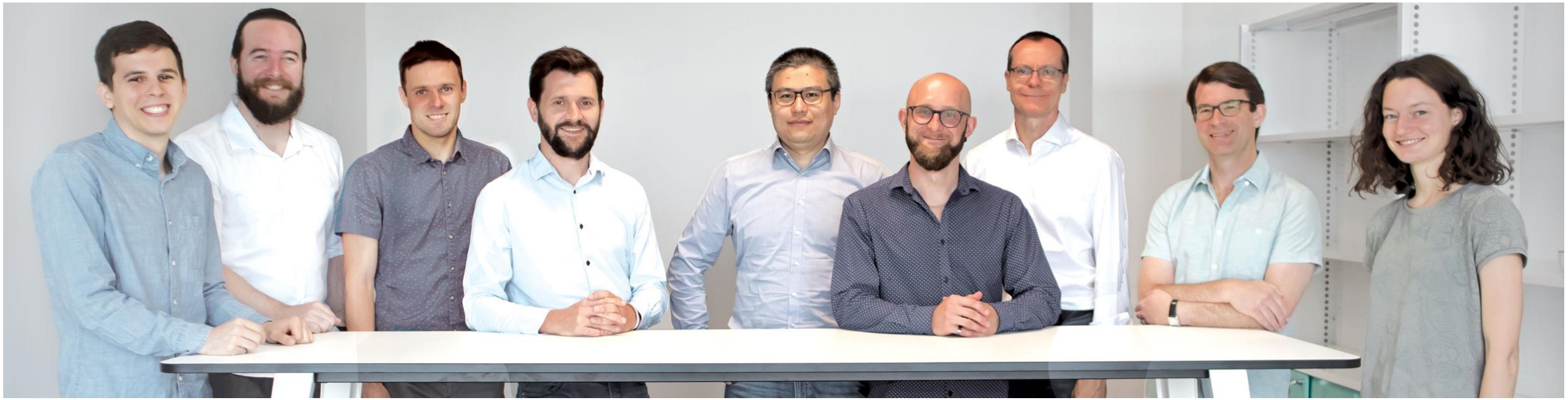
Felipe Favaro de Oliveira

Co-founder and CTO

Qnami AG – Switzerland

www.qnami.ch

Swiss Photonics, Quantum Photonics Basel – 28.10.2021



Qnami

the quantum wave

- Founded in Nov 2017; roots at University of Basel
- HQ in Basel (CH), new offices in Stuttgart (DE)
- 15 people, 11 PhD
- 60 years experience in quantum tech
- First products in the market since 2019
- International partnerships

UNI BASEL

imec

HORIBA Scientific

cnrs

HARVARD

Fraunhofer

PAUL SCHERRER INSTITUT PSI

elementsix™ a De Beers Group Company

The present of computing

Current computing paradigms are reaching their limits

By 2025

41.6 billion

devices in the IoT generating
79 zettabytes of data

By 2030

>20%

of the world's electricity
will be used for ICT

The cost of fab is raising

>13%

every year as Moore's law
slows down

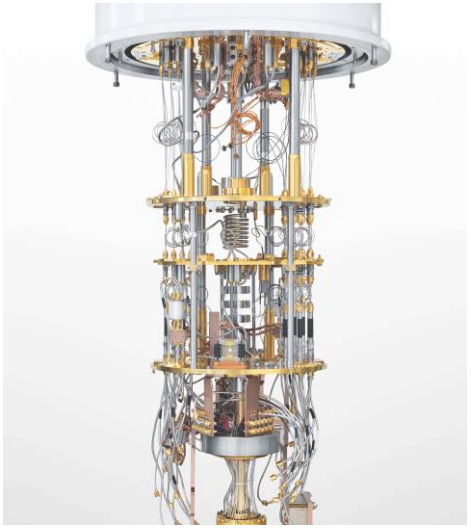
The future of computing

New technologies to reconcile performance with lower energy footprint

Spintronics-MRAM

Memory storage

- 400x lower energy footprint
- 1000x faster than eFlash
- More stable data storage
- 85% CAGR



Quantum computing

Processing power

- 1000x lower energy footprint
- Simulation of new drugs
- Network optimization
- €20bn of public investment

