



Laboratorium für
Nano- und Quantenengineering



Leibniz
Universität
Hannover

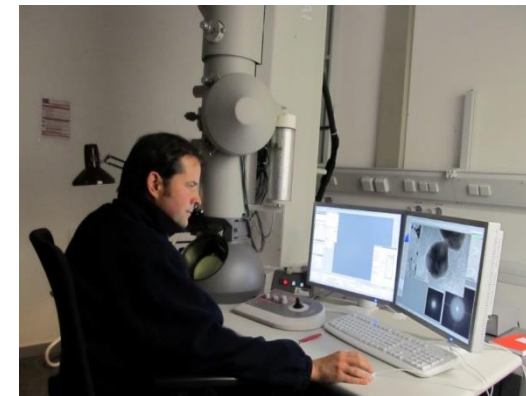
Laboratory of Nano and Quantum Engineering



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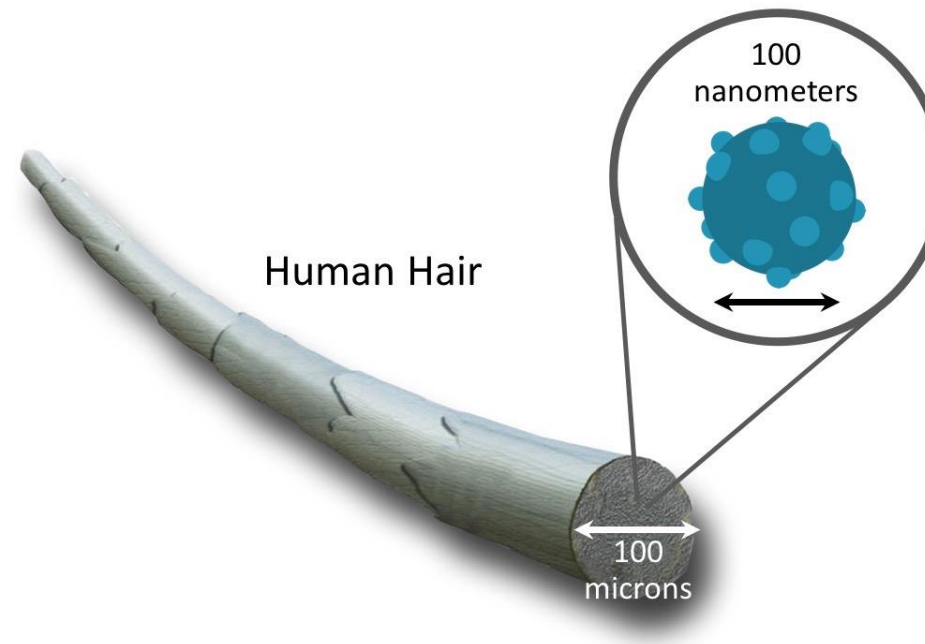
Interdisciplinary Research Centre of Leibniz University Hannover
in the field of nanotechnology

- Joint research of over 30 working groups from four faculties:
chemists, physicists, and engineers
- Study course **B. Sc. + M. Sc. Nanotechnology** with 300 students
- Doctoral program "Hannover School for Nanotechnology"
- Research building with laboratories, offices and 430 sqm clean room



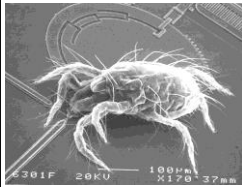
Nanotechnology

- "Nano": greek, "dwarf" or "dwarfish"
- Smaller than 100 nanometers
- New functionalities and features



Source: Massachusetts Institute of Technology, USA

Things Natural

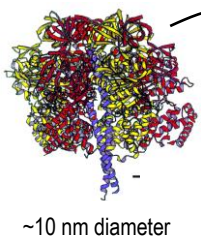


Dust mite
200 μm

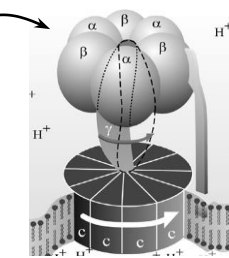


Human hair
~ 60-120 μm wide

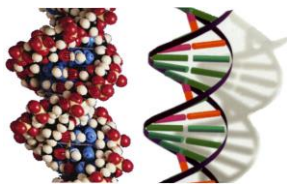
Red blood cells
(~7-8 μm)



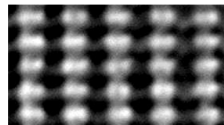
~10 nm diameter



ATP synthase



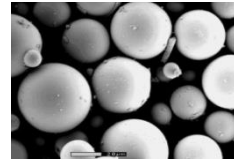
DNA
~2-1/2 nm diameter



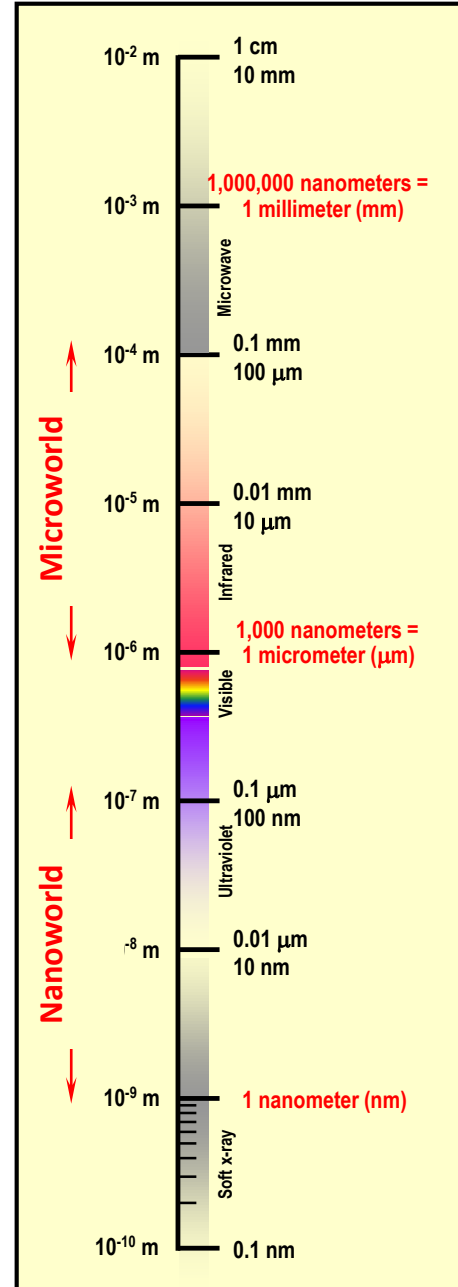
Atoms of silicon
spacing 0.078 nm



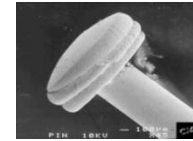
Ant
~ 5 mm



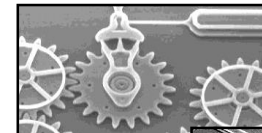
Fly ash
~ 10-20 μm



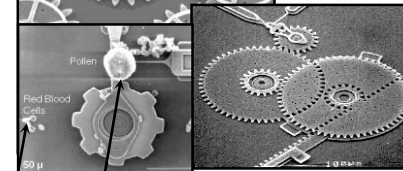
Things Manmade



Head of a pin
1-2 mm

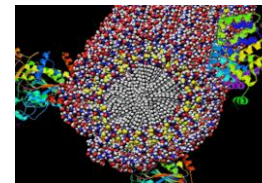
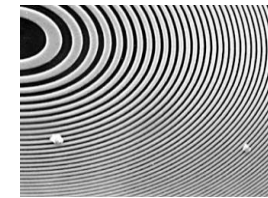


