MSE-494
Quantum materials: fundamentals and applications

Gregor Jotzu
Dynamic Quantum Materials Laboratory

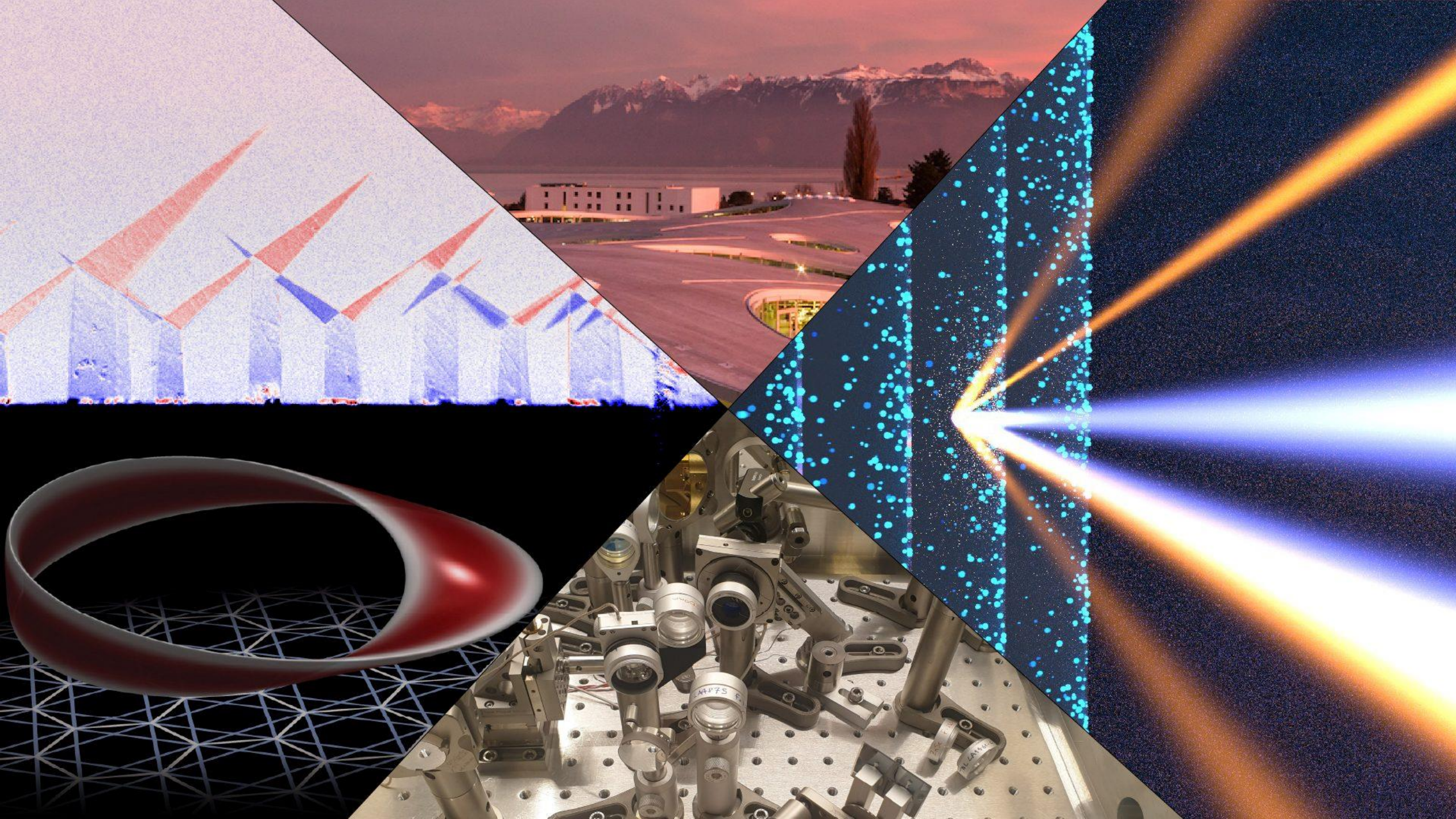
The Team

Louis Gobber

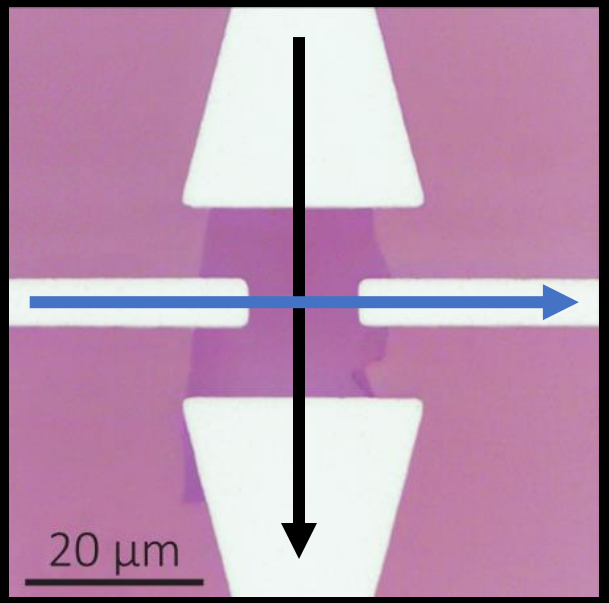
Martin Luttmann

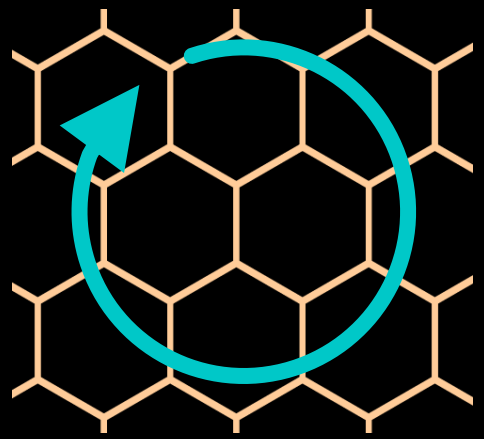
Dynamic Quantum Materials Laboratory

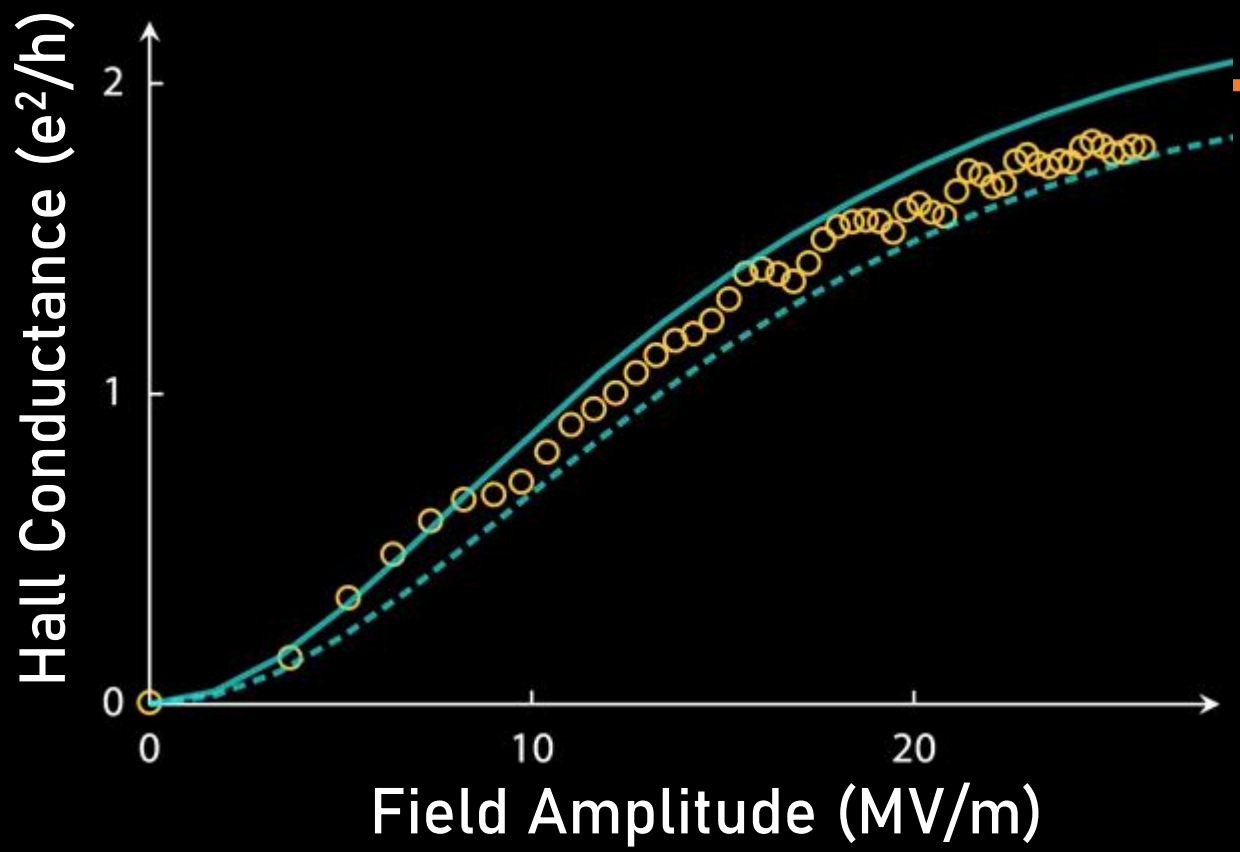
Dynamic quantum materials laboratory



Light-induced Hall Effect



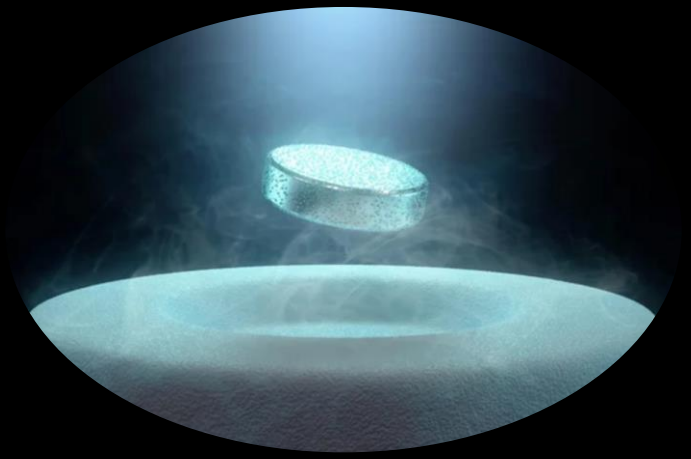