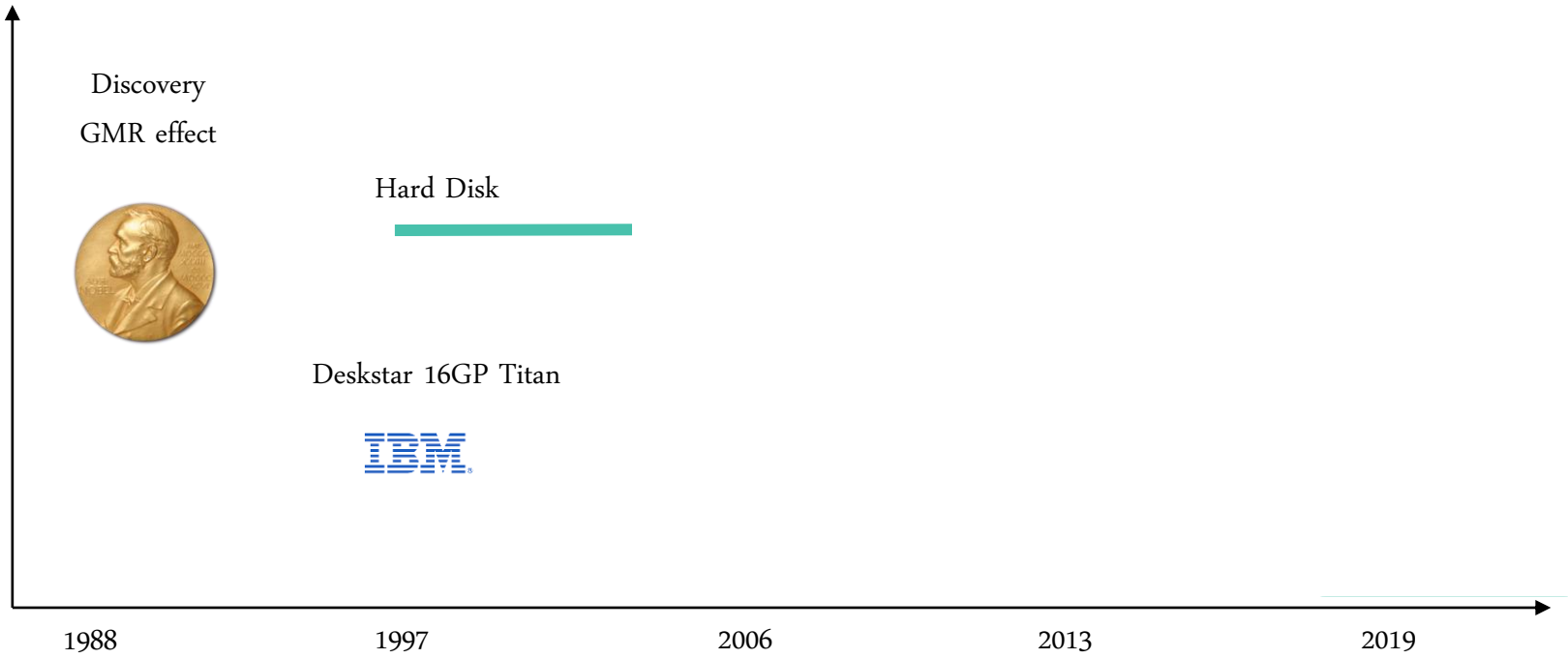
But the right quality control tools are missing!

Having the right metrology tools bring a competitive advantage

For researchers: pushing science and the understanding of novel materials, physics and devices

THALES

Prof. Albert Fert, Thales-CNRS, Nobel Prize winner



Challenge is measuring **very small magnetic fields** to understand the technology

Having the right metrology tools bring a competitive advantage

For R&D in industry, faster development for a head start in a competitive market

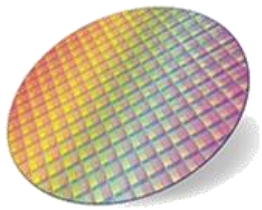
Use Case: e-MRAM

- Non-volatile memory
- Miniaturization:
  => Bit size: 10-50 nm
- New magnetic materials
  => Switching time
  => Endurance