MicroElectroMechanical (MEMS) devices
10 -100 μm wide

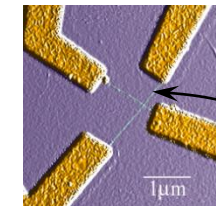


Pollen grain
Red blood cells

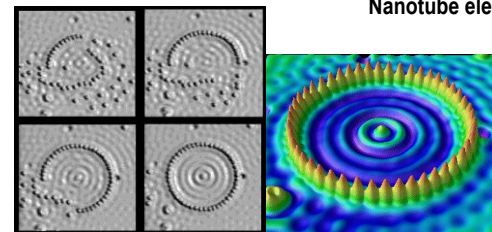
Zone plate x-ray "lens"
Outer ring spacing ~35 nm



Self-assembled,
Nature-inspired structure
Many 10s of nm



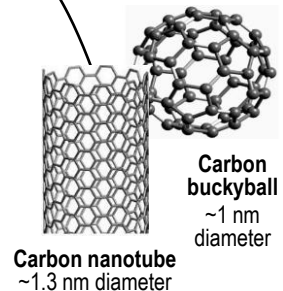
Nanotube electrode



Quantum corral of 48 iron atoms on copper surface
positioned one at a time with an STM tip
Corral diameter 14 nm

The Challenge

Fabricate and combine nanoscale building blocks to make useful devices, e.g., a photosynthetic reaction center with integral semiconductor storage.




Carbon nanotube
~1.3 nm diameter

Carbon buckyball
~1 nm diameter

 **ISFH**
Institute for Solar
Energy Research
Hamelin

IQ
Institute of
Quantum Optics

IOP
Institute of Photonics


 Institute of Physical
Chemistry and
Electrochemistry

Institute of
Gravitational Physics

Institute of
Solid State Physics

Institute of Organic
Chemistry

Institute for
Experimental Quantum Metrology

 Institute of Inorganic
Chemistry

Institute of
Applied Physics

iPAT Institute for Particle
Technology


LZH
LASER ZENTRUM HANNOVER e.V.


DIK German Institute of
Rubber Technology

MBE Institute of Electronic
Materials and Devices

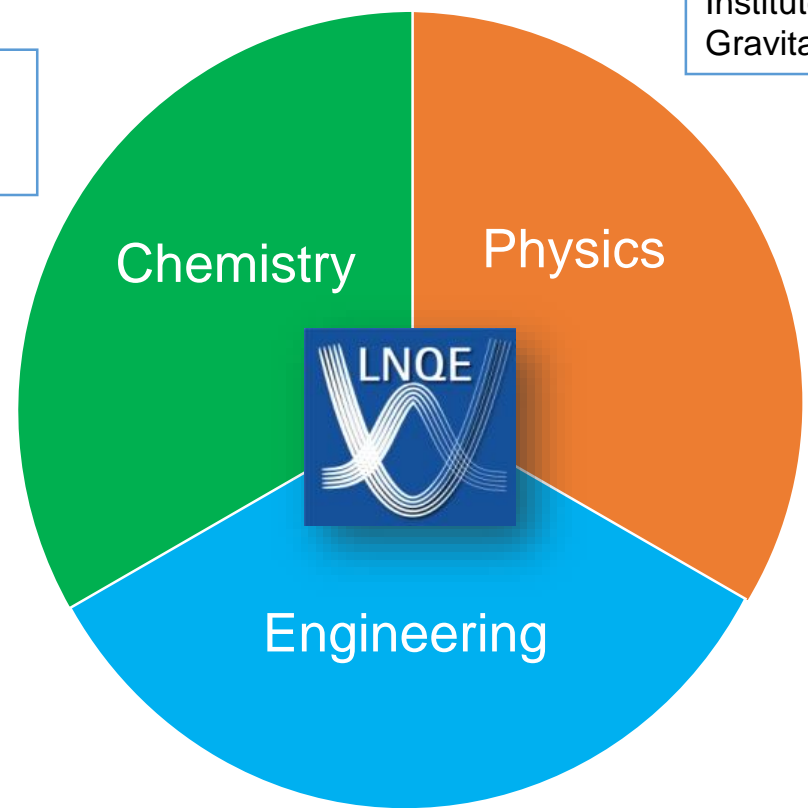
IMPT

Institute of Micro
Production Technology

 Institute for Electrical
Engineering and
Measurement Technology

 Institute of
Microelectronic
Systems

IfES Institute of
Electric Power
Systems



Education in Nanotechnology

PhD

*Hannover School for
Nanotechnology*

Lower Saxony doctoral program of the LNQE

Master of Science

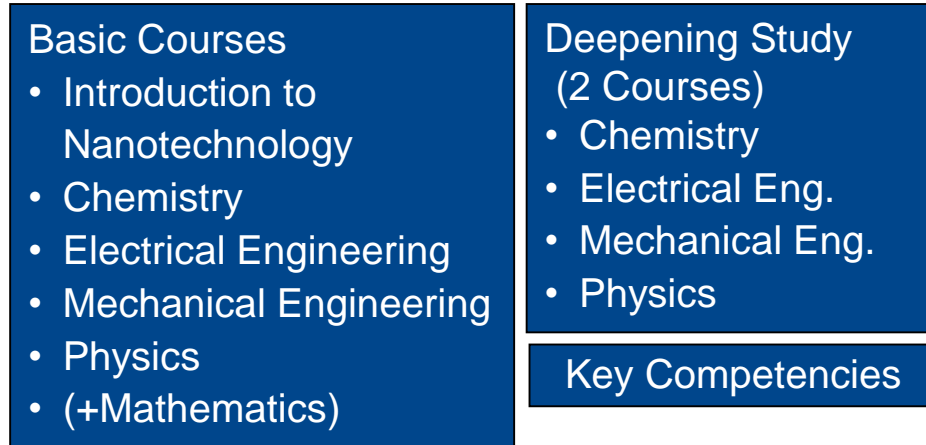
LNQE-initiated Interdisciplinary study course
"Nanotechnology" since winter semester 2008/09