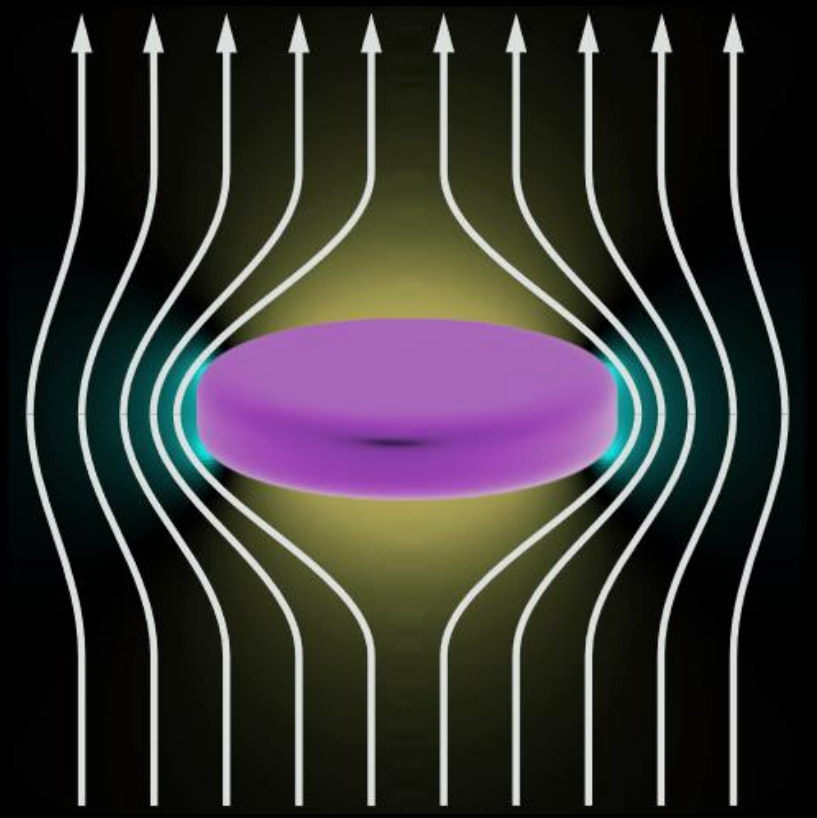


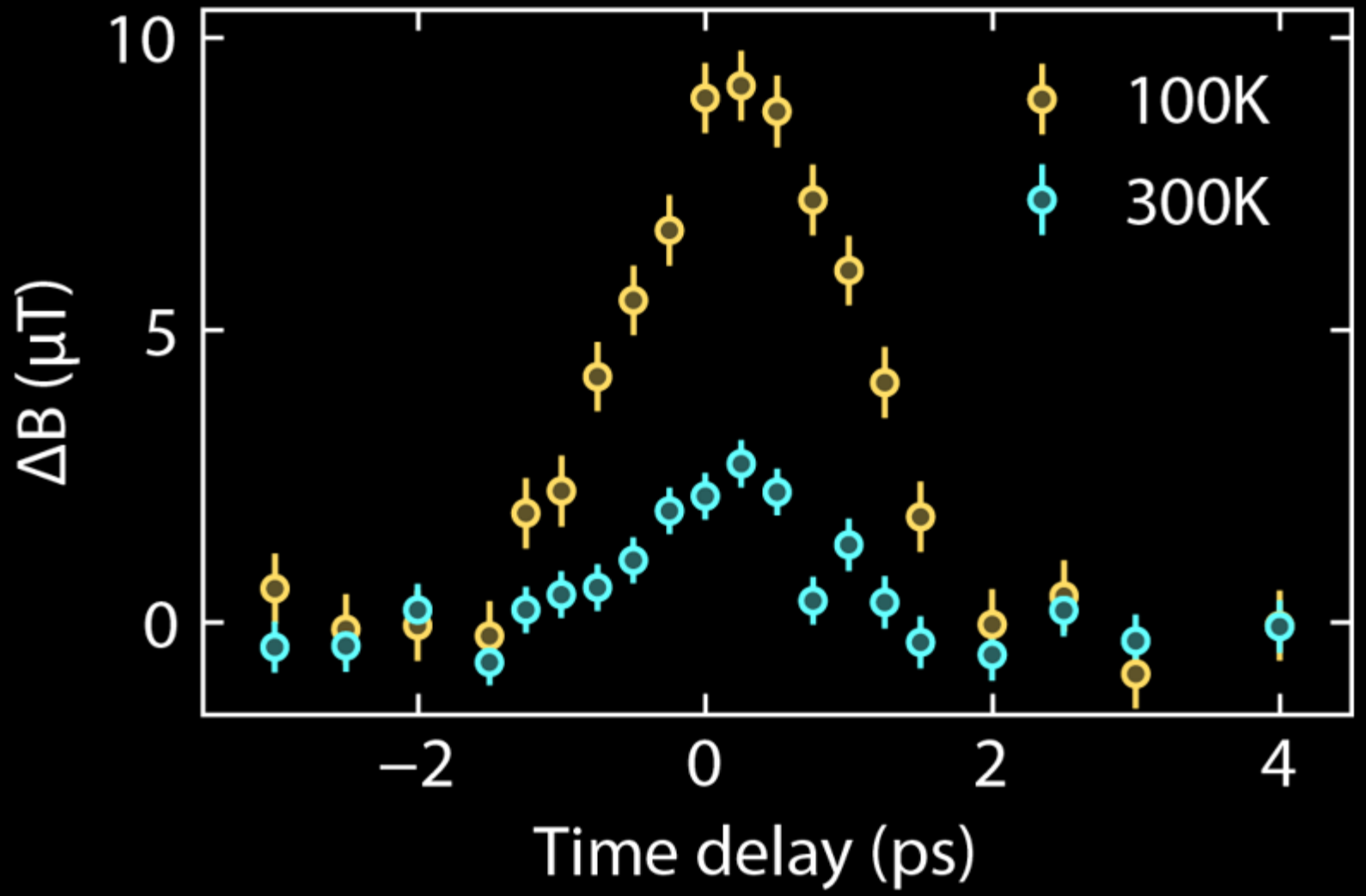
Would normally require ~10 Tesla!

Nature Physics 16, 38 (2020)

Light-induced Superconductivity







MSE-494
Quantum materials: fundamentals and applications

The participants (i.e. You)

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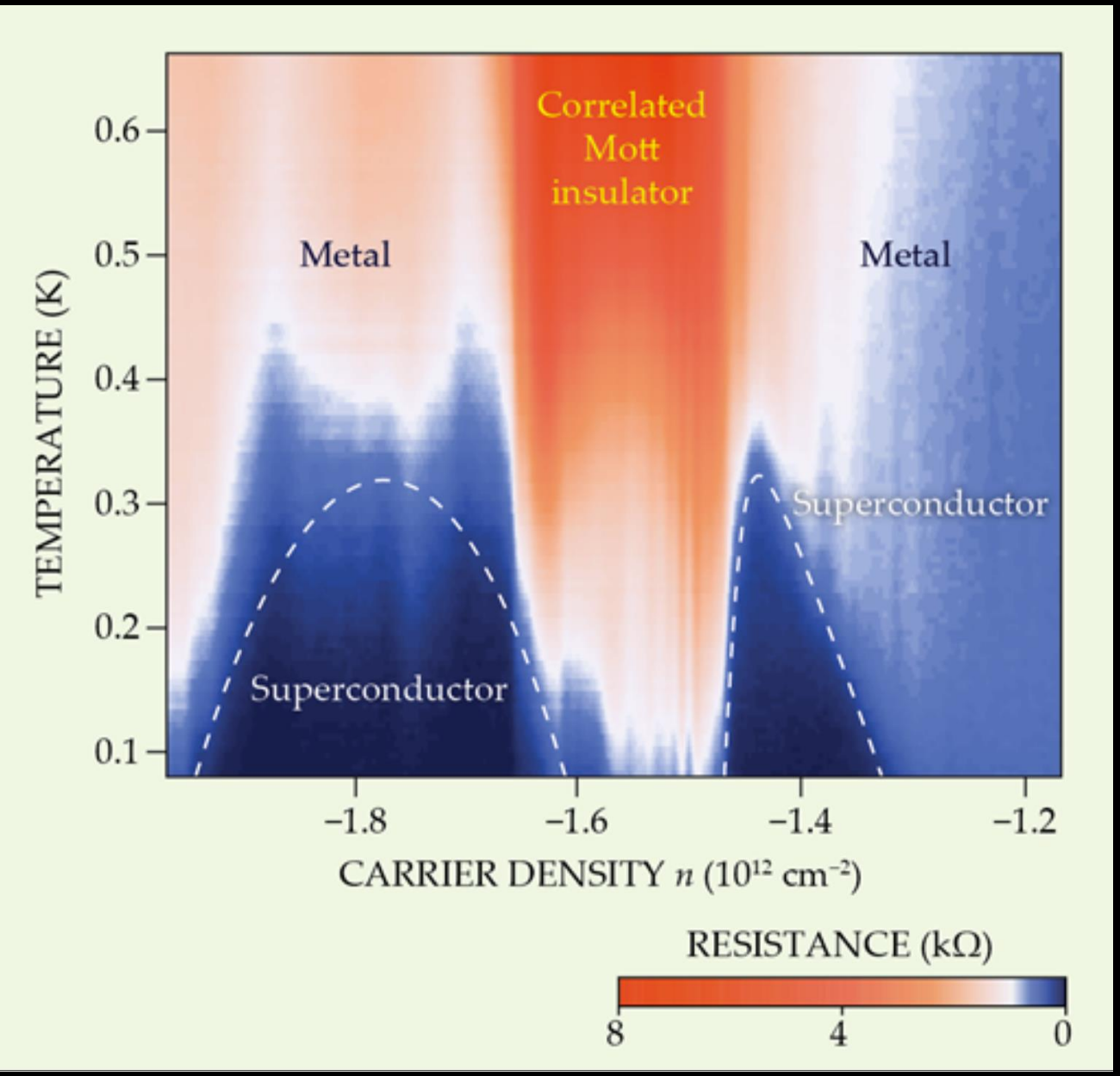
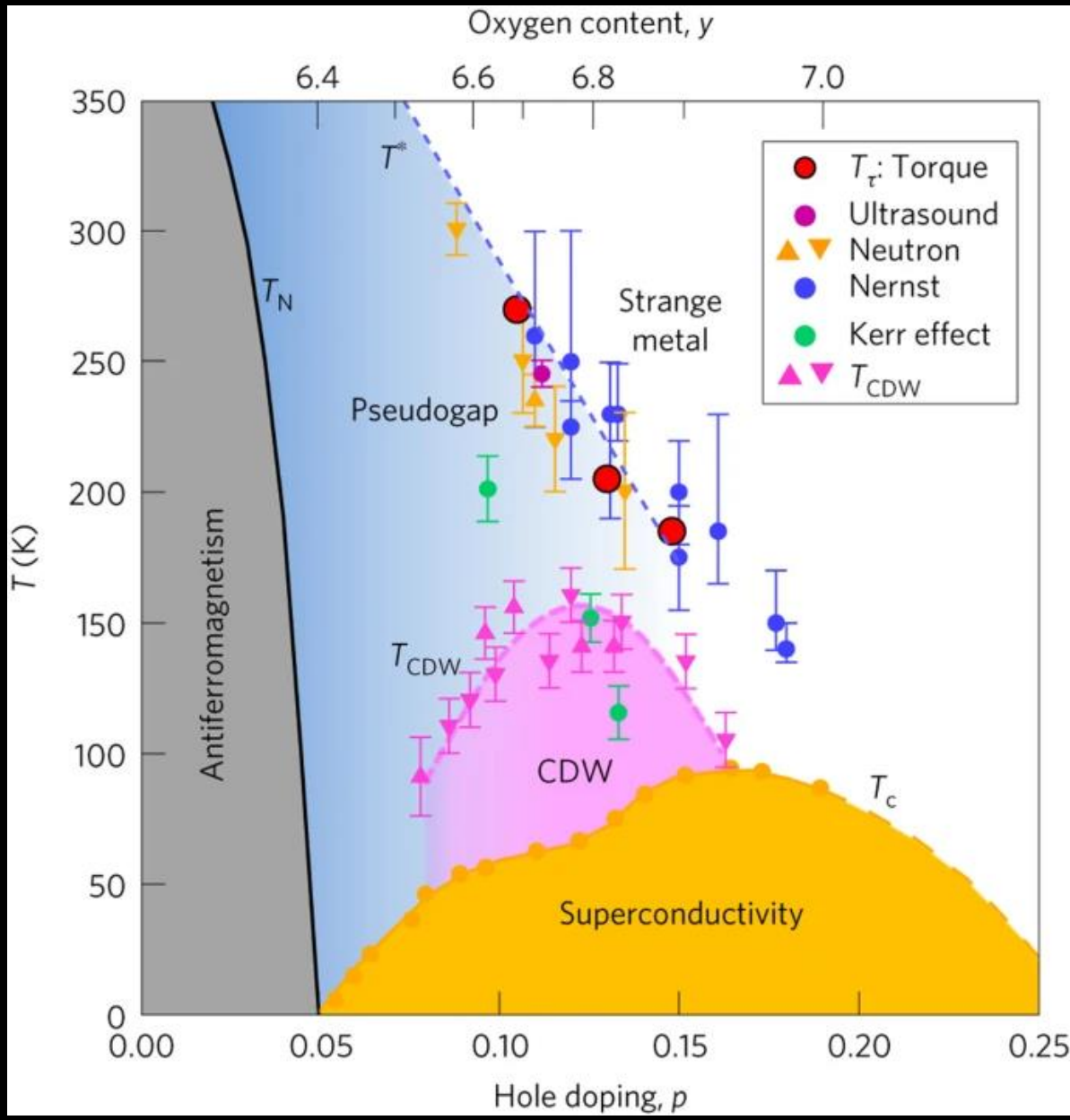
Quantum materials: fundamentals and applications