tsmc

SAMSUNG

Wafer production → Front end engineering → Back-end engineering → Packaging



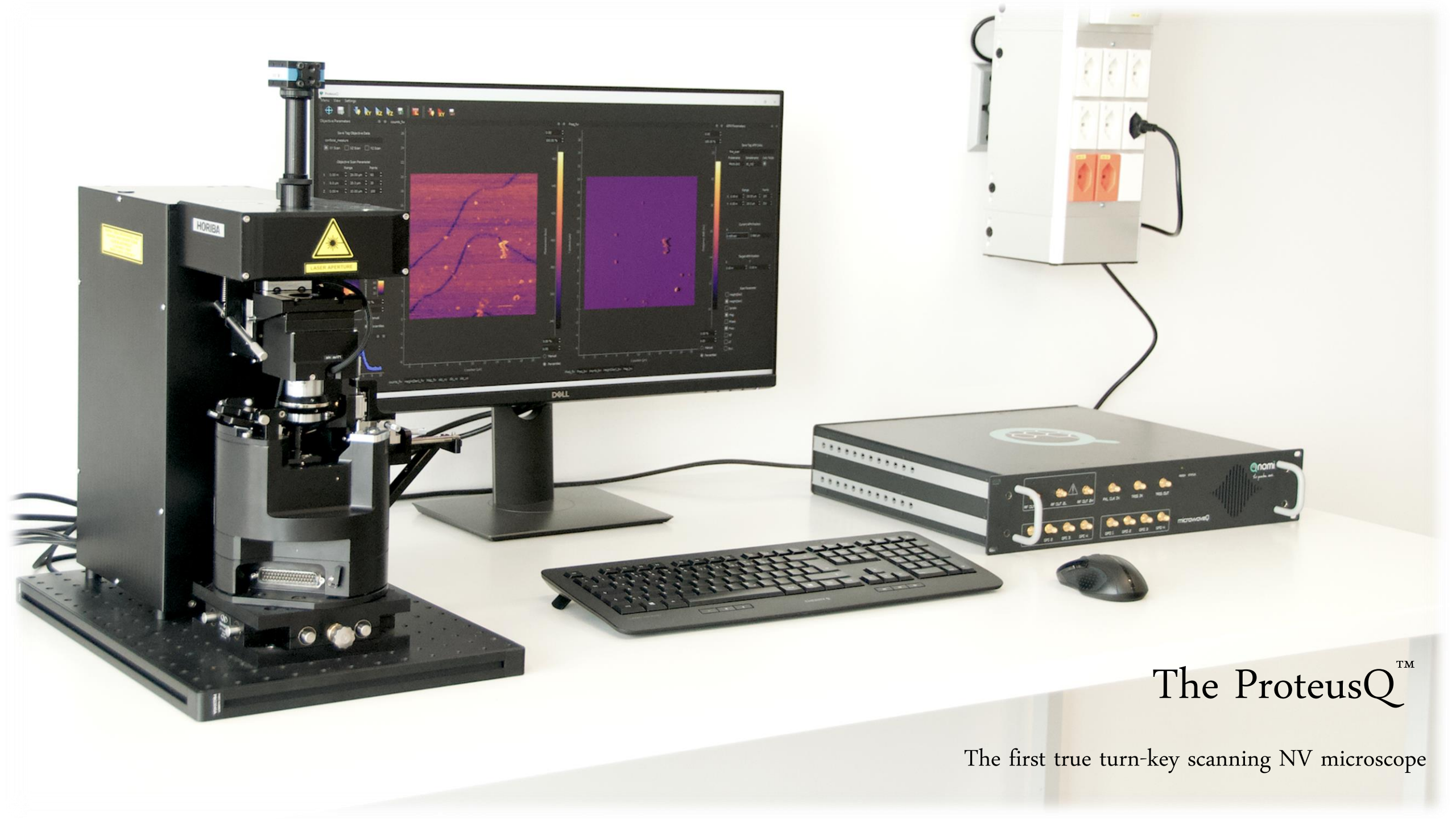
R&D phase:

(avg. time of 48 months)

1 month
100x in price
100x iterations (**trial and error**)

Product ready for market

Challenge is measuring **very small magnetic fields** to understand the technology