Bachelor of Science

Core subjects Chemistry, Electrical Engineering,
Mechanical Engineering and Physics

Study Course Nanotechnology

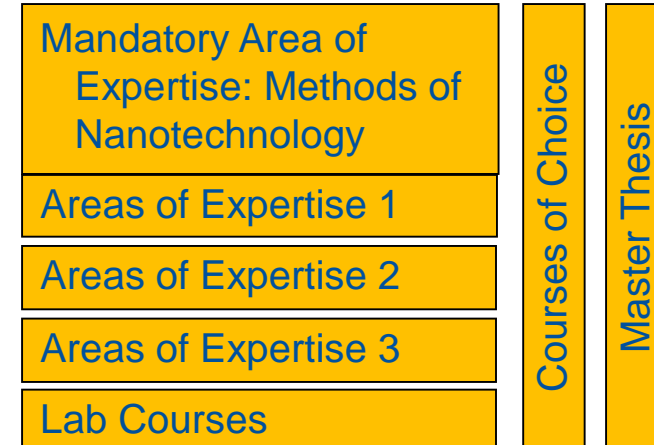
Bachelor of Science



Internship

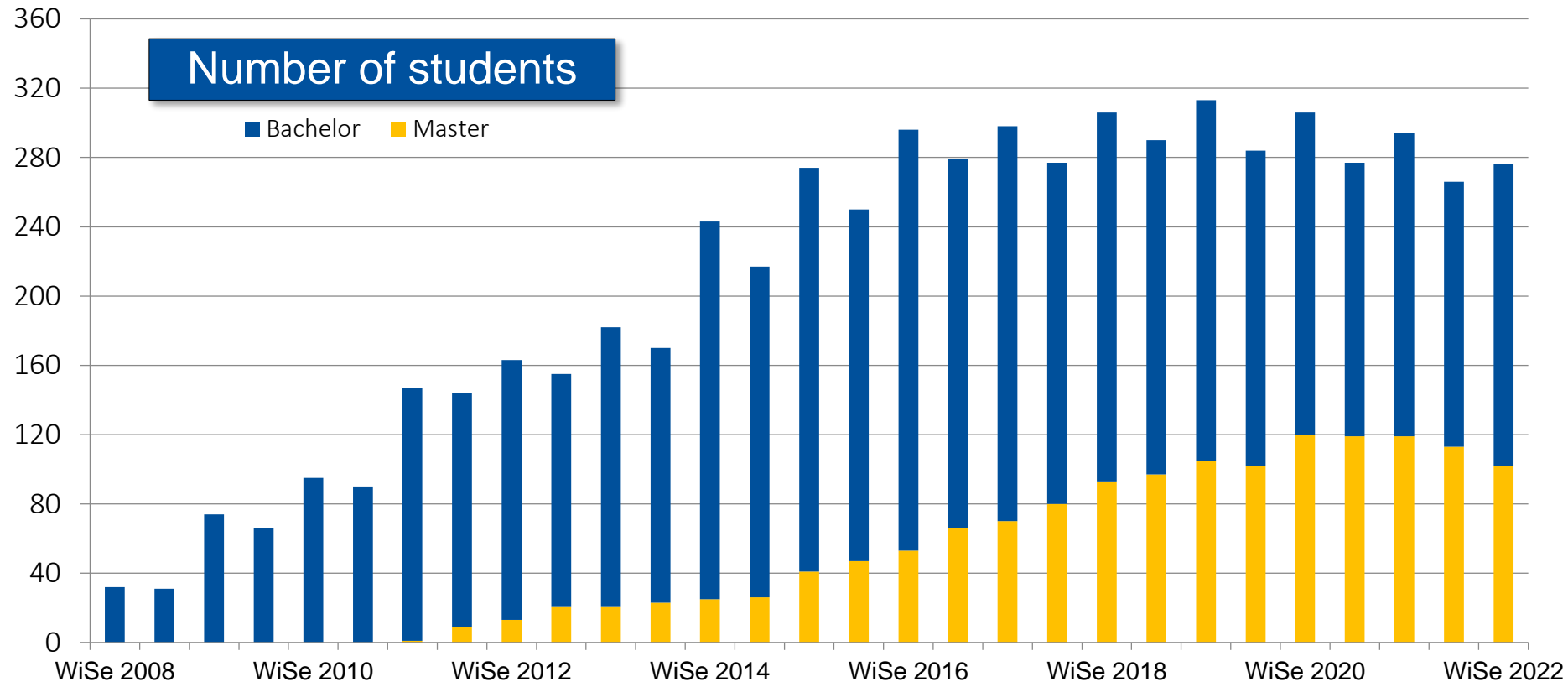
Bachelor Thesis

Master of Science



- Interdisciplinary degree program initiated by the LNQE
- Core subjects Chemistry, Electrical Engineering, Mechanical Engineering and Physics

Nanotechnology study programme

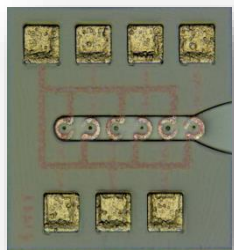
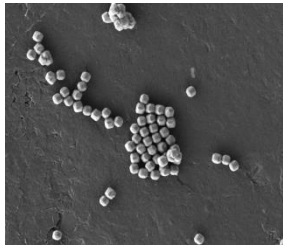


Degrees 2022: B. Sc. : 23 M. Sc. : 37

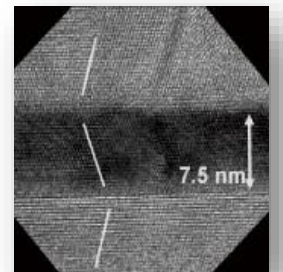
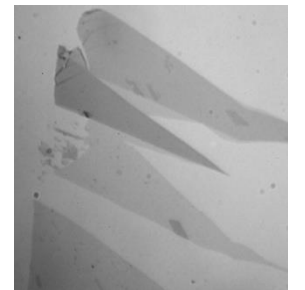
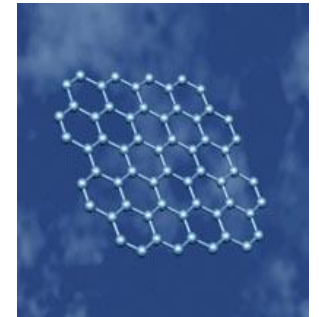
Percentage of female students: 26 %

Certificate
"Leibniz Quality in Teaching"
successfully obtained

Hannover School for Nanotechnology (hsn)