Rich phase diagrams

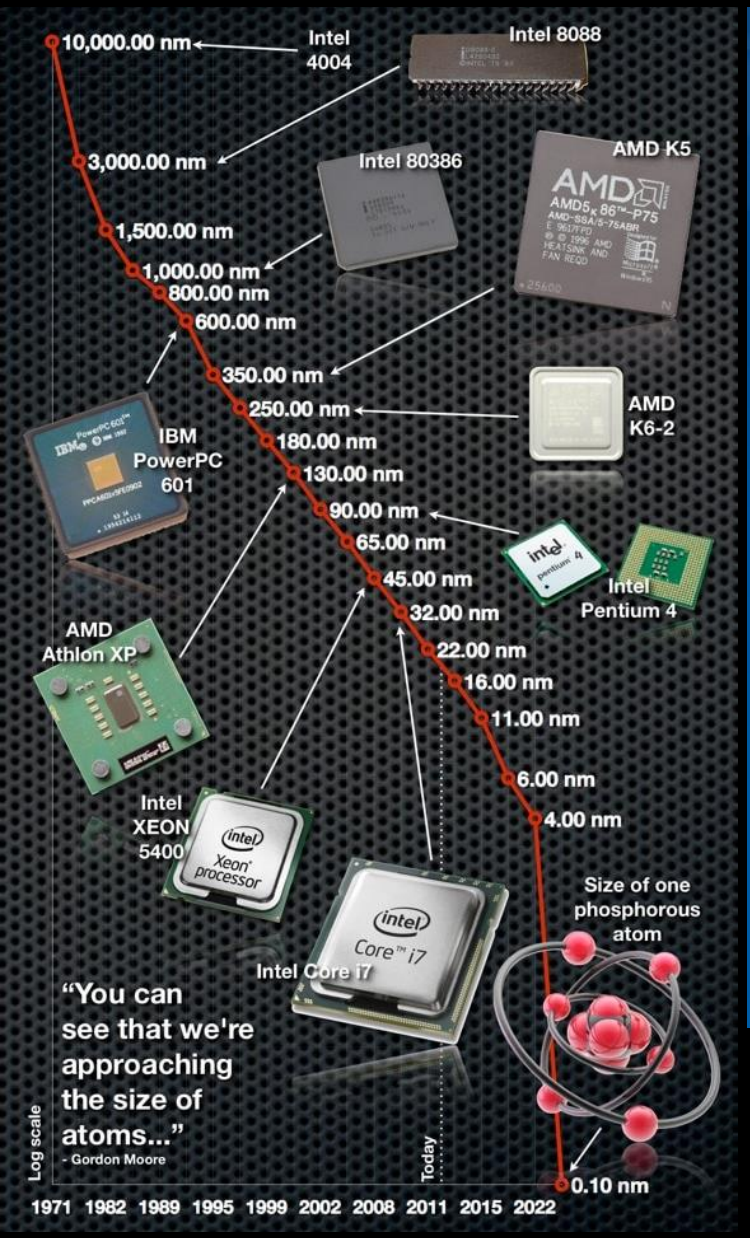


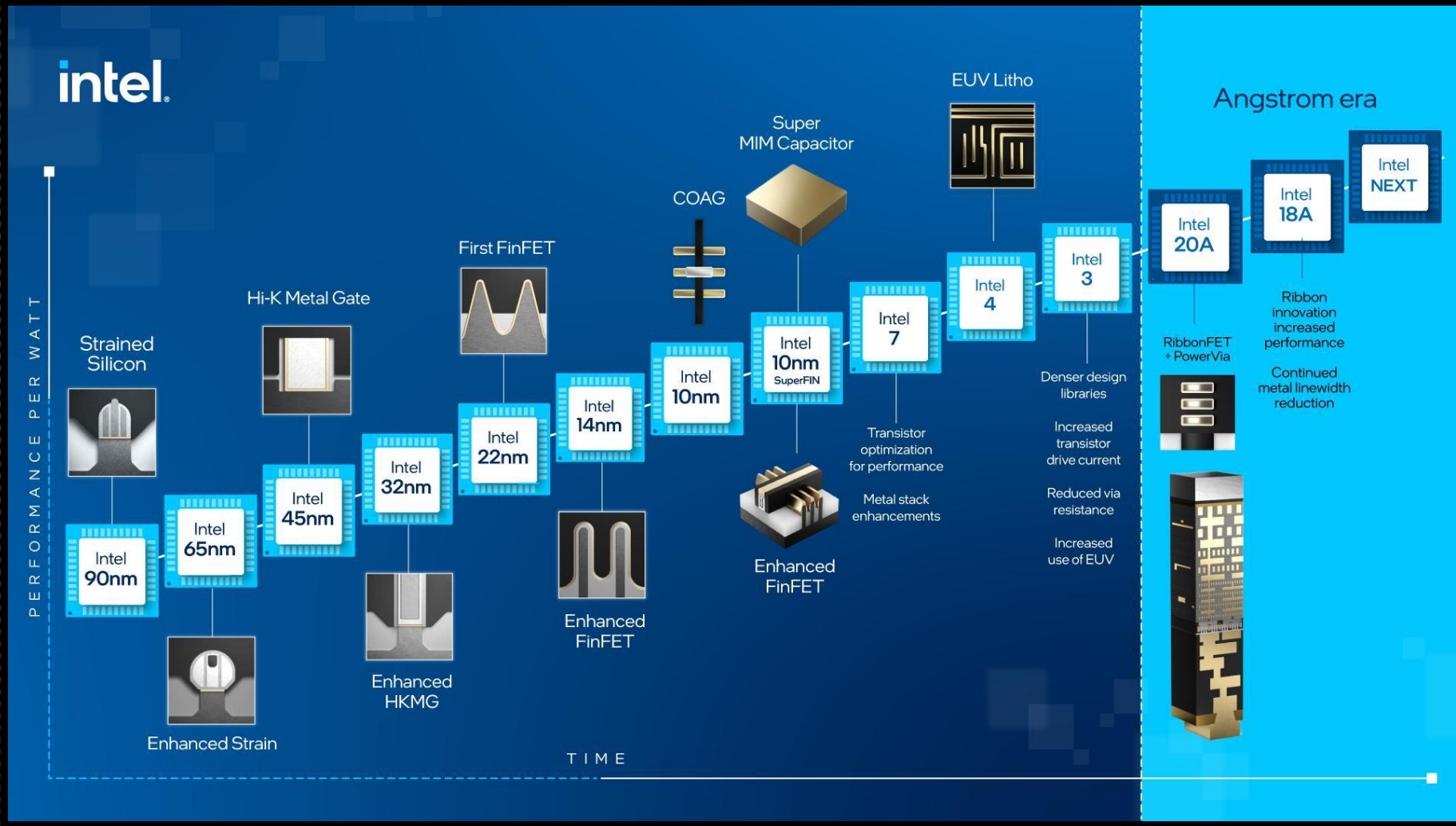


Physics Today **77** (4), 38–44 (2024)

Nature Phys **13**, 1074–1078 (2017)

