Danube University Krems.
The University for Continuing Education.

Nanotechnologie und Materialien in der Sensorik

Center for Integrated Sensor Systems (CISS)

(Center· Expertise · Research · Selected Projects)

Wilfried Hortschitz

Danube University Krems (DUK)

- **Public university for life-long learning**
  - Research-guided, practice-oriented teaching
  - Interdisciplinary approach in teaching and research
  - International lecturers and partner universities
- **Faculties**
  - **Health and Medicine**
  - **Business and Globalization**
  - **Education, Arts and Architecture**
- **Centers for excellent research**
- **6,000 students per year**
- **450 employees**
- **Commercial and modern management**
- **Own earnings 77%**

CISS — Key Facts

- **History**
  - April 2004: Established at the Austrian Academy of Sciences
  - April 2013: Affiliation to the Danube University Krems (DUK)
- **Status Quo**
  - 33 researchers, focus on interdisciplinary research
  - Multinational & interdisciplinary team (electrical and mechatronics engineers, physicists, computer and software scientists, mathematicians, micro technologists, biochemists)
  - Located at the Technology and Research Center (TFZ) in Wiener Neustadt
- **Output**
  - > 1000 peer-reviewed articles and presentations at international conferences
  - High rate on third-party funding in national and international research projects (>50 Million Euros since 2004)
  - (Co)Host of multiple international conferences
  - Comprehensive network of research and company partners
  - Awards: best paper, best theses, best project awards, invited keynotes, ..

Cooperation partner research 2015/16

Technische Universität Wien
Johannes Kepler Universität Linz
Universität Wien
Montanuniversität Leoben
Medizinuniversität Wien
Institut für Hochenergiephysik, Wien
Landesklinikum Krems
Landesklinikum St. Pölten
Klinikum Wels-Grieskirchen
Wassercluster Lunz
MedAustron, Wiener Neustadt
Austrian Institute of Technology (AIT)
CEST Kompetenzzentrum für elektrochemische Oberflächentechnologie GmbH, Wiener Nuestadt
AC²T research GmbH, Wiener Neustadt
ACMIT GmbH, Wiener Neustadt
Austrian Center of Competence in Mechatronics, Linz Center of Mechatronics GmbH, Linz
Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Wien
ALDIS GmbH
FH Burgenland, Pinkafeld
FH Wiener Neustadt
Universität Augsburg
TU Chemnitz
TU Dresden
Technische Universität Darmstadt
Universität Bielefeld
Universität Regensburg
Albert-Ludwigs-University Freiburg
Universität Bremen
Universität Erlangen-Nürnberg
Hochschule Ostwestfalen-Lippe
Fraunhofer-Anwendungszentrum Industrial Automation (IOSB-INA)
Institut für Automation und Kommunikation, Magdeburg
Leibniz Institute for Solid State and Materials Research (IFW), Dresden
Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences, Polen
School of Chemistry and Chemical Engineering, Zhongkai University, Guangzhou, China
ETH Zürich
CERN, Schweiz
University of Exeter, UK
University of York, UK
CNRS Institut Neel, Grenoble, Italien
Jožef Stefan Institute, Ljubljana, Slowenien
Universität Novi Sad, Serbien
Trinity College Dublin, Irland
Universität Leuven, Niederlande
Universität Catania, Italien
Universität Brescia, Italien
Universität Palma de Mallorca, Spanien
Technische Universität Sofia, Bulgarien
National Chao Tung University, Taiwan
University of California, Davis, USA
University of Maryland, MD, USA
National Institute of Science of Technology, USA
National Institute for Materials Science (NIMS), Tsukuba, Japan

Cooperation partner industry 2015/16

E+E Elektronik GmbH, Engerwitzdorf
Infineon AG, Villach und München
Oregano Systems GmbH, Wien
nxtControl GmbH, Leobersdorf
EVN Wasser, Maria Enzersdorf
Seelcon GmbH, Bergland
INAUT GmbH, Ruprechtshofen
ZKW, Amstetten
OCC, Mödling
Profactor GmbH, Steyr
OFI GmbH, Wiener Neustadt
tfic textile and fashion innovations and concepts e.U., Mistelbach
High Tech Coatings GmbH, Miba Coating Group, Vorchdorf
Happy Plating GmbH, Wiener Neustadt
Attophotonics GmbH, Wiener Neustadt
MED-EL GmbH, Innsbruck
Austriamicrosystems, Unterpremstätten
Reder Domotic GmbH, Pottenstein
PIU-Printex GmbH, Wien
Braincon Technologies GmbH, Wien
GeTEC Microscopy GmbH, Langenlois
SCL Sensor.Tech.Fabrication GmbH, Wien

Fresenius Medical Care, Bad Homburg, Deutschland
Steinberg & Partner, Soes, Deutschland
VACUUMSCHMELZE GmbH & Co. KG, Deutschland
Siemens AG, Deutschland
SIMetris GmbH, Deutschland
microfab GmbH, Deutschland
Seagate Technology, UK
Meggitt A/S, Dänemark
Xensor Integration B.V., Niederlande
Imasonic SAS, Frankreich
Toyota Motor Corporation, Japan