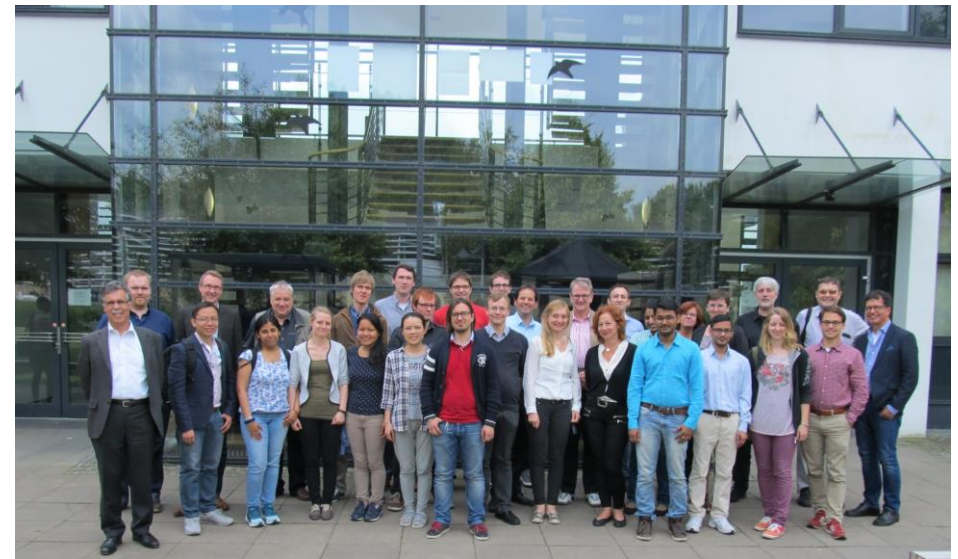


- Lower Saxony doctoral program of the LNQE of the Leibniz University Hannover together with the Hannover University of Applied Sciences
- Interdisciplinary education of young scientists in the highly topical field of nanotechnology
- Hsn has set itself the goal of providing excellent training without quality loss in excellent research projects with the shortest possible doctorate duration
- Tailored course offer
- Supervision with supervisor + co-supervisor



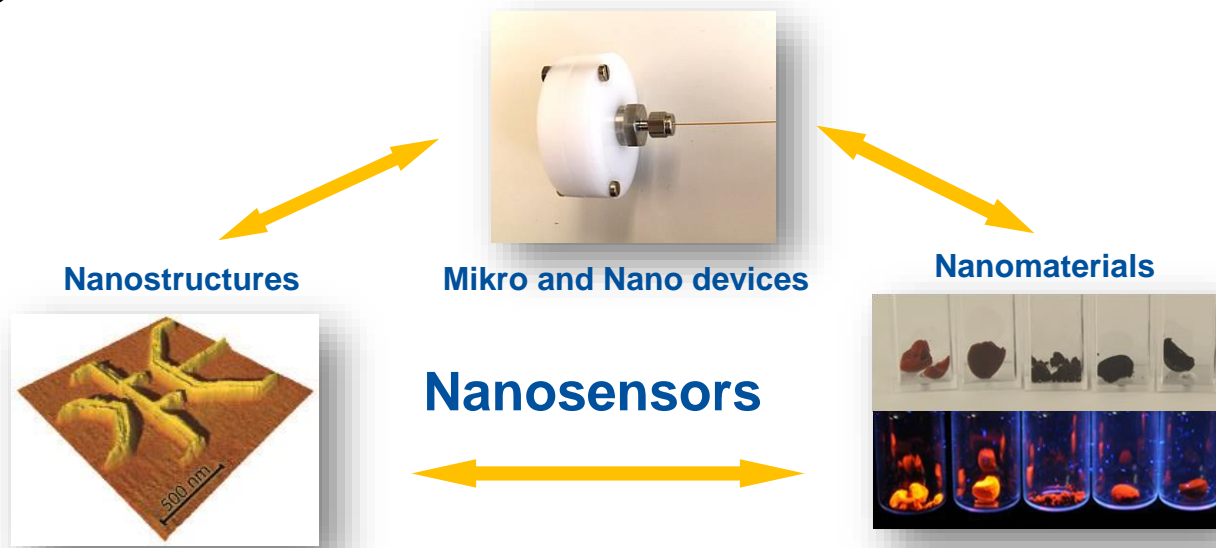
Doctoral program “*Hannover School for Nanotechnology*” Section *hsn–energy* (2012 – 2016)

- PhD program for 15 PhD students with a Georg-Christoph-Lichtenberg fellowship + additional students from the research groups.
- Focus on nanotechnology for energy research: nanomaterials and nanoengineering for energy conversion, energy storage or energy transport
- 159 applications from 28 different countries
- Funding: MWK with 1.000.000 Euro



Doctoral program “*Hannover School for Nanotechnology*” Section *hsn–sensors* (2016 – 2020)

- PhD program for 12 PhD students with a Georg-Christoph-Lichtenberg fellowship + additional students from the research groups.
- Focus on nanotechnology for sensing: sensors with nanoscale surfaces, sensors that transfer information from the nanoscopic world to the macroscopic world, and sensors that use nanoeffects as a sensing principle
- 301 applications from 50 different countries
- Funding: MWK with 800,000 euros



Doctoral program “*Hannover School for Nanotechnology*” Section *hsn-digital* (2019 – 2024)

- PhD programme for 15 doctoral students with a Georg Christoph Lichtenberg scholarship + other students from the research groups.
- Focus on nanotechnology for digitalisation: nanomaterials and quantum technologies for the digital transformation
- 170 applications from 33 different countries
- Funding: MWK with 1,000,000 euros



Quantum technologies



Nanostructures



Nanomaterials

Digital
Transformation

Integration of the LNQE into the Excellence Strategy

- Members of the LNQE are represented in all three clusters of excellence at the LUH as leading scientists:

QuantumFrontiers
(7 PIs)