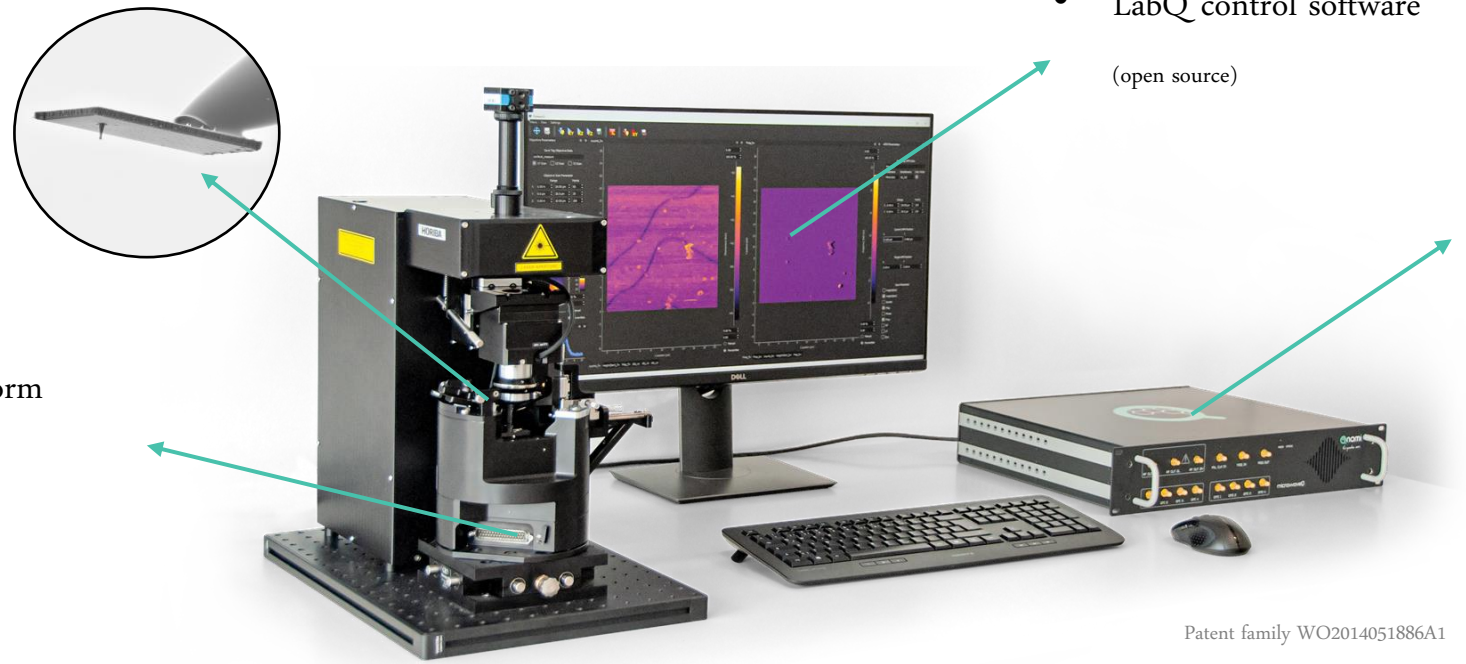
The ProteusQ™

The first true turn-key scanning NV microscope

The Qnami ProteusQ™

The perfect combination of advanced AFM technologies and quantum sensing

- Diamond Quantilever sensor technology
- LabQ control software (open source)
- MicrowaveQ control electronics
- Atomic resolution AFM platform



Patent family WO2014051886A1

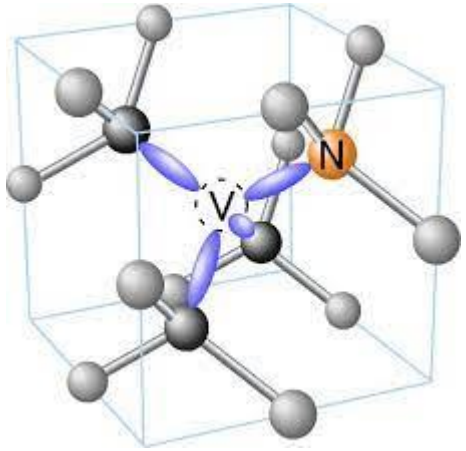
Powered by HORIBA Scientific

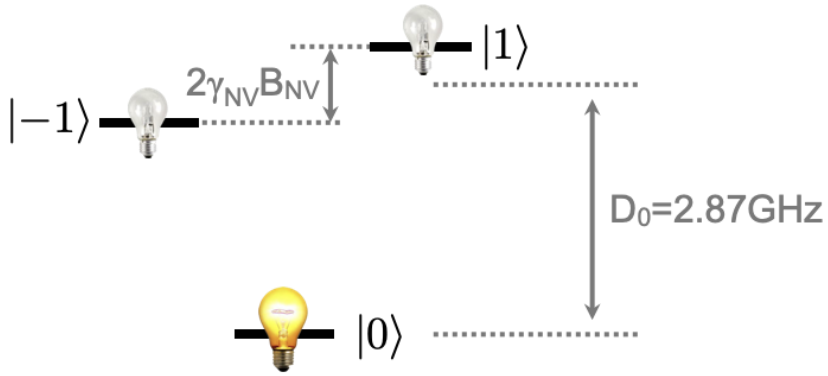
The go-to tool for the characterization of quantum and magnetic materials with unprecedent precision