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Micro and Nano Sensors

Hubert Brueckl

Distributed Systems and Sensor Networks

Albert Treytl

Modeling and Simulation

Thomas Schrefl

Water and Environ-mental Sensors

Martin Brandl

Danube University Krems
Center for Integrated Sensor Systems
Viktor Kaplan Str. 2 E
2700 Wiener Neustadt, Austria

Homepage
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Email
First.LastName@donau-uni.ac.at

Research Fields

Micro and Nano Sensors

Inertial & Resonant Sensors
Spintronics & Metamaterials
Thermal Sensors & Actuators
Magnetic Sensors
Hybrid Microsystems
Physical Biosensors
Viscosity Sensors

Distributed Systems and Sensor Networks

Data Management and Coordination in Sensor Networks

Localization and Clock Synchronization

Security in Sensor Networks

RFID in Sensor Networks

Modeling and Simulation

Analytical and Semi-analytical Modeling

Numerical and Network Modeling

Sensor Simulation and Optimization

Material Modeling and Characterization

Process Characterization and Optimization of MEMS/NEMS processes

Water and Environmental Sensors

Optical and Fluorescent Biosensors

Thermal Lens Spectroscopy

Online Water Quality Monitoring

Electrochemical Detection (e.g, E. coli)

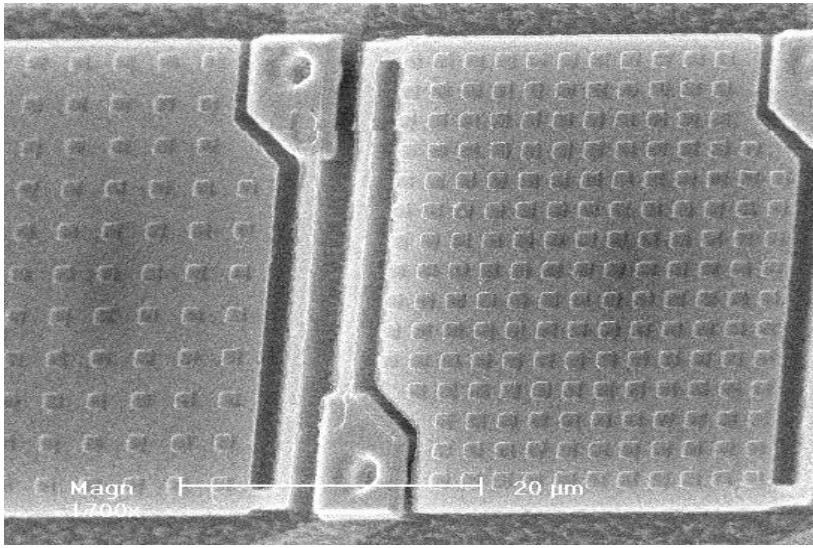
2016

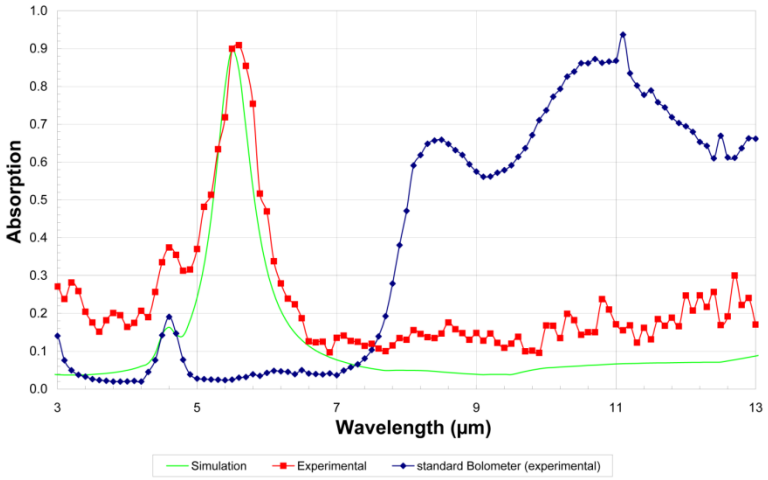
Infrared Detectors and µ-Bolometer Cameras

- **Features**
  - Sensitivity range: 3-15 µm (thermal IR)
  - Uncooled operation
- **History**
  - Night vision for military
- **New applications**
  - Thermography: energy saving
  - Night vision: automotive
  - Infrared camera for mobile phones
  - Gas detection (fingerp

IR Bolometa

- metamaterial implementation
- fully CMOS compatible
- no resonator required
- simpler fabrication rules
- sharp absorption resonance
- tunable wavelength
- extension to visible
- extension to µ-wave possible