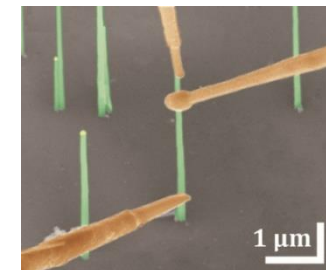
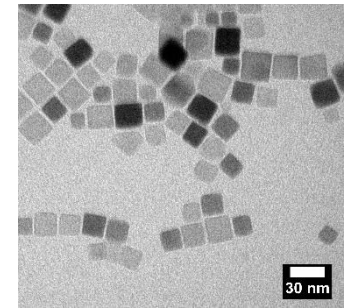
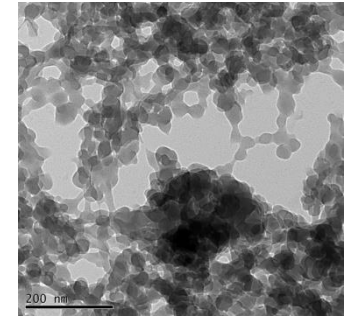
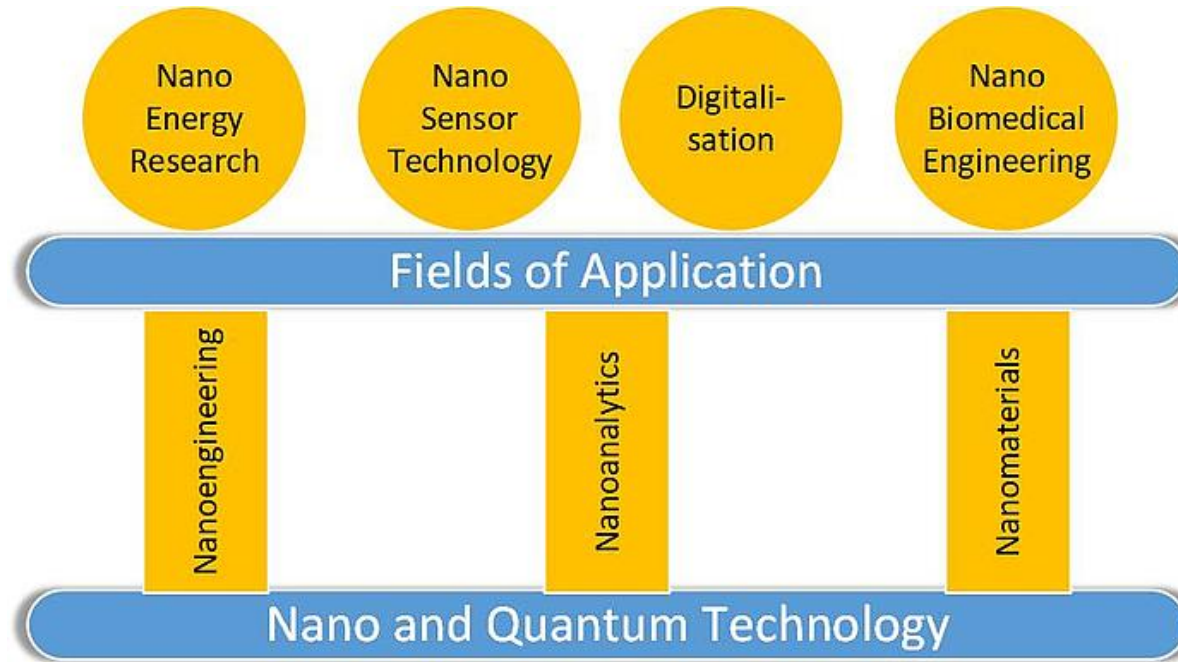
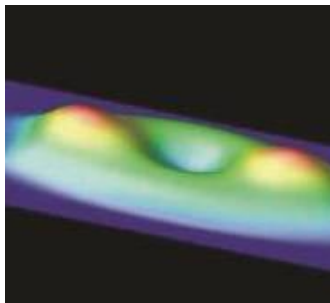
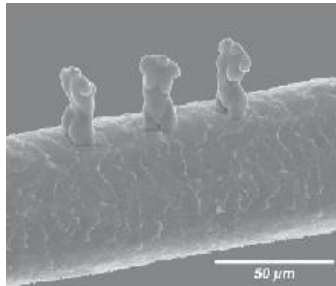
PhoenixD
(4 PIs)



Hearing4all 2.0
(2 PIs)



Research Priorities of the LNQE



LNQE Research Building



LNQE Research Building

- 05/2007: The 14 million Euro LNQE new building is funded as a *research building* (“Forschungsbau ”according to Article 91b of the German Basic Law).
- Ranking of the German Science Council: 5th place out of 22 applications
- 11/2009: Opening
- First research building at Leibniz University Hannover



LNQE Research Building



Areas:

- Labs (435 m²): laser laboratories, chemical laboratories, test laboratories
- Research clean room (409 m²)
- Office space for 50 people (509 m²)

Sharing by the LNQE working groups:

- Individual laboratories for projects of the working groups
- Central clean room & transmission electron microscope for everyone

Mixed funding through:

- Presidential Board / Central
- Involved faculties
- LNQE members (membership fees + expenses)

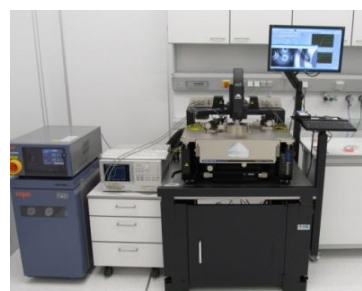
Technology offer in LNQE research building