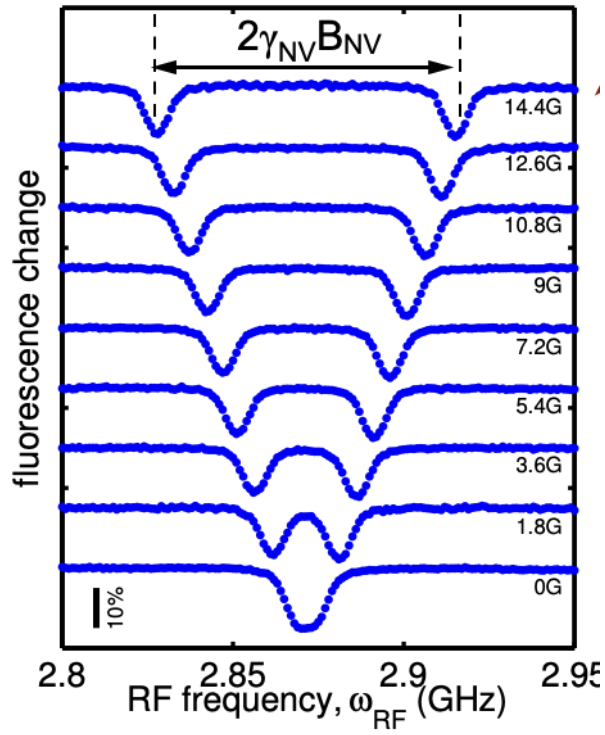
- Magnetic sensitivity ~ 1 $\mu T/Hz^{1/2}$
- Spatial resolution down to ~20nm
- Non-invasive measurements
- LabQ and MicrowaveQ: all you need for quantum sensing

Quantilever technology: engineered defects 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**