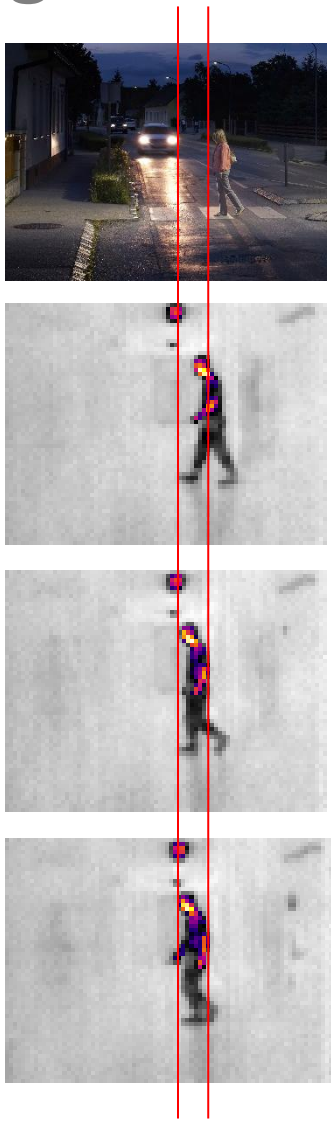


µ-Bolometer ⇒ µ-Bolometa

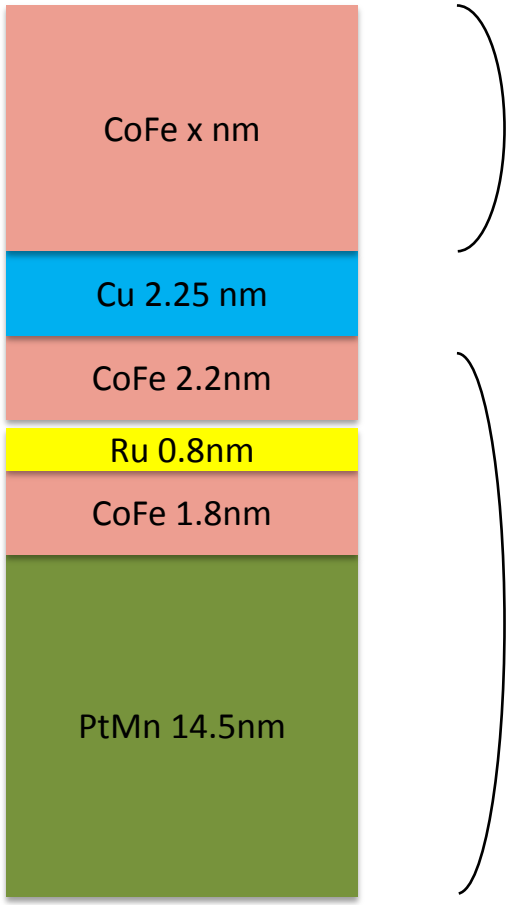
T. Maier, H. Brückl "Wavelength-tunable microbolometers with metamaterial absorbers" Optics Letters 34, 3012 (2009)

Canopus – Sensors for Smart Traffic Management

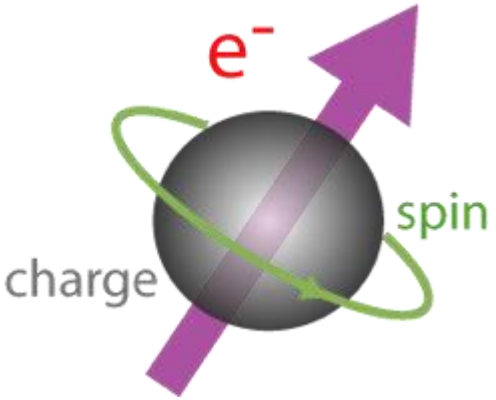
- **Recognition of different traffic participants**
  - Pedestrians, cyclists, cars, busses, trucks
- **Development of low-pixel infrared sensor**
  - micro bolometer based with 80x60 pixel
  - Local autonomous signal processing
  - Wireless connection to traffic management/street lighting
- **Investigations of different recognition algorithms**
  - Usability for embedded systems
  - E.g. HOG descriptor + SVM
- **Applications**
  - Smart street lighting, optimizing intersection traffic, construction area monitoring, …