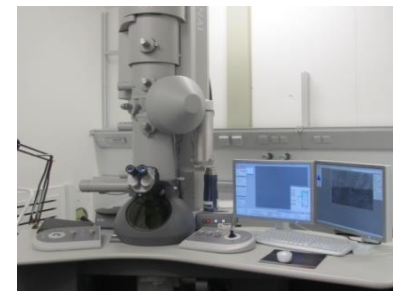
Photolithography



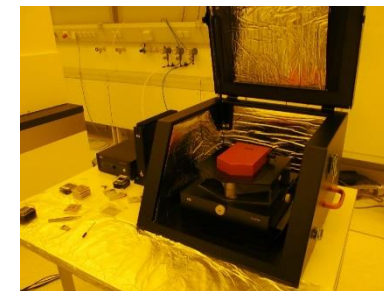
Electron beam lithography



Wafer-Probe Station



TEM



AFM



Spectral ellipsometer



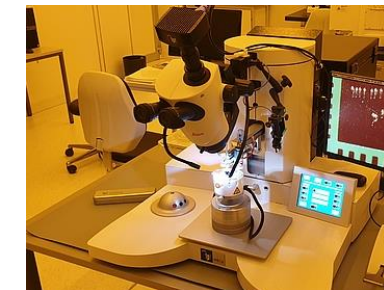
Plasma-CVD



Confocal microscope



Sputtering system



Wire bonder



Implanter



Ovens systems



Evaporation coating system

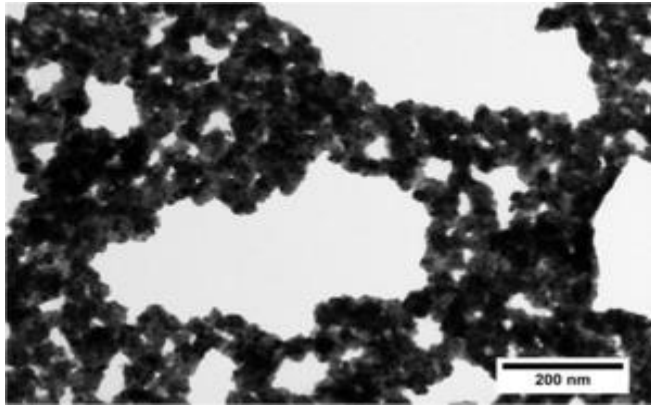


Rapid thermal processing

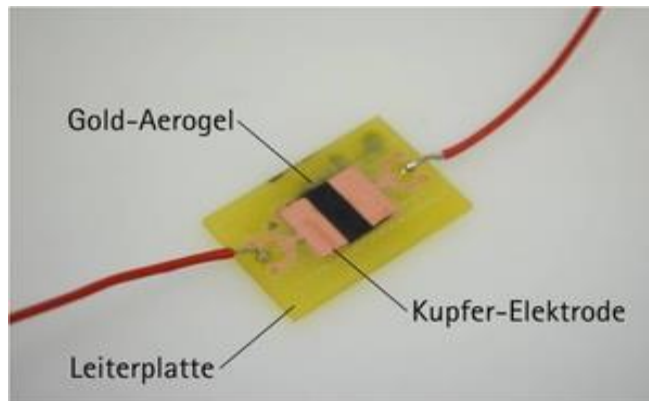


RIE

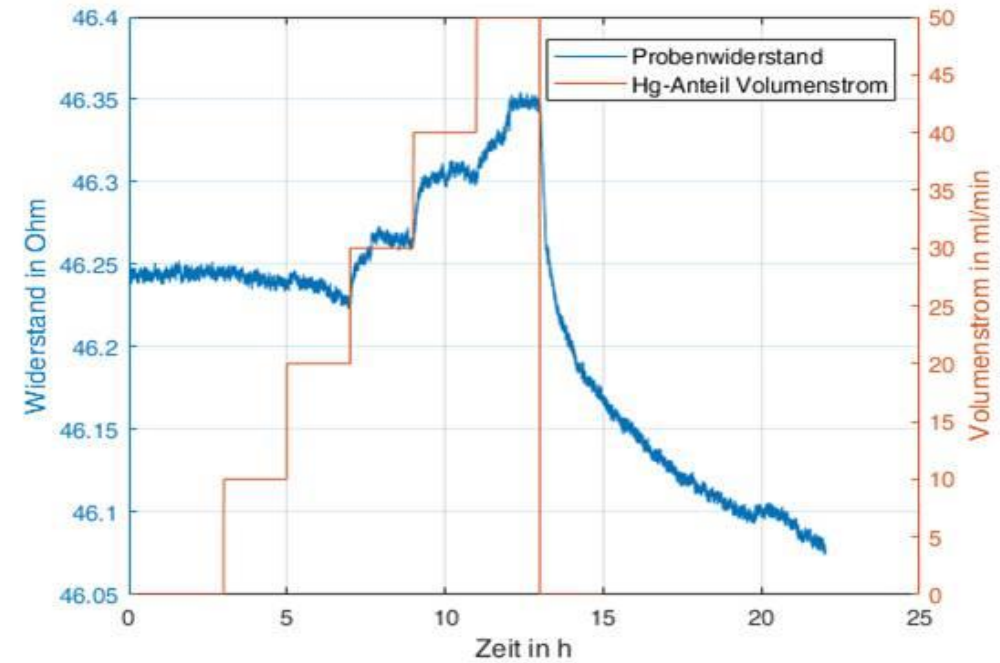
Gold aerogels for detection of mercury



Gold aerogel from 4 nm gold nanoparticles

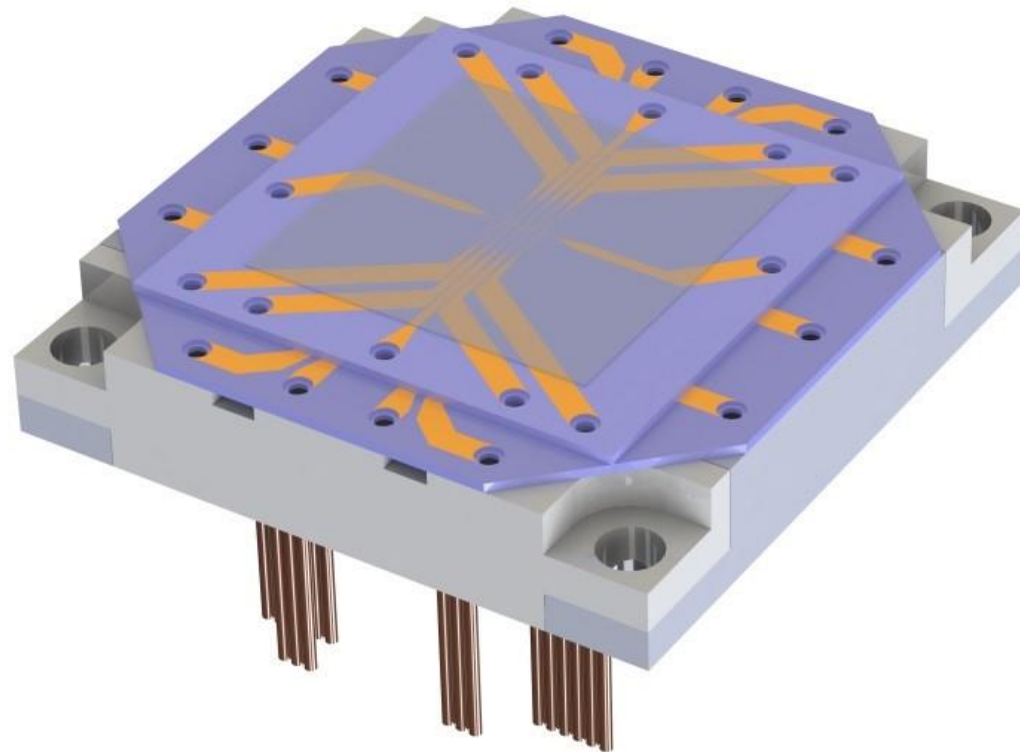


First version of the mercury sensor

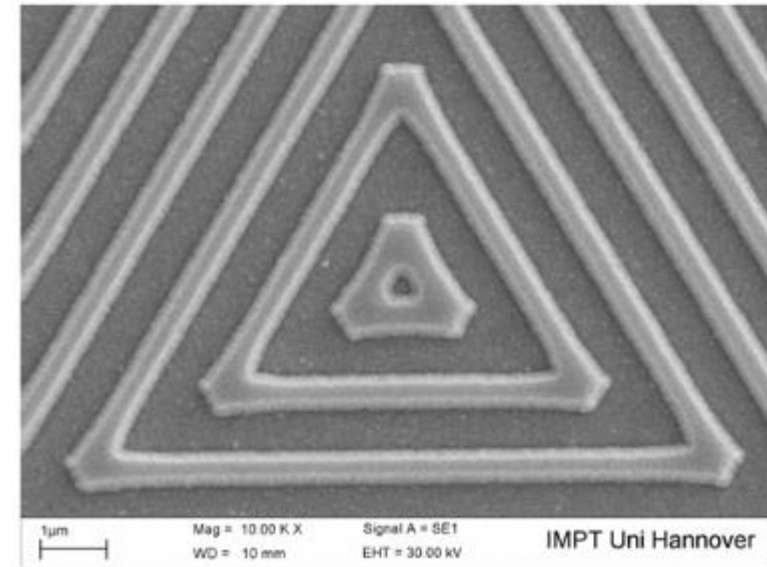


Gold aerogel sensor for mercury exposure

Atom chips with integrated optical gratings for the generation of Bose-Einstein condensates