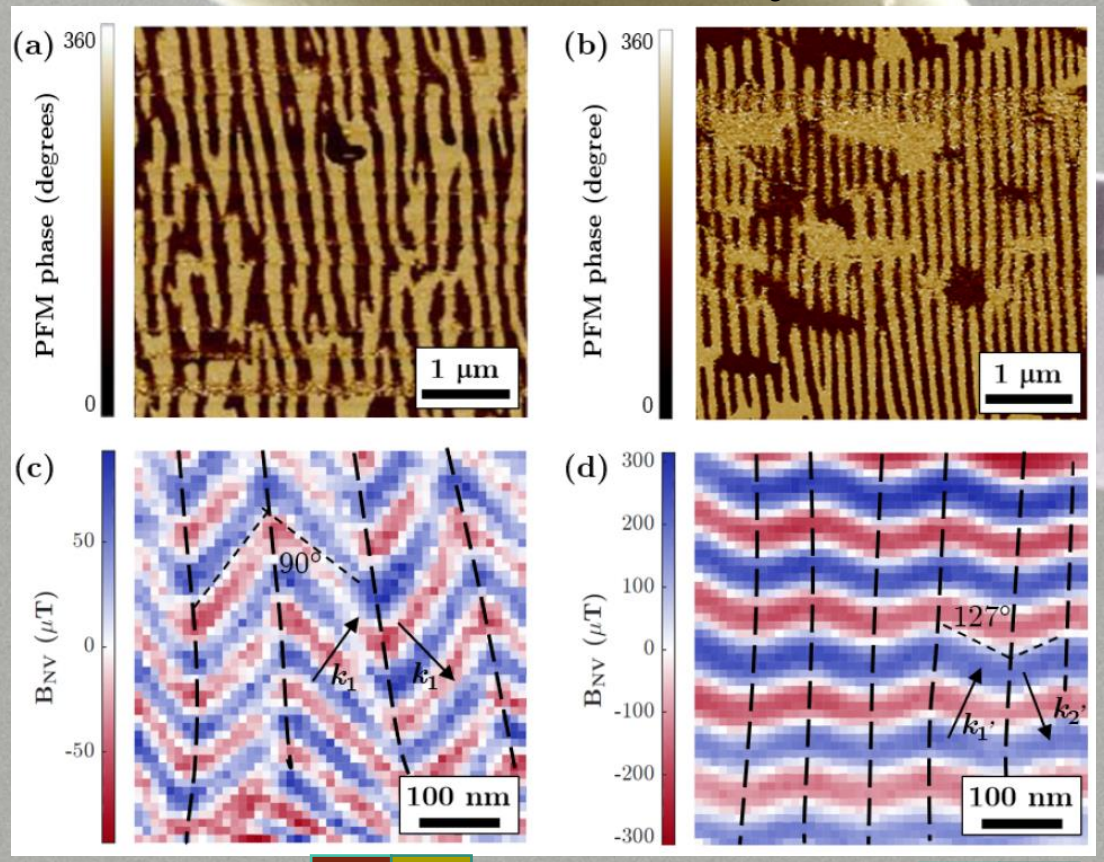
1 um

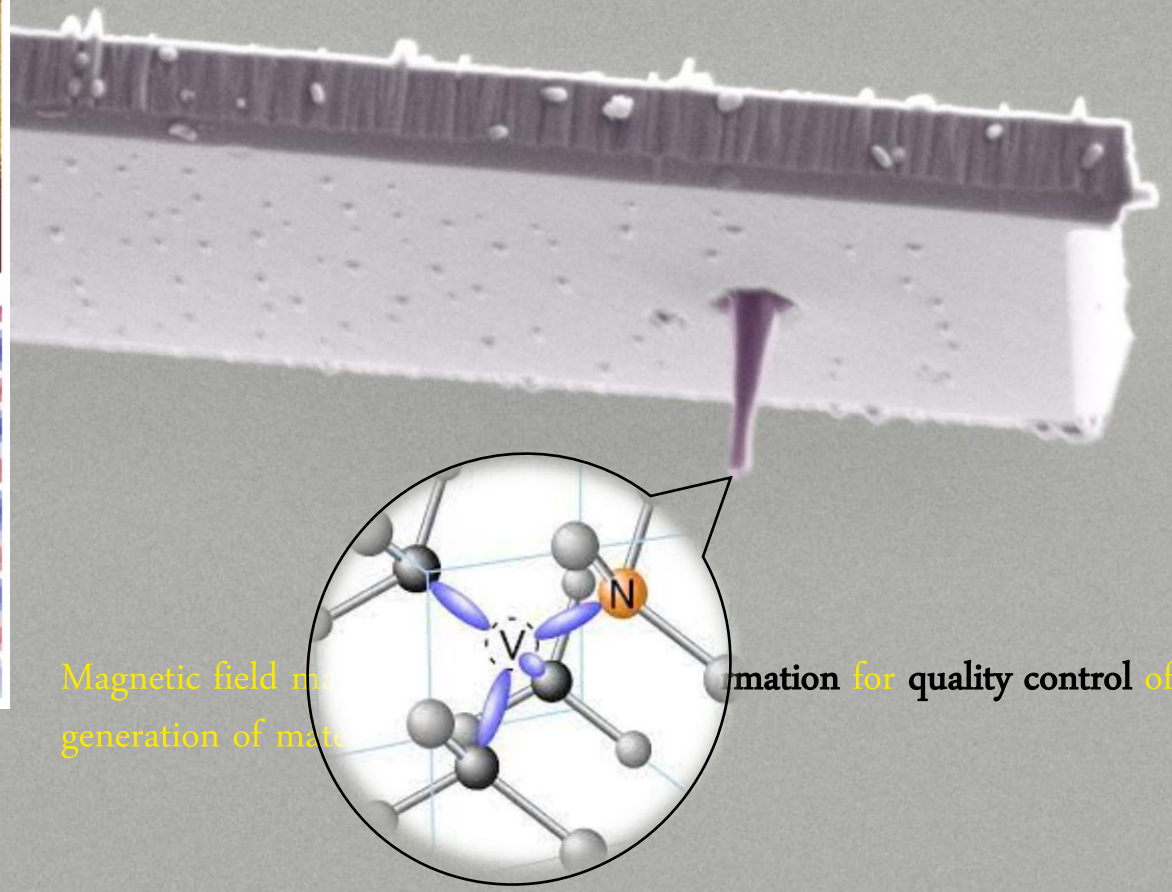
The Quantilever™

A single atomic defect in an all-diamond nano-probe

Low strain level

High strain level





Magnetic field m mation for **quality control** of the next generation of ma

Type 1

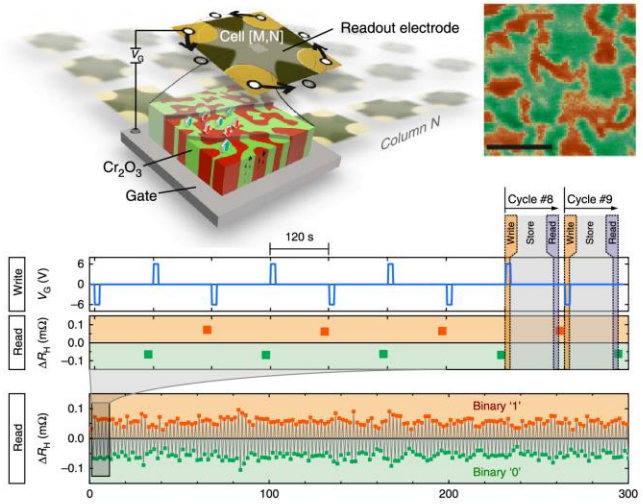
P_3^- P_4^-

Type 2

P_3^- P_4^-

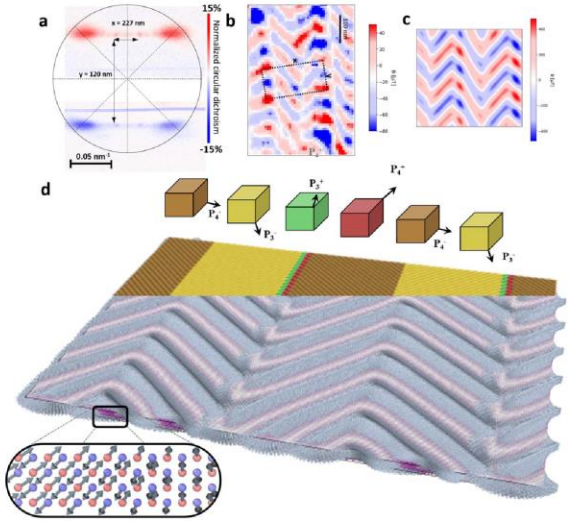