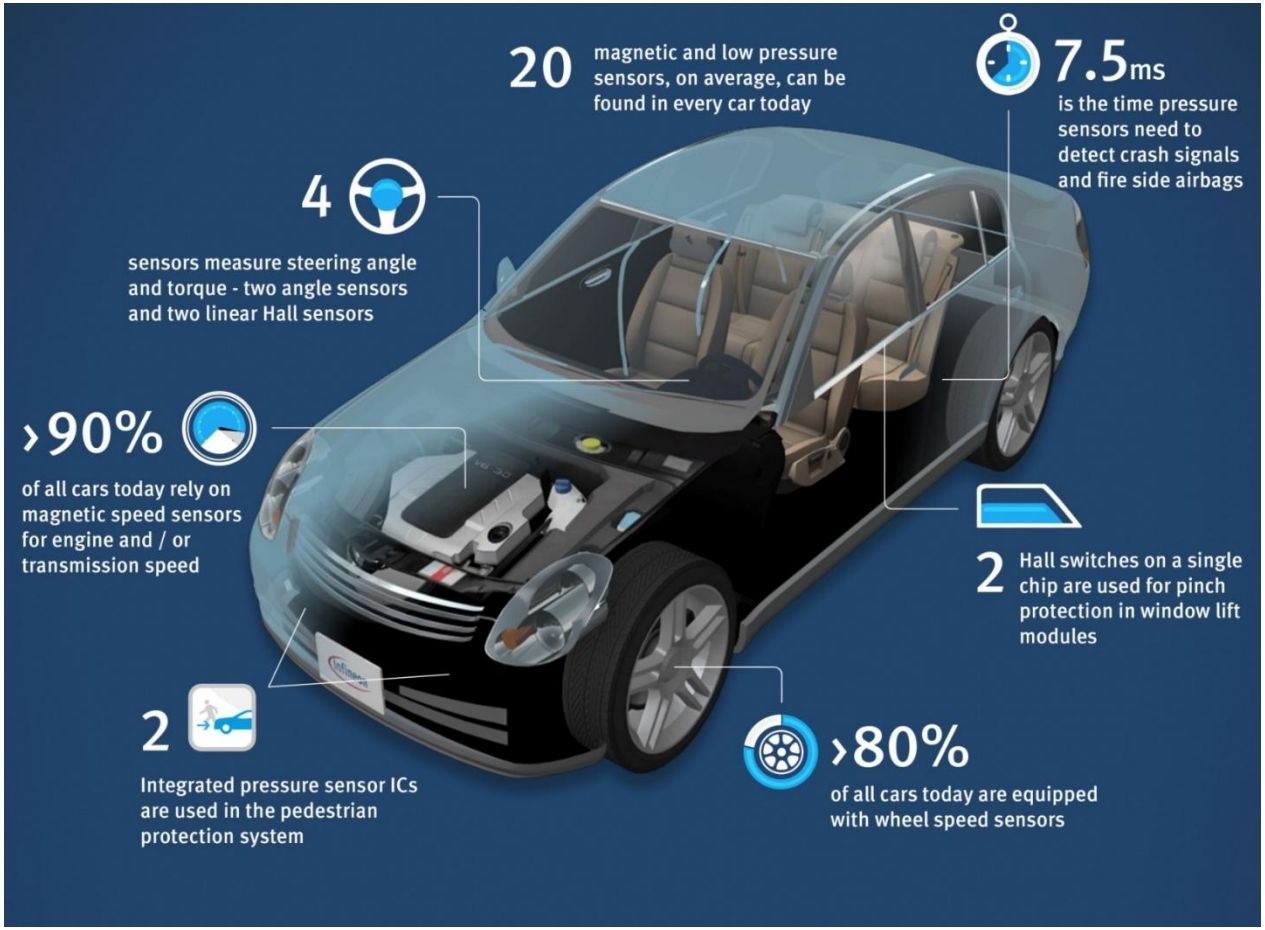
Spintronics and Magnetoresistive Sensors



Hubert Brückl



Automotive Sensors (VUT, Infineon)