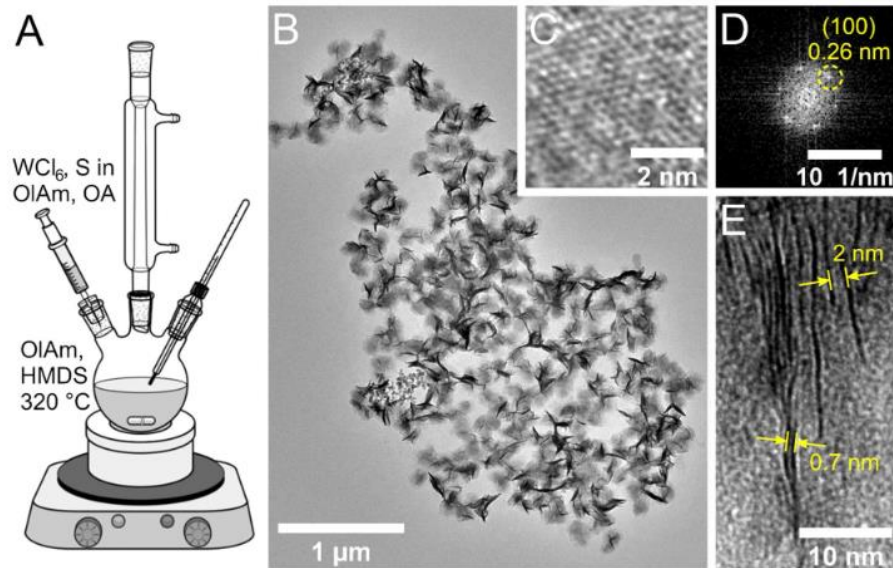


Structure of the atomic chip system

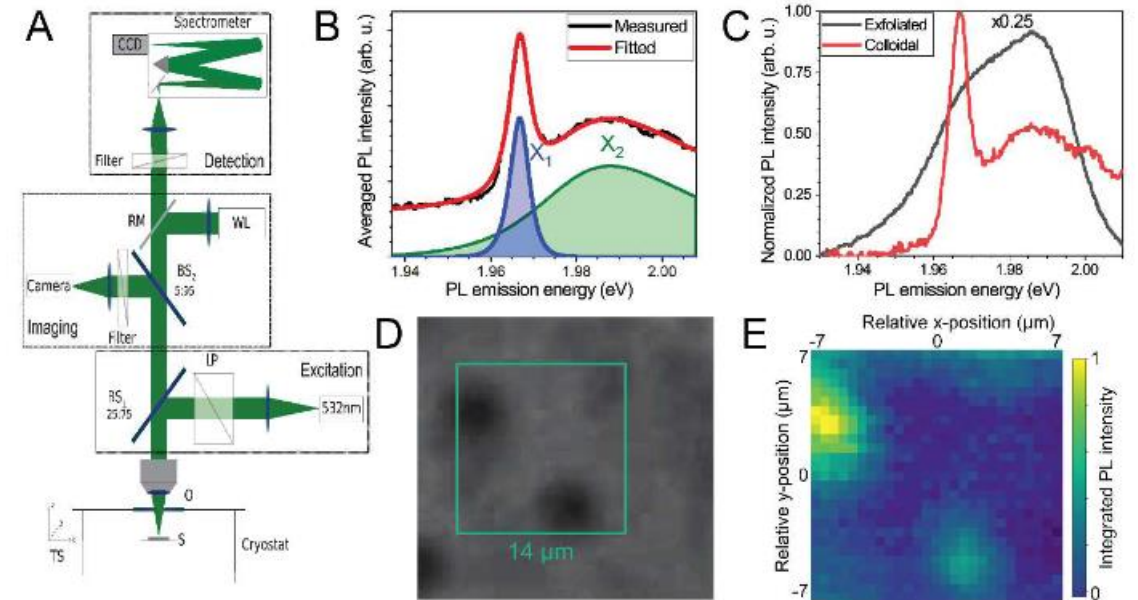


Optical grating consisting of three 1D gratings

Room Temperature Micro-Photoluminescence Studies of Colloidal WS₂ Nanosheets

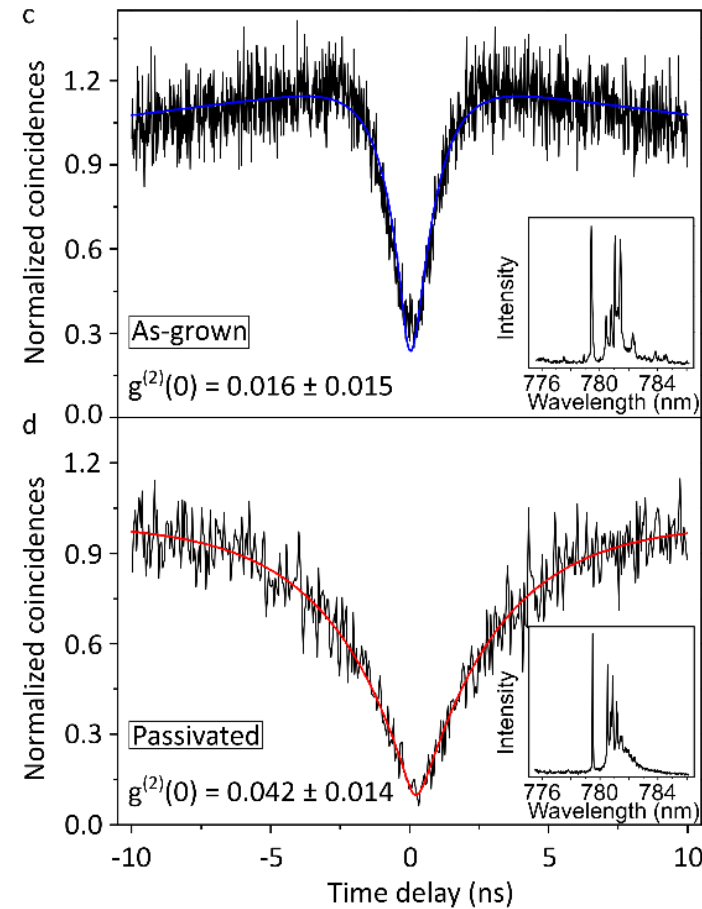
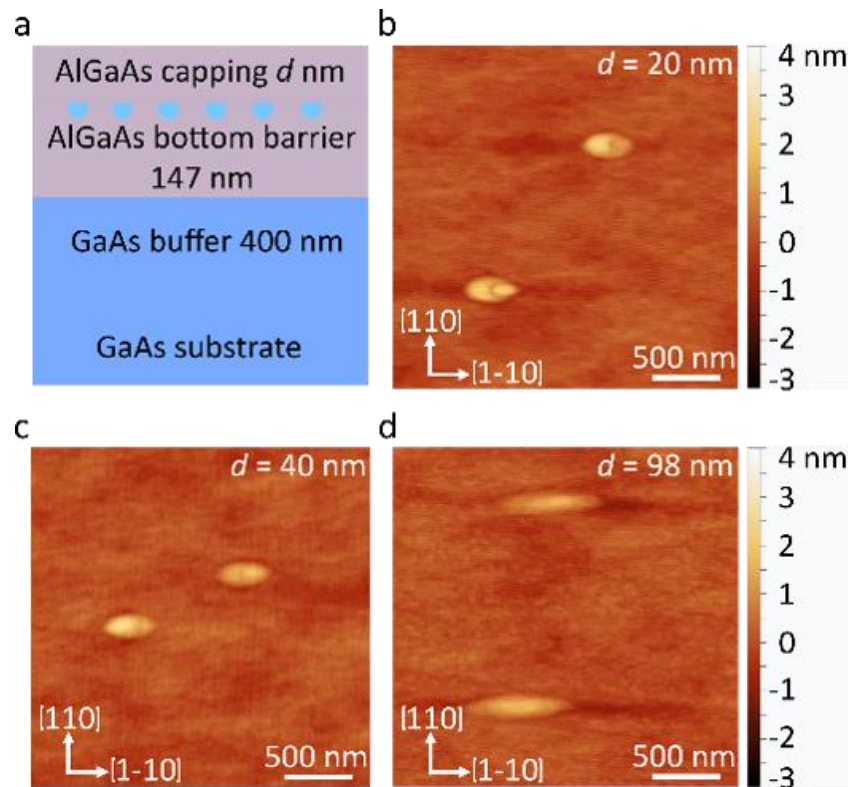


Colloidal WS₂ Nanosheets
(quasi two-dimensional (2D) transition
metal dichalcogenides (TMDs))



Room Temperature Micro-Photoluminescence
measurements

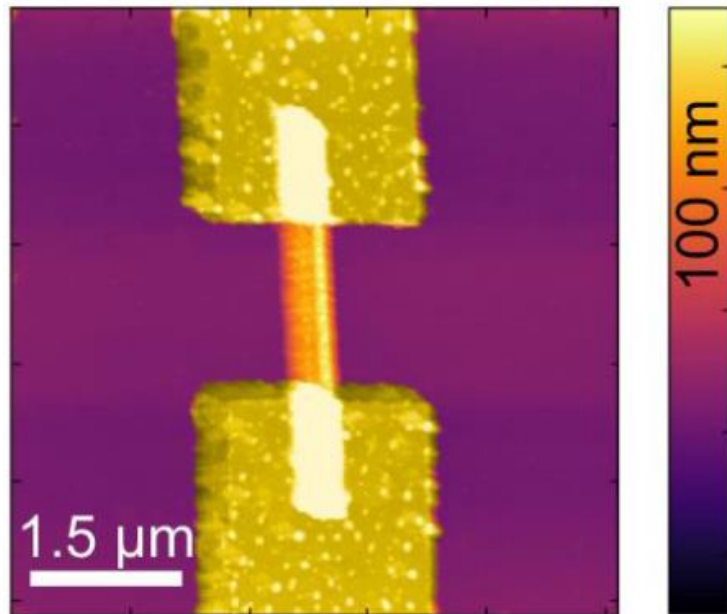