Patent family WO2014051886A1

M-RAM



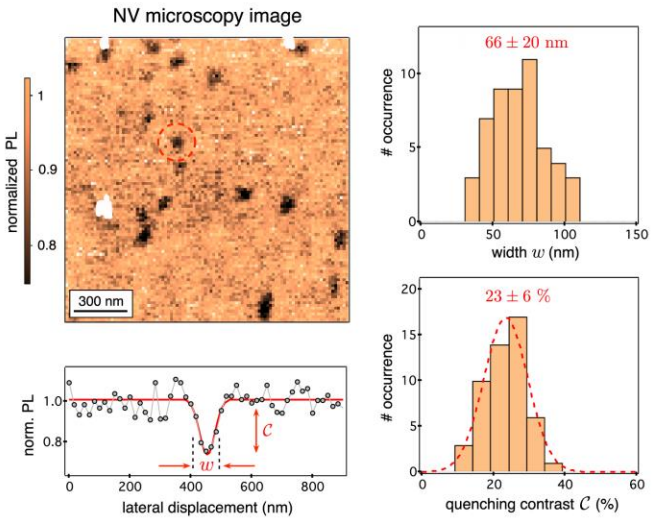
T. Kosub et al, Nature Communications,10.1038/ncomms13985

Multiferroic Antiferromagnets



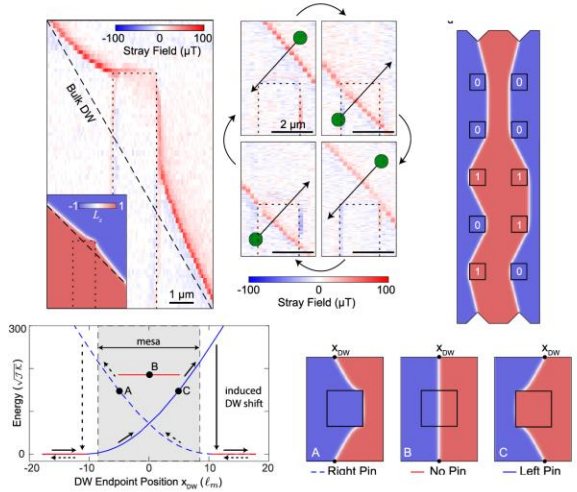
J.-Y. Chauleau et al, Nature Materials,1038/s41563-019-0516-z

Topological Magnetic Skyrmions



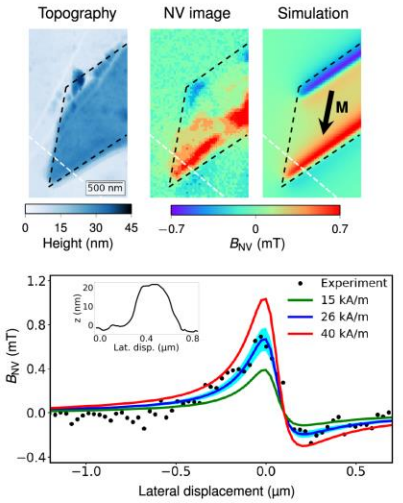
K. Gaurav Rana et al, Physical Review Applied, 10.1103/PhysRevApplied.13.044079