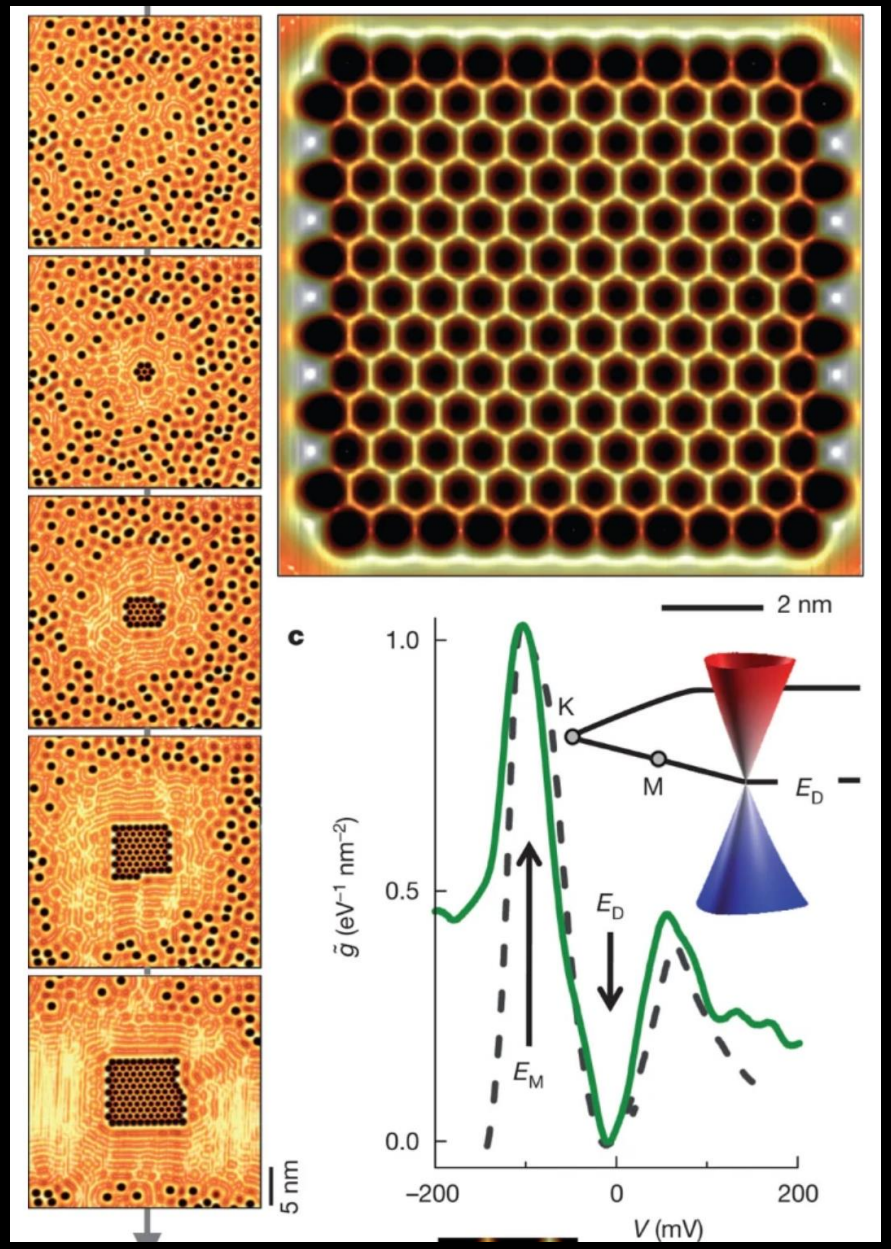
Technological necessity and opportunity





"2nm in 2025, 1nm in 2027"?
Features more like 40nm

Technological necessity and opportunity



CO molecules arranged
molecule by molecule
on a Cu(111) surface

Nature 483, 306–310 (2012)

Technological necessity and opportunity

CO molecules arranged
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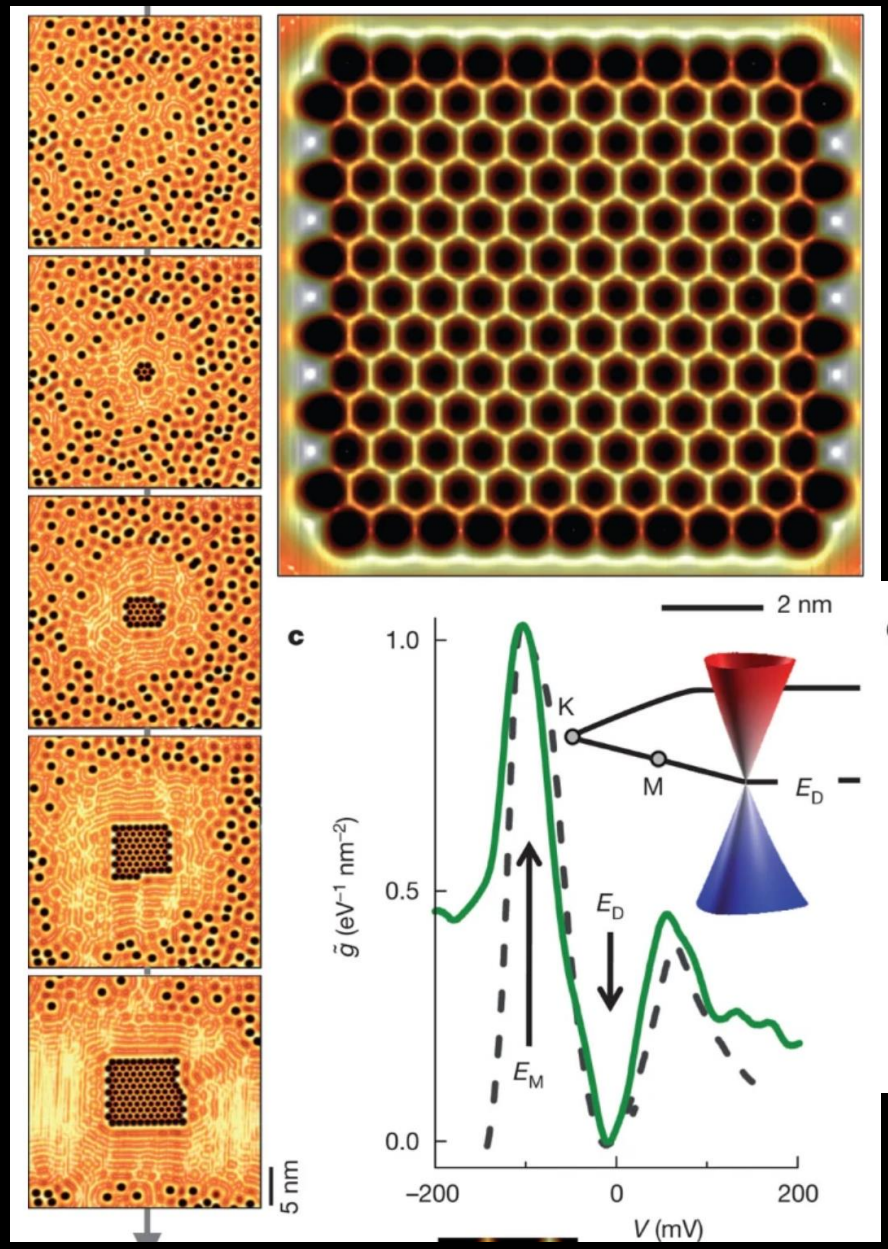
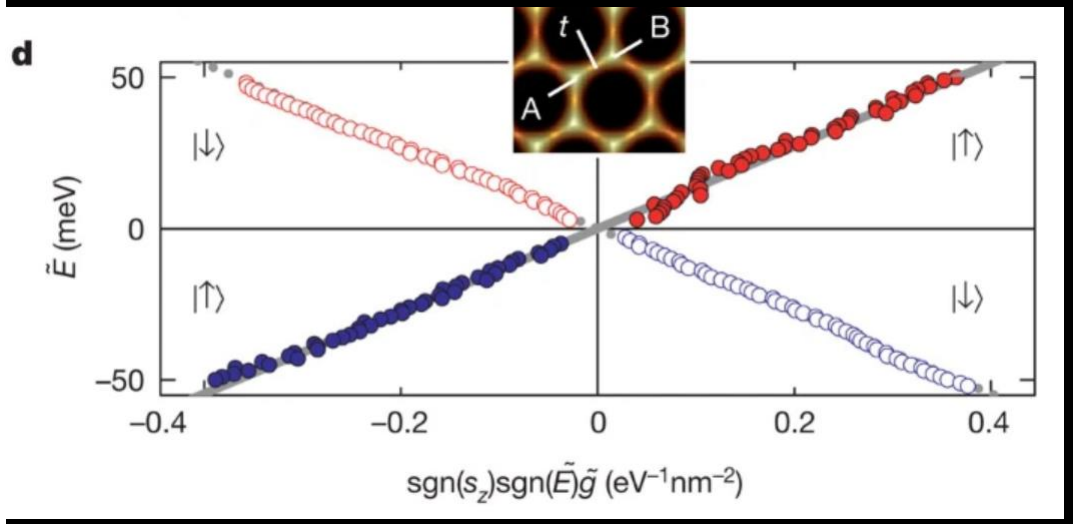
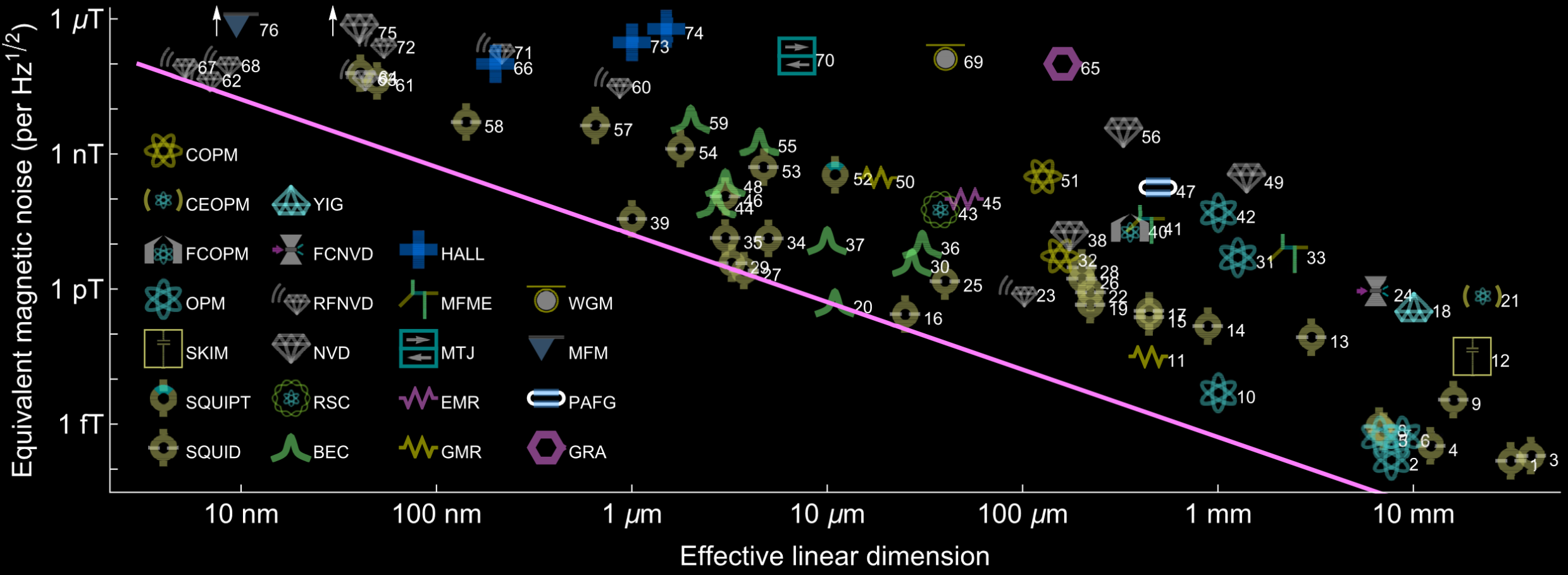




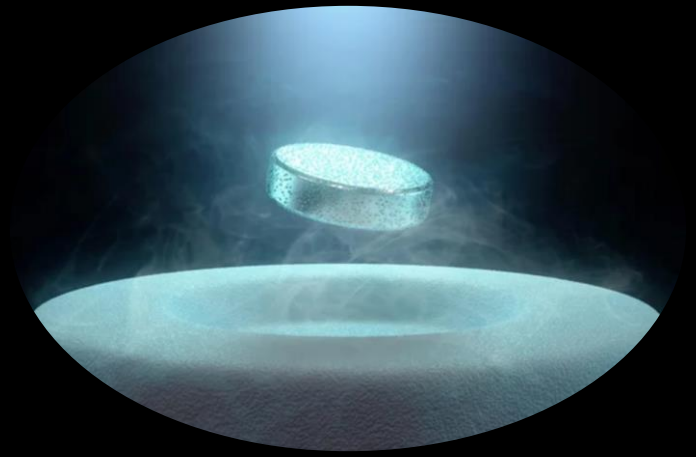
Nature 483, 306–310 (2012)