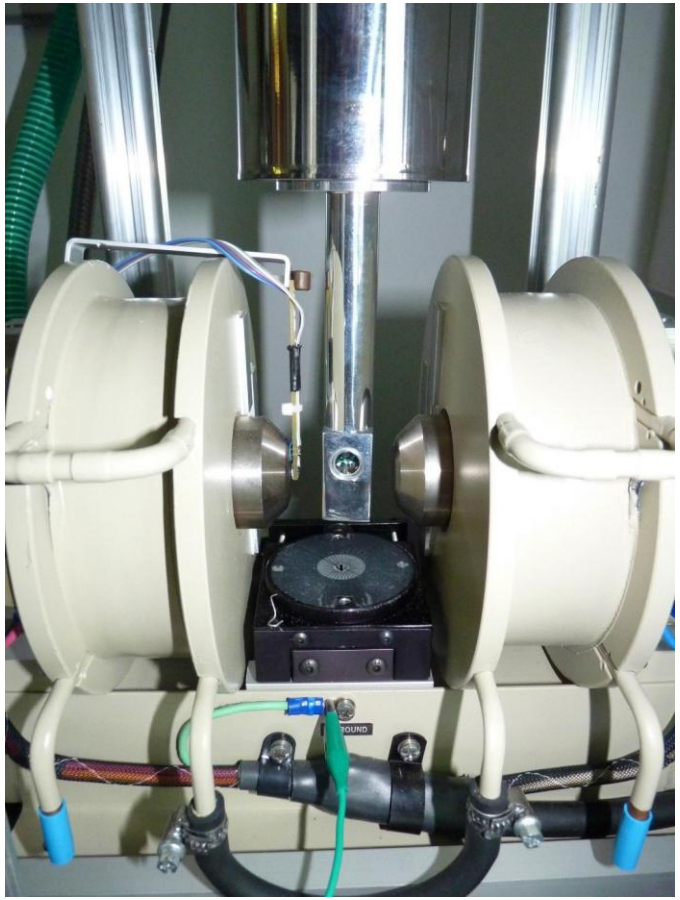
infineon

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

Christian Doppler Forschungsgesellschaft

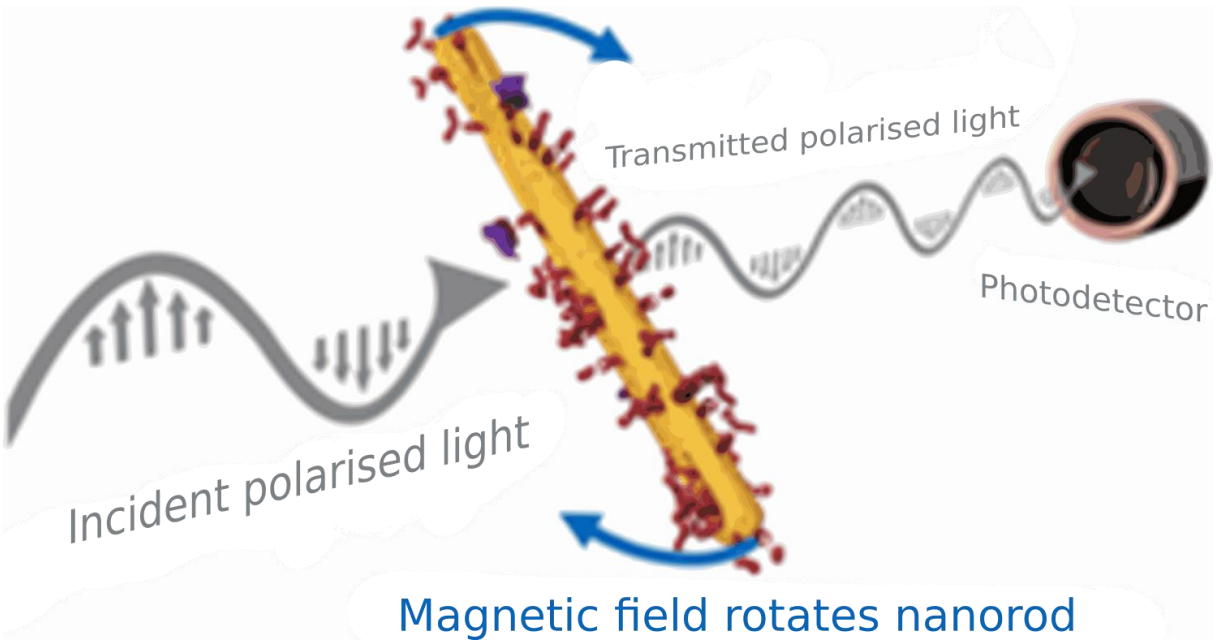
Next generation of magnetic sensors: from Hall and AMR to GMR and TMR

Analytical system for magnetic and magnetoresistive films and sensors



- Linear and rotating magnetic fields up to 0.5 T
- Cryostat from Advanced Research Systems, US, between 20K and 450K
- Software from SensorSolutions XMR
- Evaluation of magnetoresistance, magnetization, magnetic susceptibility, noise, current-voltage-curves
- Alternating Gradient Magnetometer (AGM) and Magneto-Optical Kerr Effect (MOKE) (only at room temperature)

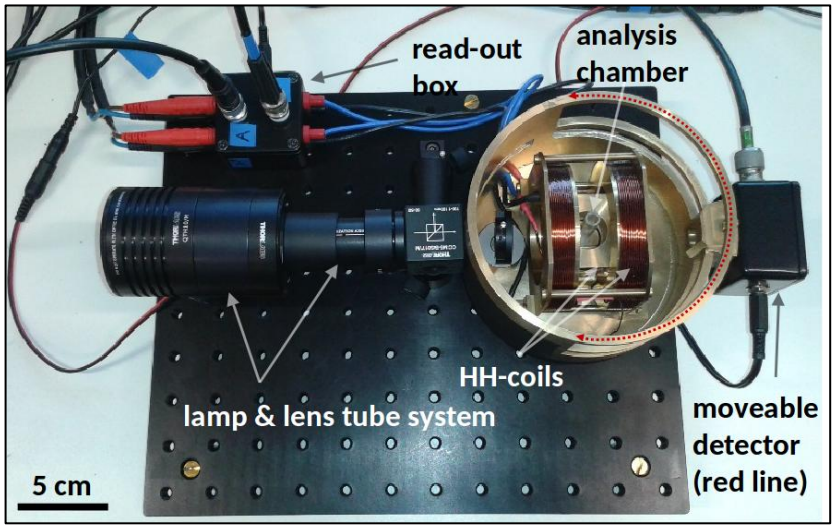
Idea: Magnetic Lab-on-a-Bead for biomolecular diagnostics



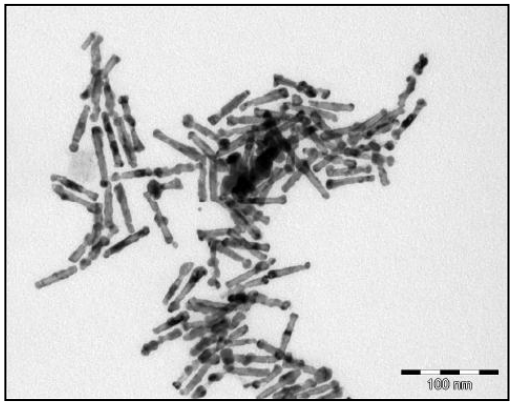
Functionalized magnetic nanoparticle in fluid

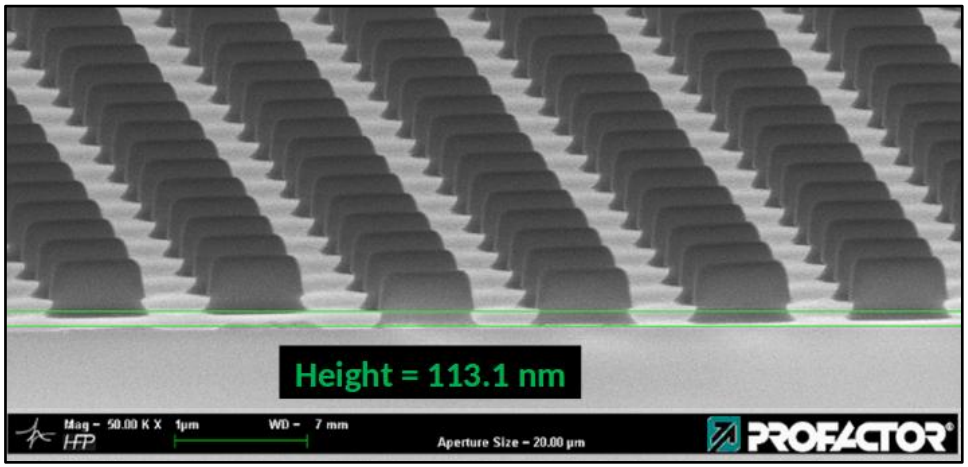
- Increase of molecule number due to specific binding
- Increase of hydrodynamic volume
- Phase lag of rotating nanoparticle

Advantages of this method



- Point-of-care use
- Simple
- Fast
- Desktop or hand-held
- Real-time: binding process observable
- Magnetic: active control
  (accelerated binding ?)