Antiferromagnet bits



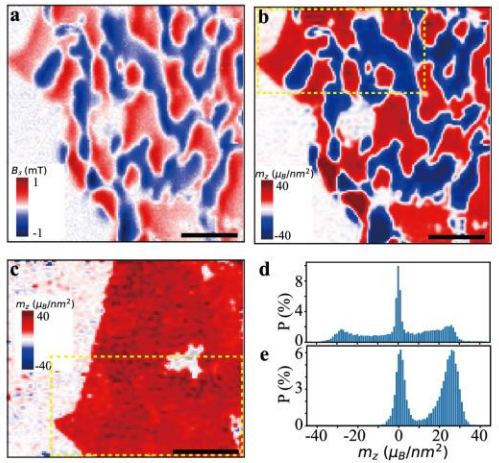
N Hedric et al, Nature Physics, 10.5281/zenodo.3941994

vdW Magnets at RT



F Fabre et al, Physical Review Materials, 10.1103/PhysRevMaterials.5.034008

vdW Magnets at LowT



Q.-C. Sun et al, Nature Communications,10.1038/s41467-021-22239-4

Qnami

the quantum wave

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- Contact our sales for information on our products
- Test your application in our App Lab

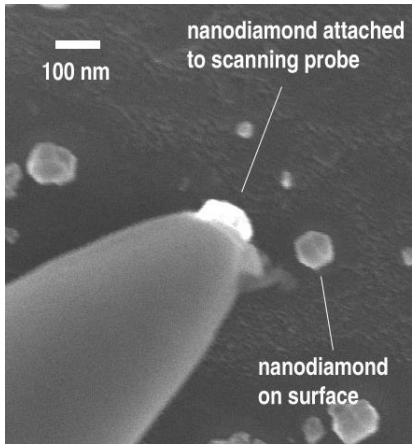
Open positions right now!

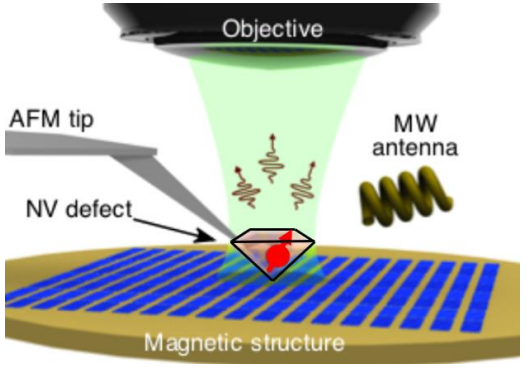
Join the #quantumwave

The Quantilever™

A sensor with improved performance...

First attempts: nano-diamonds attached to AFM tips





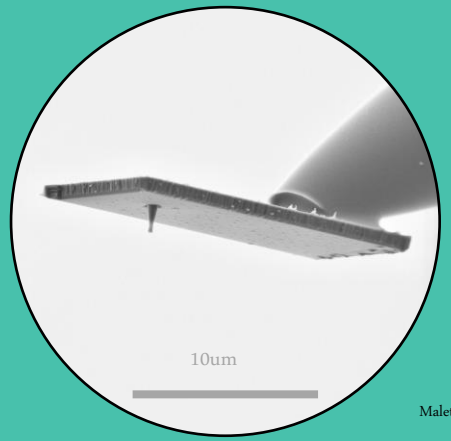
L. Rondin et al, Appl. Phys. Lett. 100, 153118 (2012)

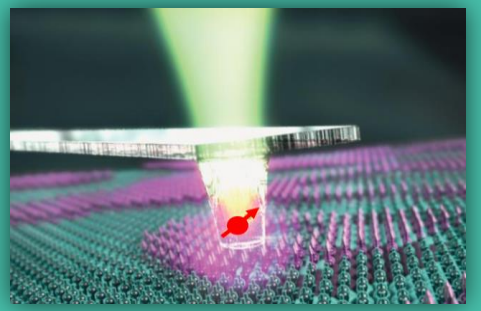
- Poor success rate, no reproducibility
- Resolution > 100 nm (random position of nanodiamond, unknown position of NV within nanodiamond)
- Poor spin properties and inefficient optical read-out limit sensitivity (> 10 µT/Hz$^{1/2}$)

P. Maletinsky et al, Nat.Nano. 7(5), 3120-324 (2012)

WO2014051886A1

The innovation: all-diamond scanning probes





Maletinsky et. al. Nature Nano 7, 320/ Patent US20150253355A1

- High level of control, excellent reproducibility
- High resolution < 50nm (limited only by NV depth)
- Excellent spin properties (coherence) and optical waveguide improves sensitivity (1 µT/Hz$^{1/2}$)