Technological necessity and opportunity



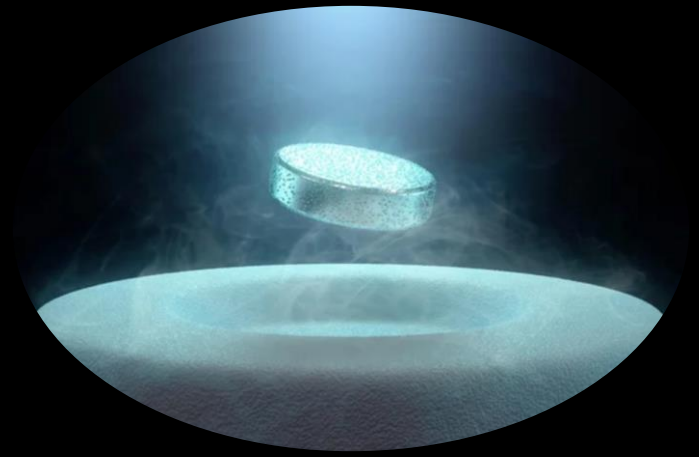
Rev. Mod. Phys. 92, 021001 (2020)

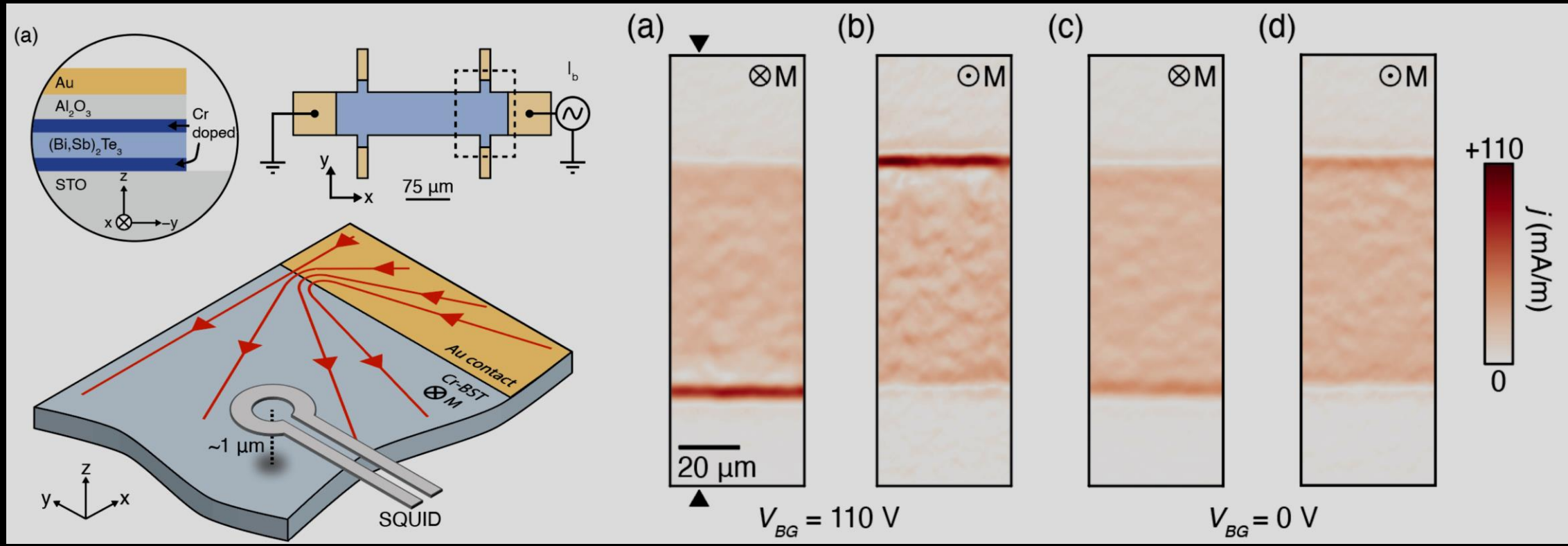
New effects



Rev. Mod. Phys. 92, 021001 (2020)

New effects





arXiv 2501.11666

New effects – when electrons don't scatter (that much)

Course overview

PART 1: Zero dimensions

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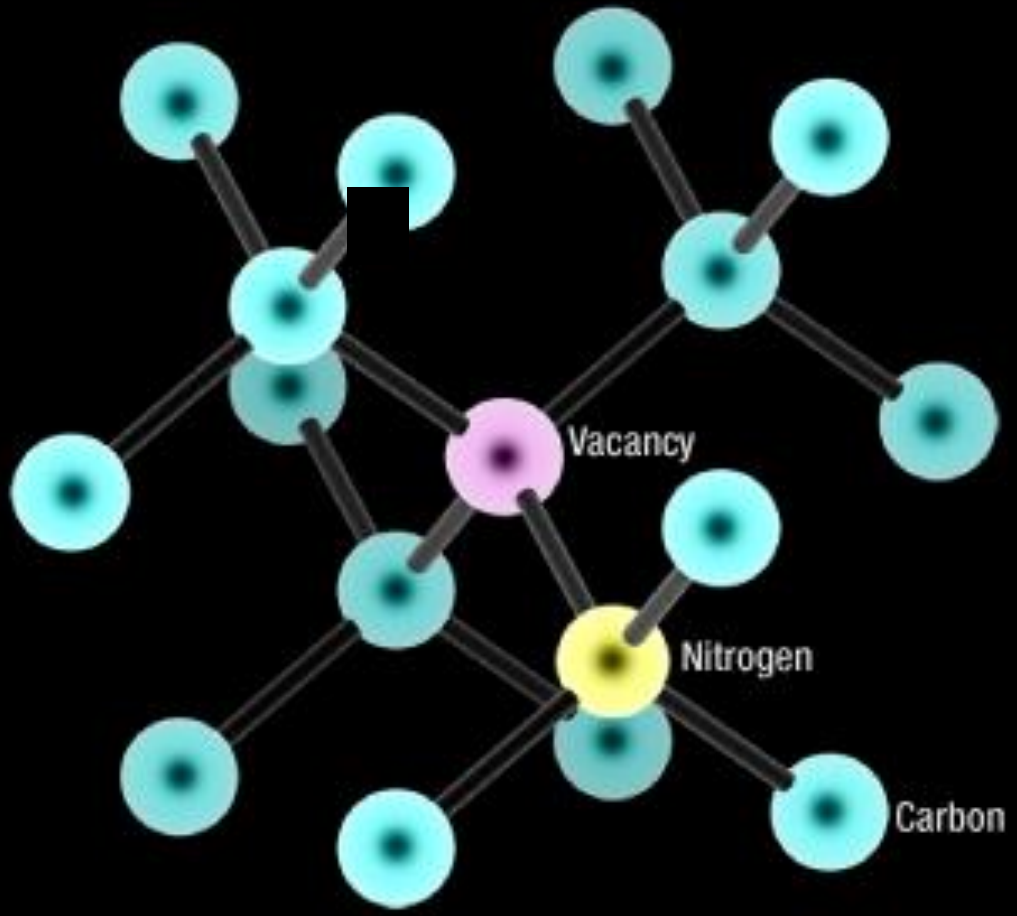
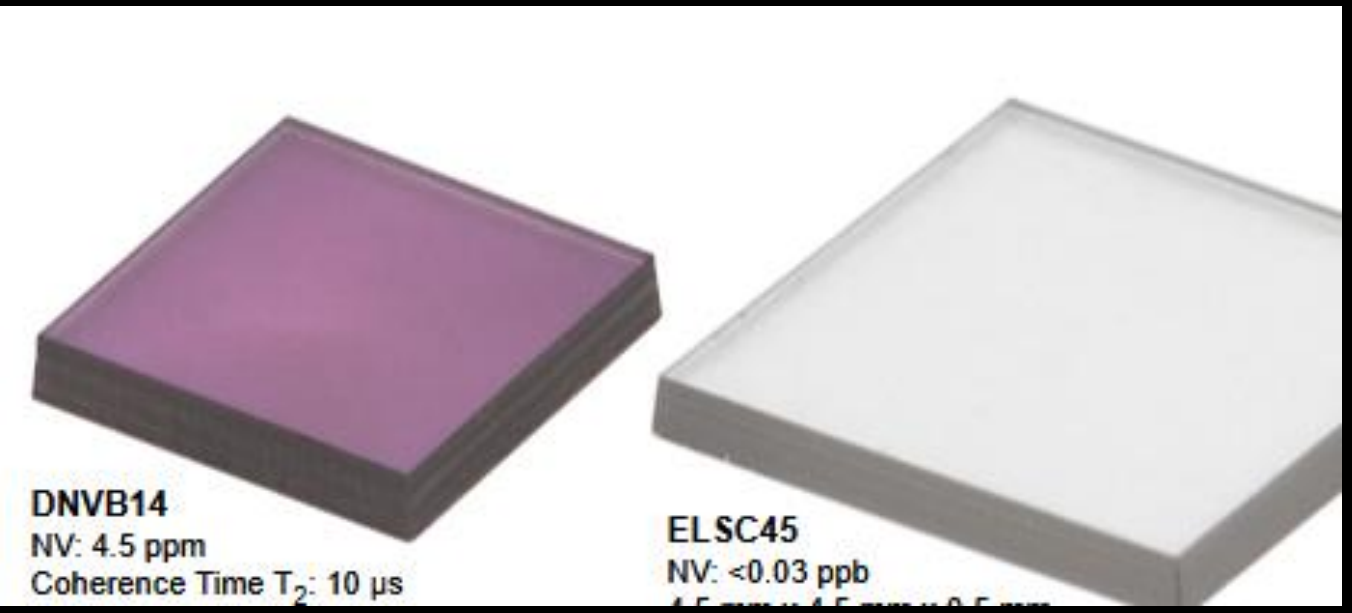
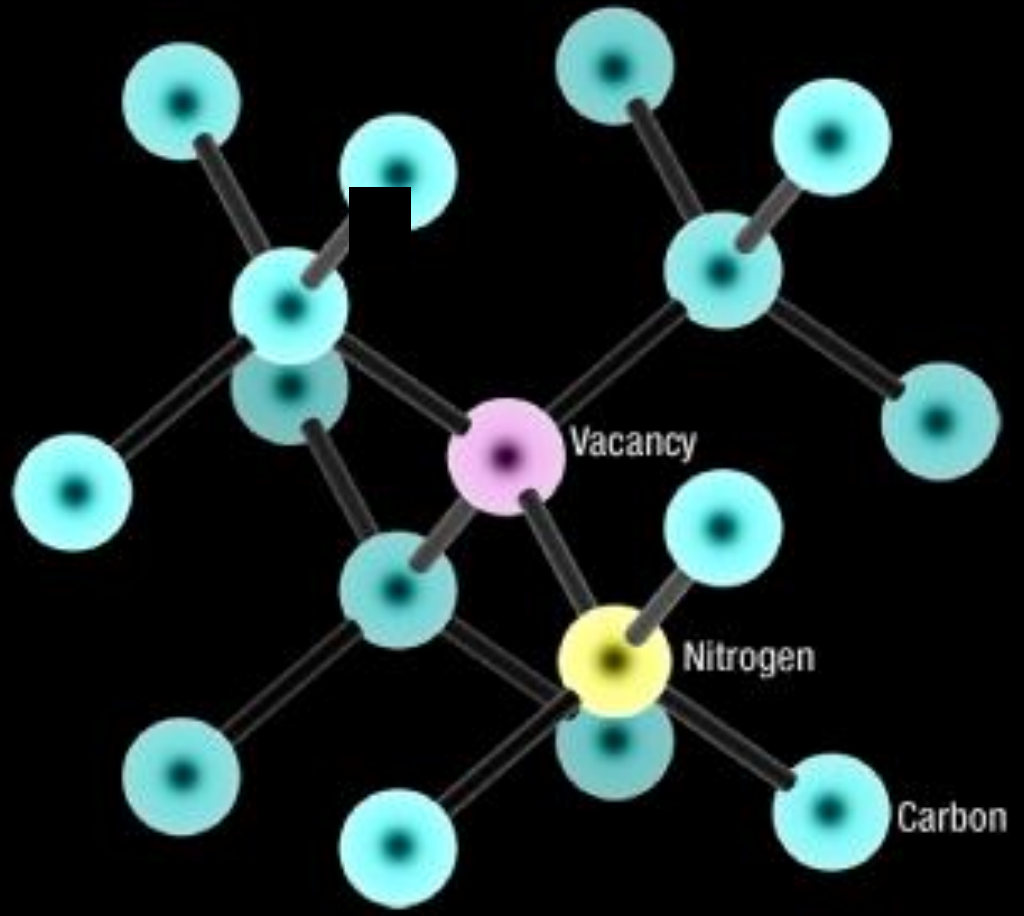
Diamond Nitrogen-Vacancy centers