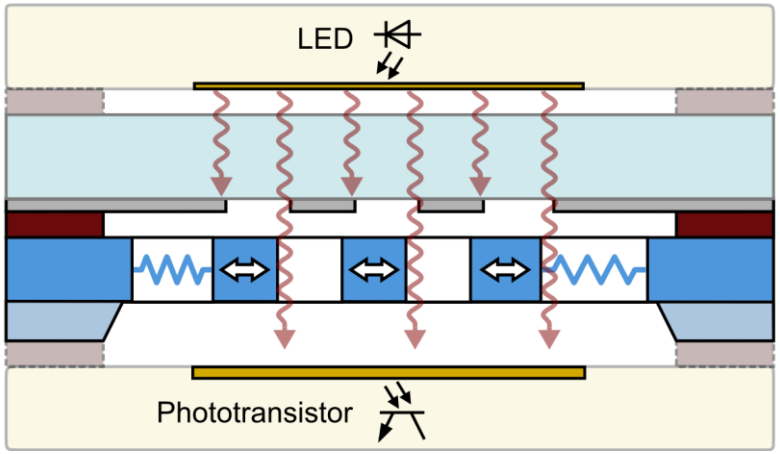


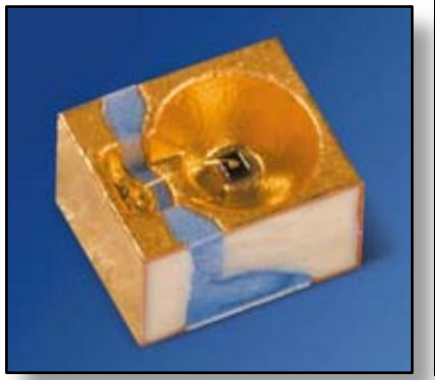


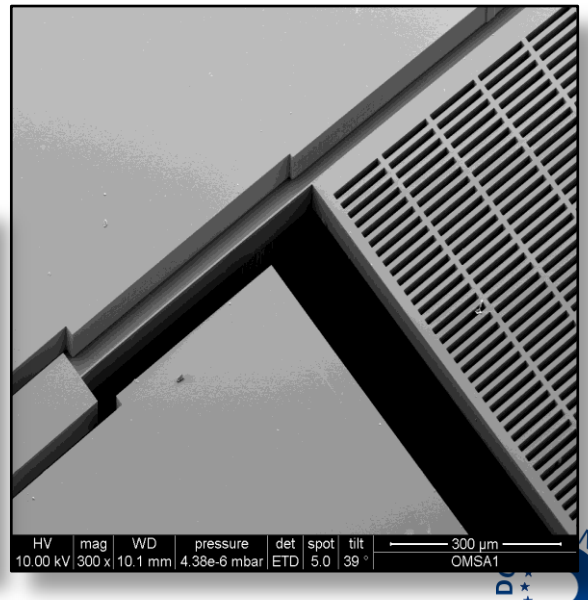
Hybrid MOEMS

- **Transduction principle**
  - Light flux modulation
  - Spatially separated gratings
- **Features**
  - Simple fabrication
  - Designable output characteristic
  - sub-pm/√Hz displacement resolution
  - Galvanic separation of force input and opto-electronic readout
  - Self-test capability (via feedback control)

- **Applications**
  - Displacement sensor with sub-pm resolution
  - Inertial or vibration sensor
  - Magnetic gradient sensor
  - Electrostatic field sensor (ElFiS)
  - Earth quake sensor