Single photon emission from ODT-passivated near-surface GaAs quantum dots



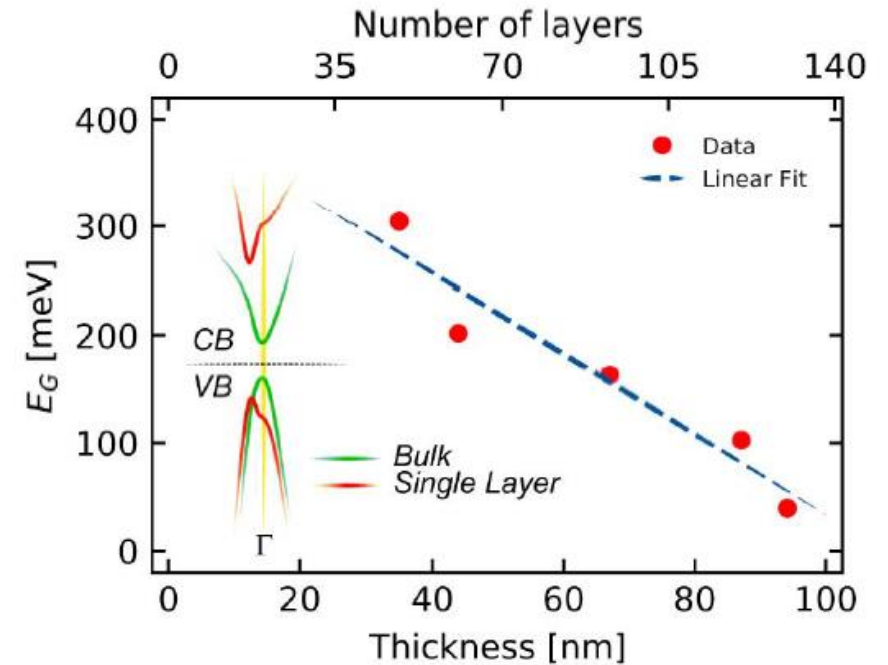
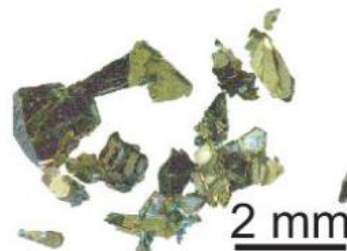
The anti-bunching dip at the zero time delay indicates the emission of single photons. Inset: PL spectra of the measured QDs.

(a) Schematic representation of the sample structure. (b)-(d) Atomic force microscopy images of GaAs quantum dots.

Thickness-dependent gap energies in thin films of HfTe5



AFM image of a contacted acicular HfTe5 crystal.



Bandgap energies E_G as a function of sample thickness with a linear fit