PART 1: Zero dimensions
Diamond Nitrogen-Vacancy centers



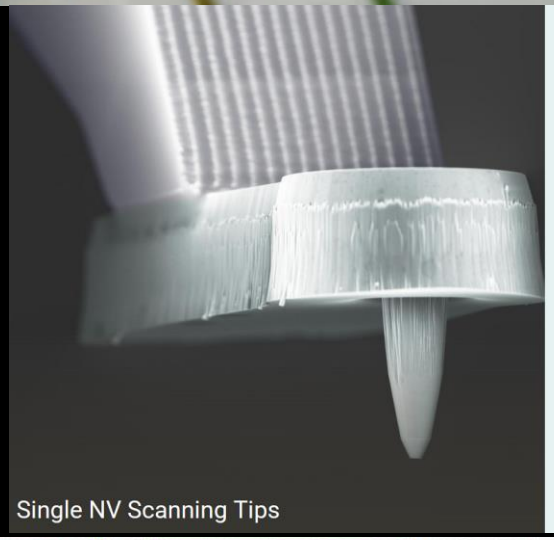


QUANTUM SENSING SOLUTIONS

Fast, versatile NV microscopes, high performance probes and more.

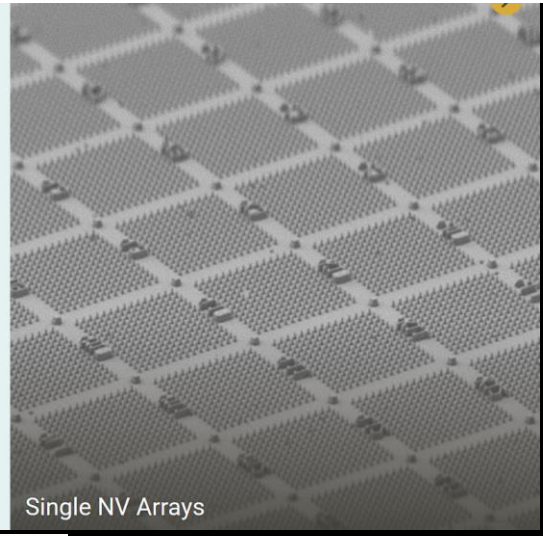
ZABRE

Qnami

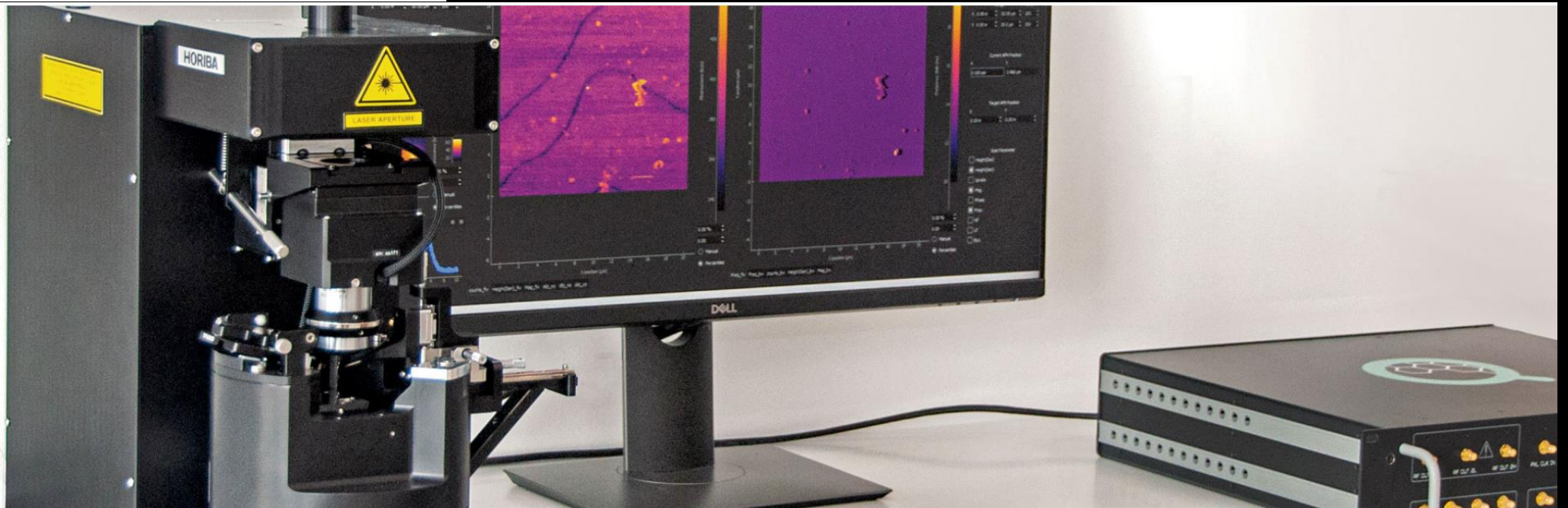


Single NV Scanning Tips

QSM - Quantum Scanning Microscope

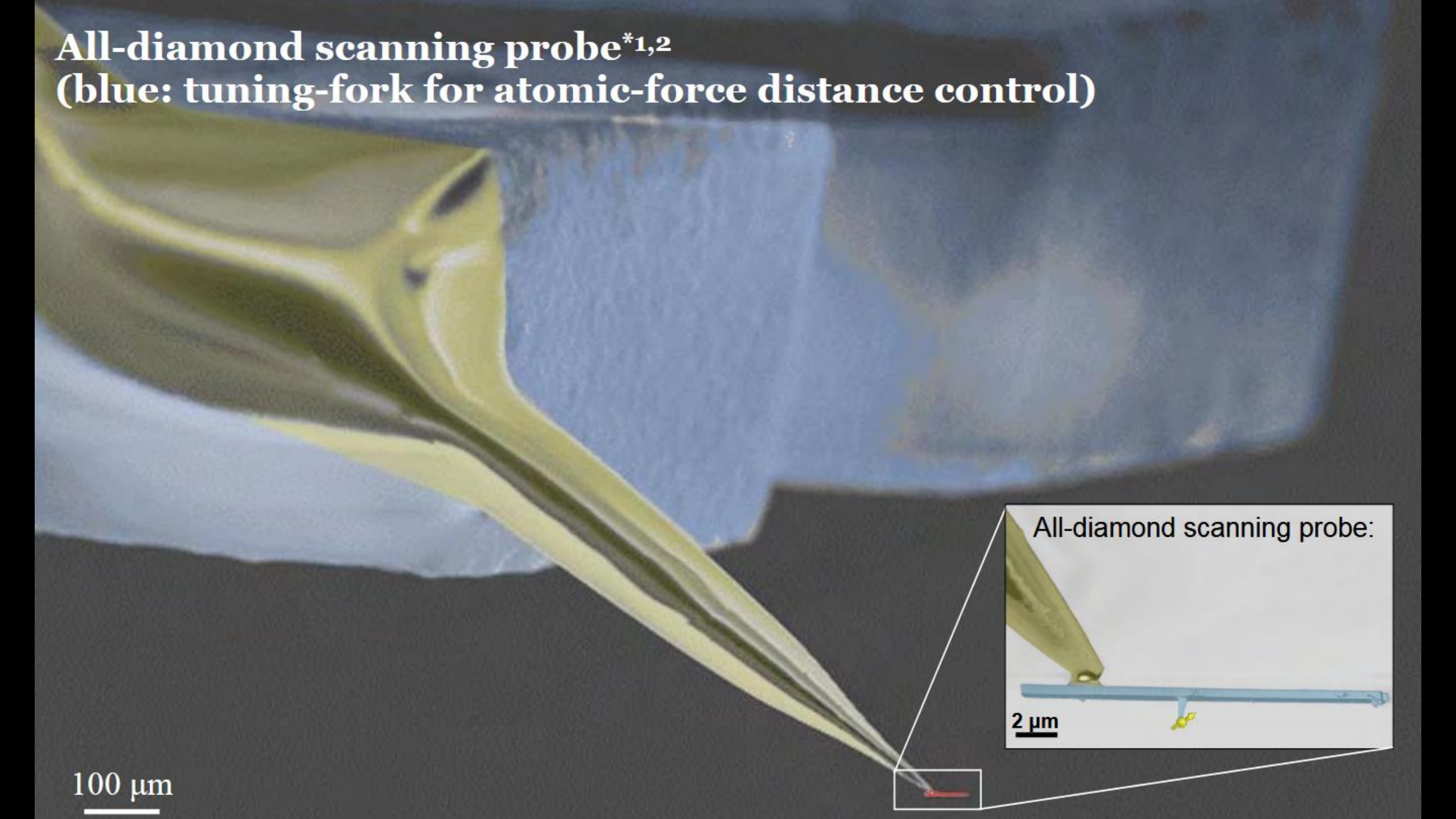


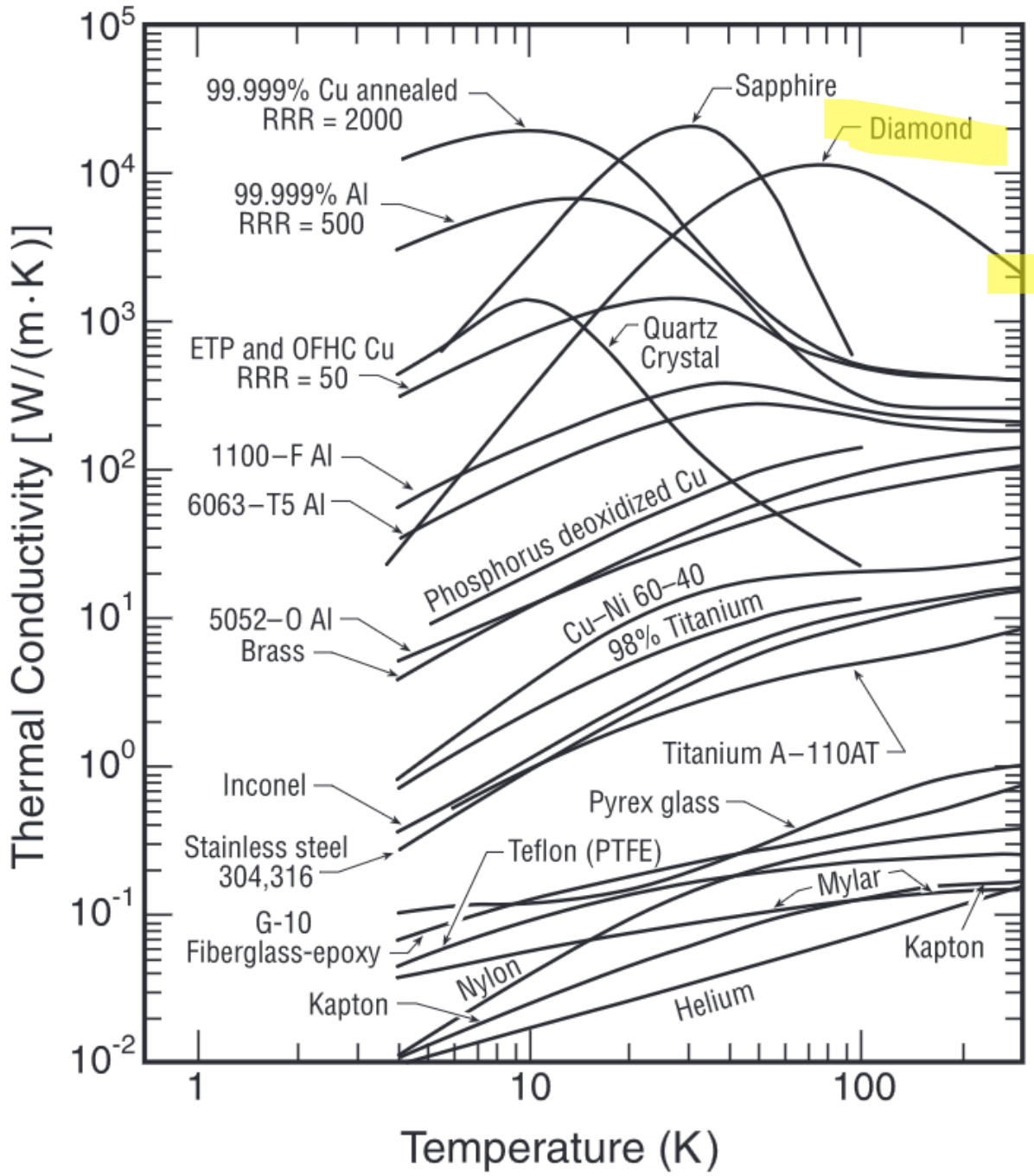
Single NV Arrays

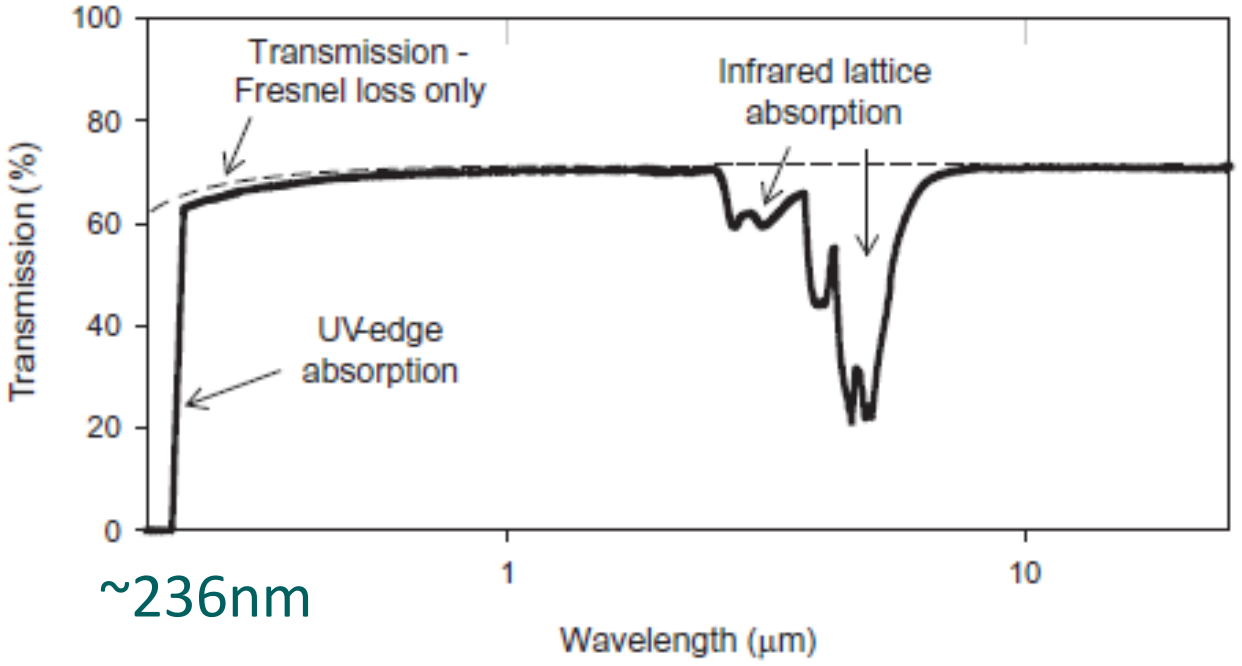


@EPFL:
SB-IPHYS:
Galland
STI-IMX:
Jotzu

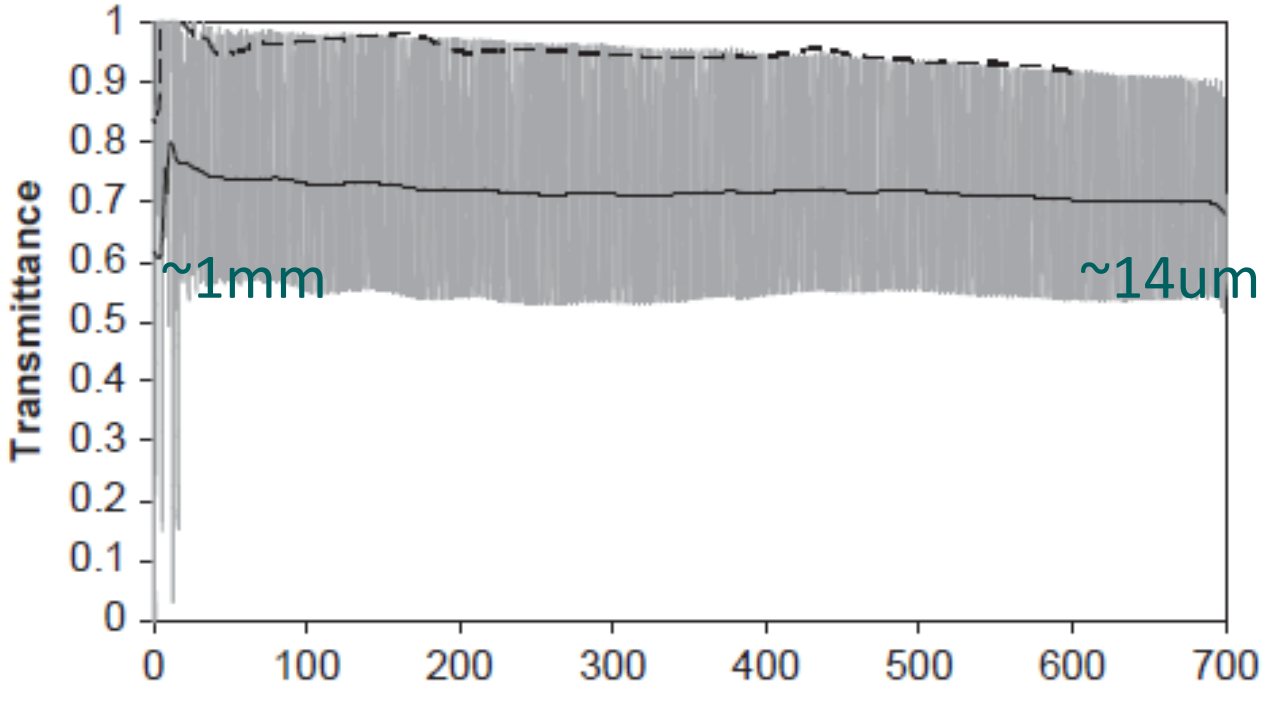
All-diamond scanning probe*[1,2]
(blue: tuning-fork for atomic-force distance control)




Thermal Conductivity [W/(m·K)]
Temperature (K)
99.999% Cu annealed
RRR = 2000
99.999% Al
RRR = 500
ETP and OFHC Cu
RRR = 50
1100–F Al
6063–T5 Al
5052–O Al
Brass
Inconel
Stainless steel
304,316
G-10
Fiberglass-epoxy
Kapton
Sapphire
Diamond
Quartz
Crystal
Phosphorus deoxidized Cu
Cu–Ni 60–40
98% Titanium
Titanium A–110AT
Pyrex glass
Teflon (PTFE)
Mylar
Kapton
Nylon
Helium

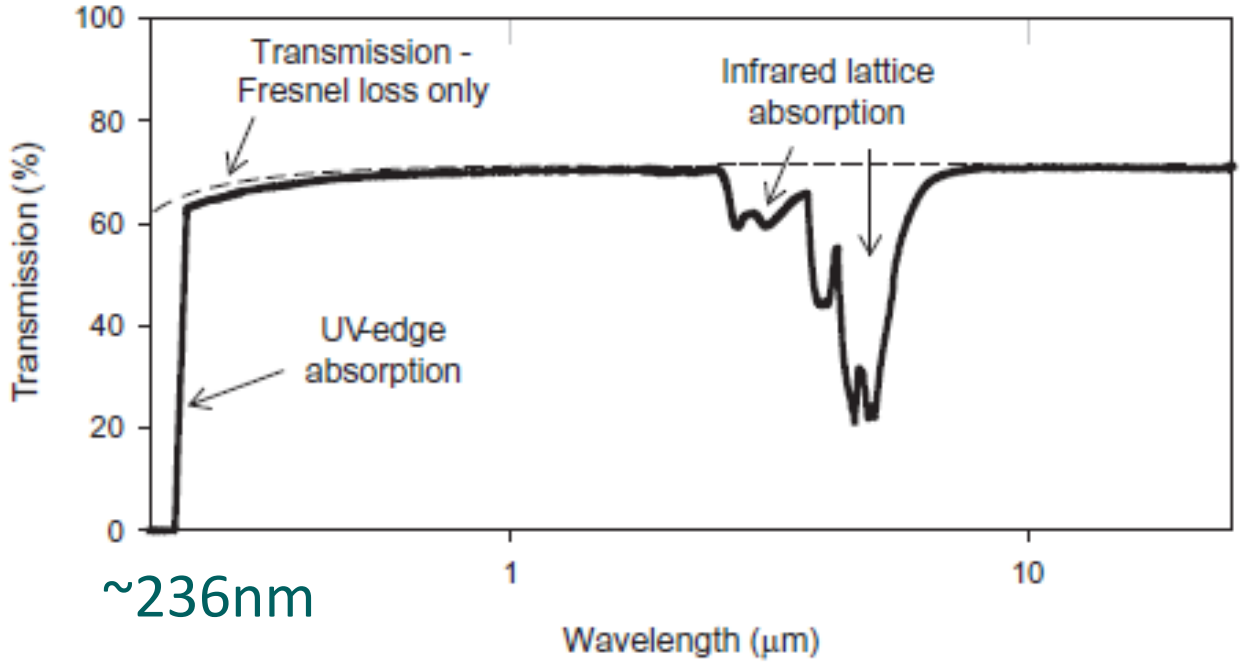


~236nm

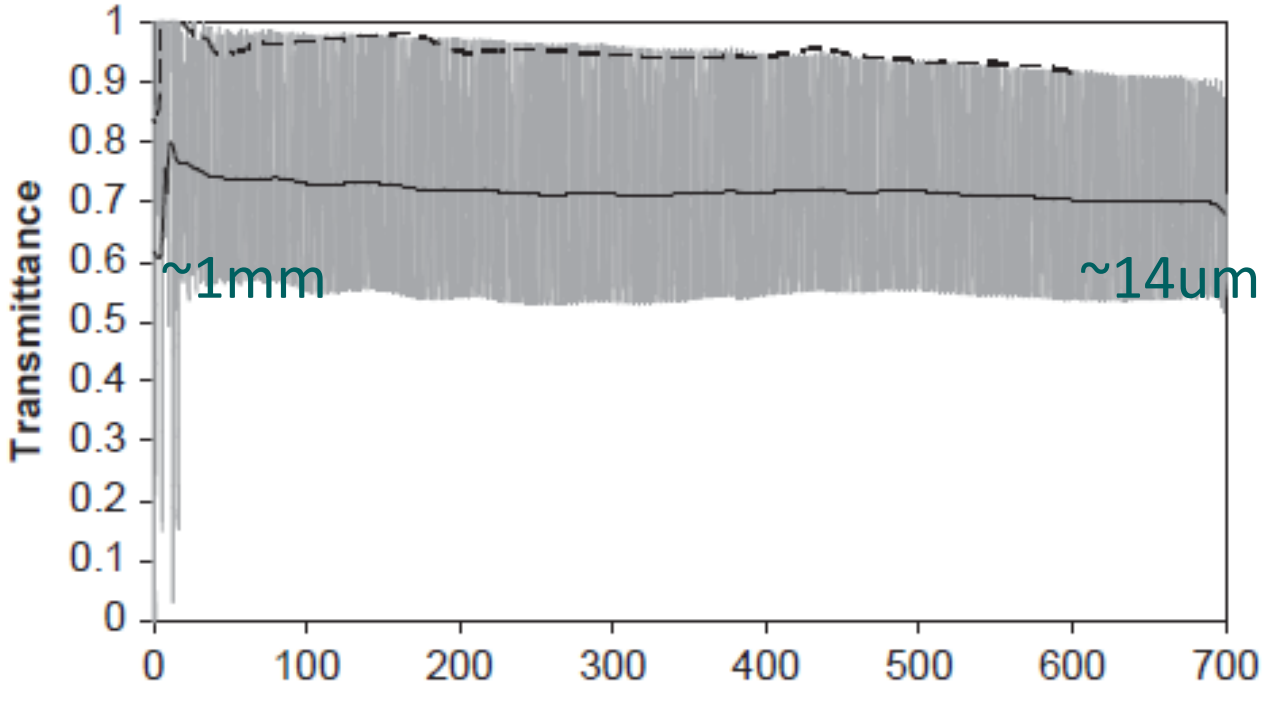


~1mm

~14um



~236nm



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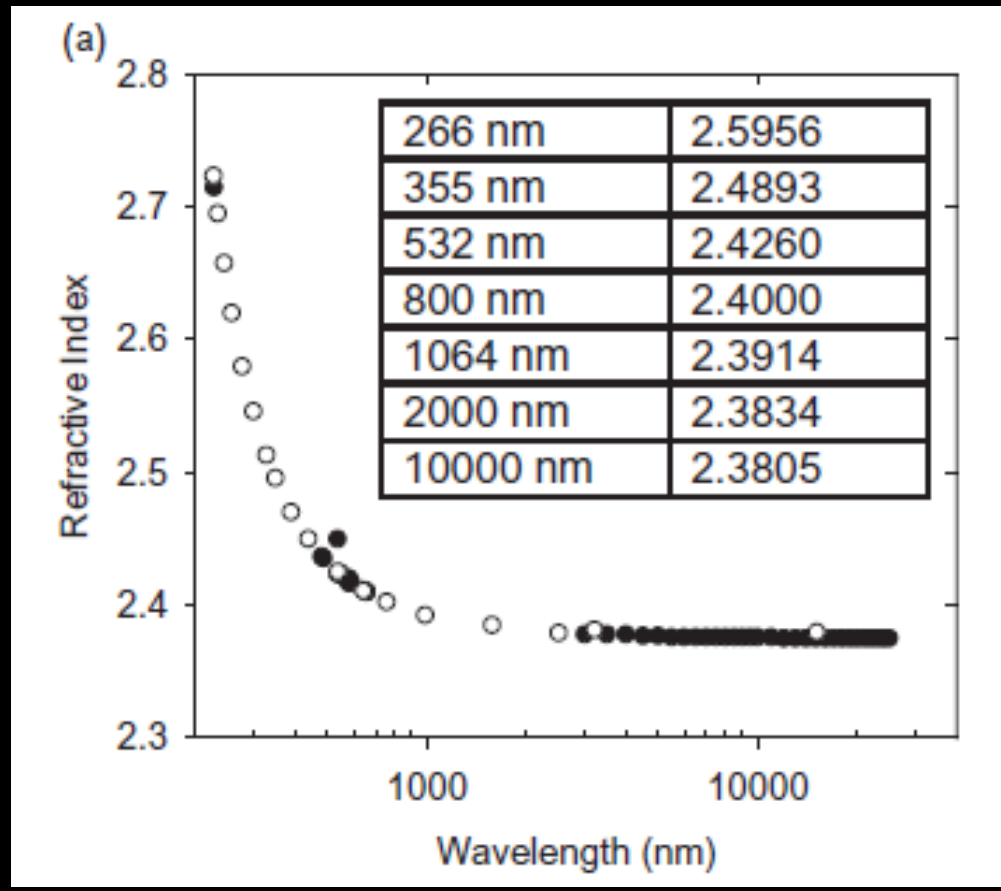

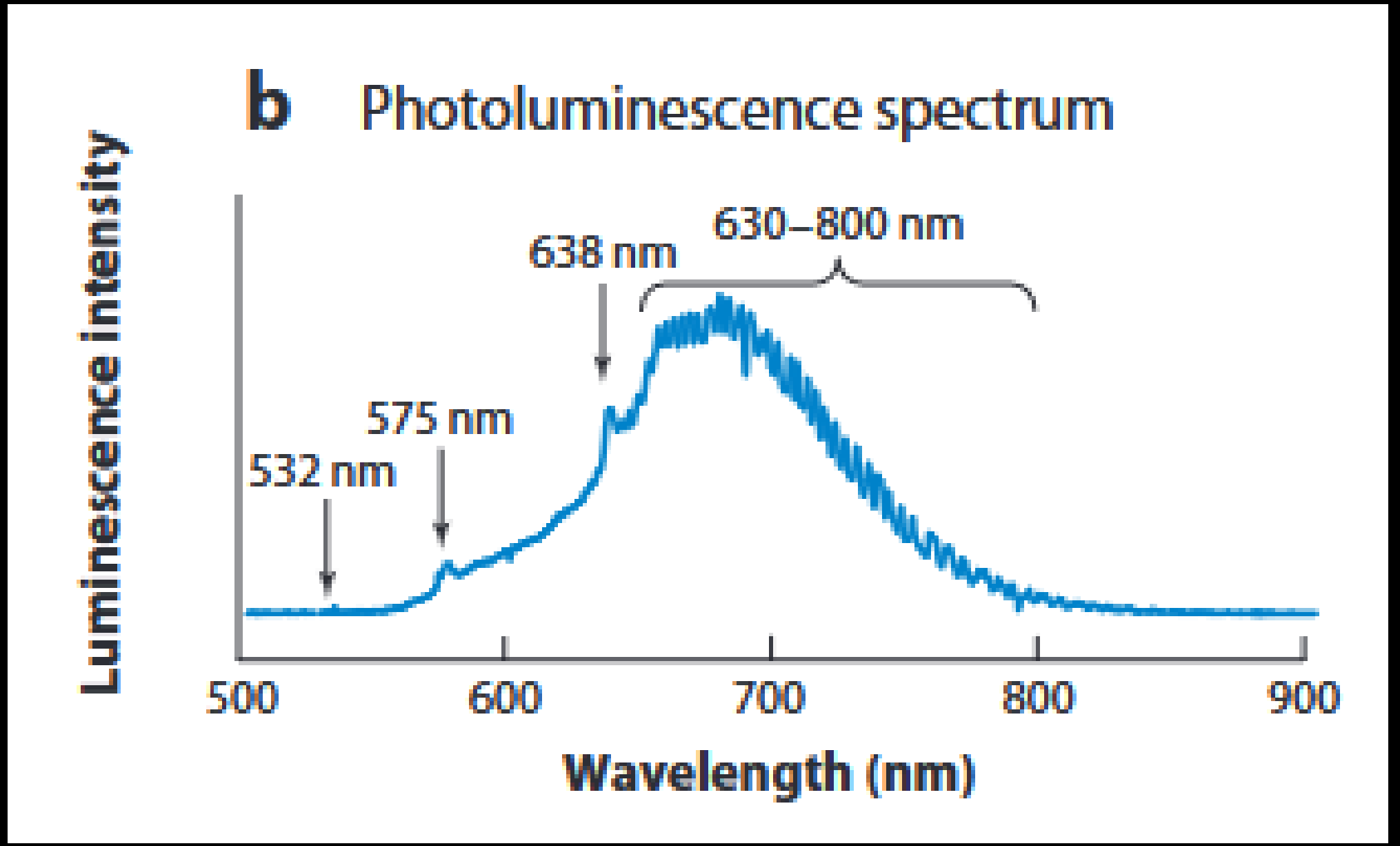
b Photoluminescence spectrum
Luminescence intensity
638 nm
630–800 nm
575 nm
532 nm
500
600
700
800
900
Wavelength (nm)