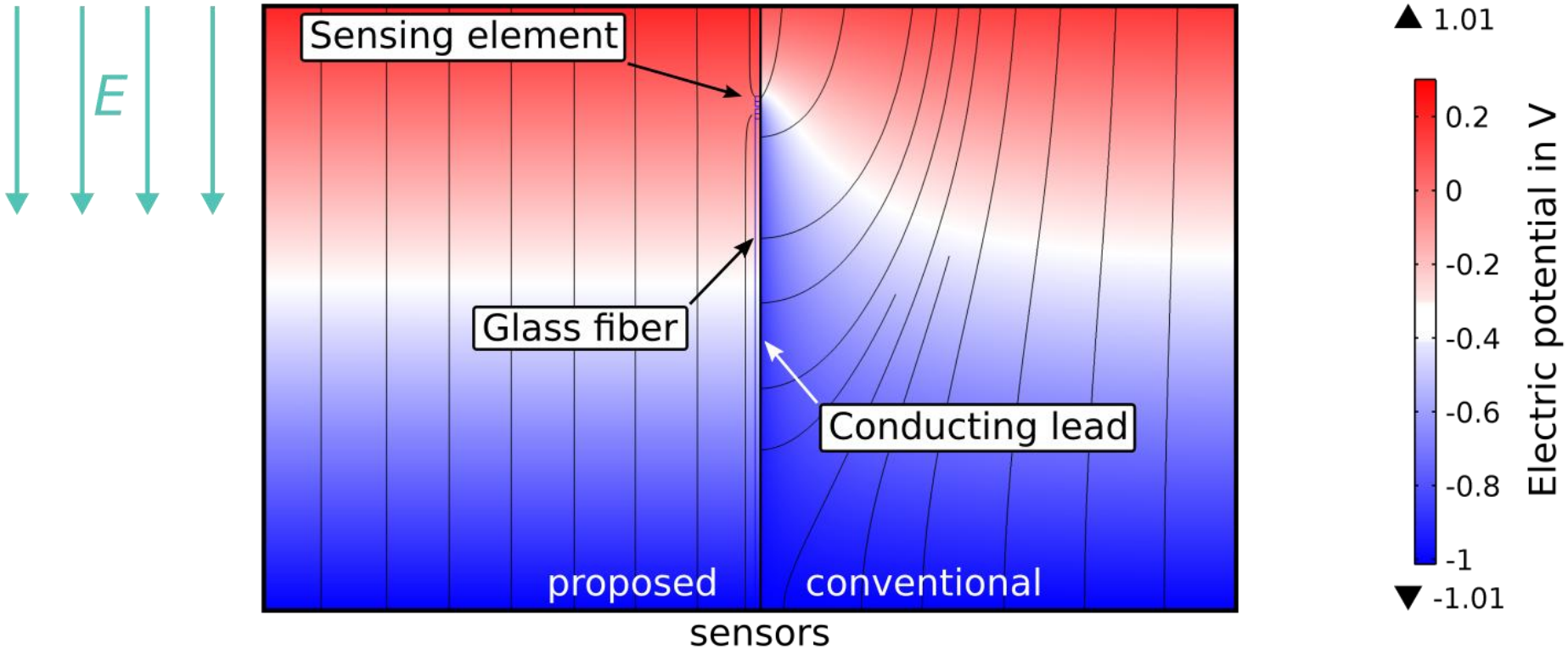






Galvanic decoupling in E-field measurement

Distribution of the electric potential around the grounded sensor



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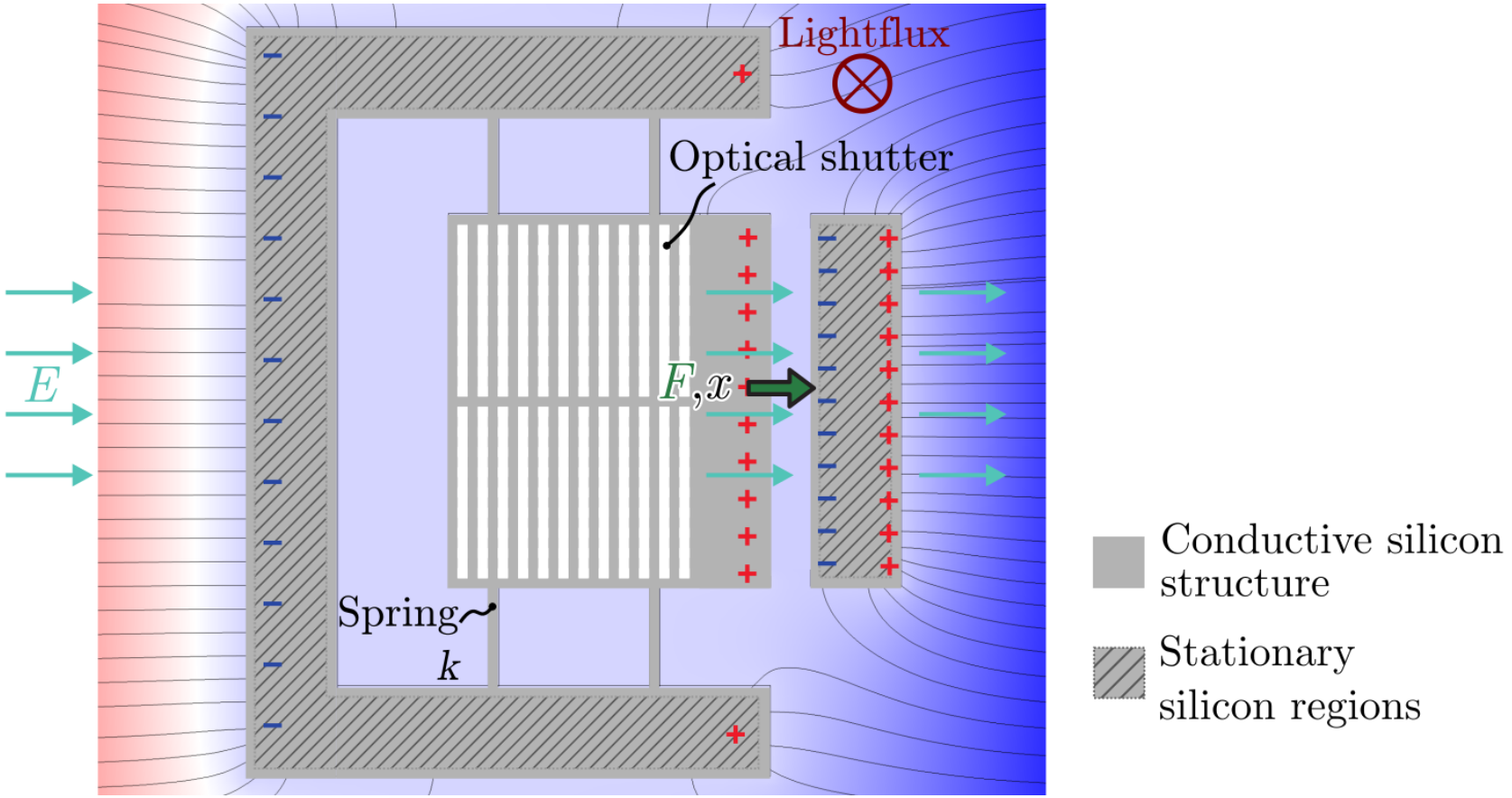
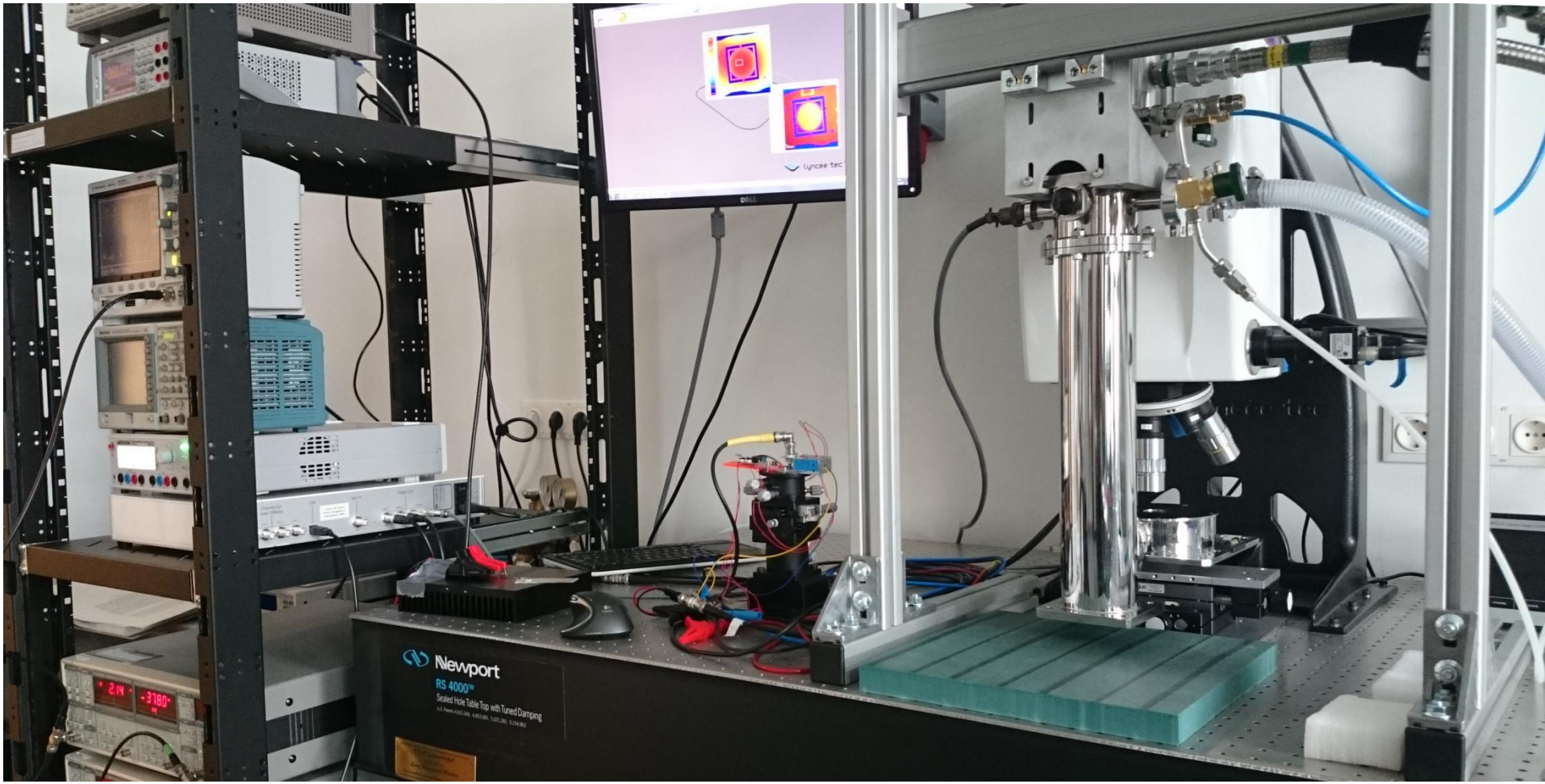


Applications in industry

- ESD
  - Monitor facilities for solid state electronics e.g. soldering stations
  - Harmful effects of importance in industry, including gas, fuel vapor and coal dust explosions
- Precaution against collision with powercables in aviation
- Industry
  - Electrostatic precipitator
  - Electrostatic supported painting

Digital Holografic Microscope R-2100 from Lyncee Tec



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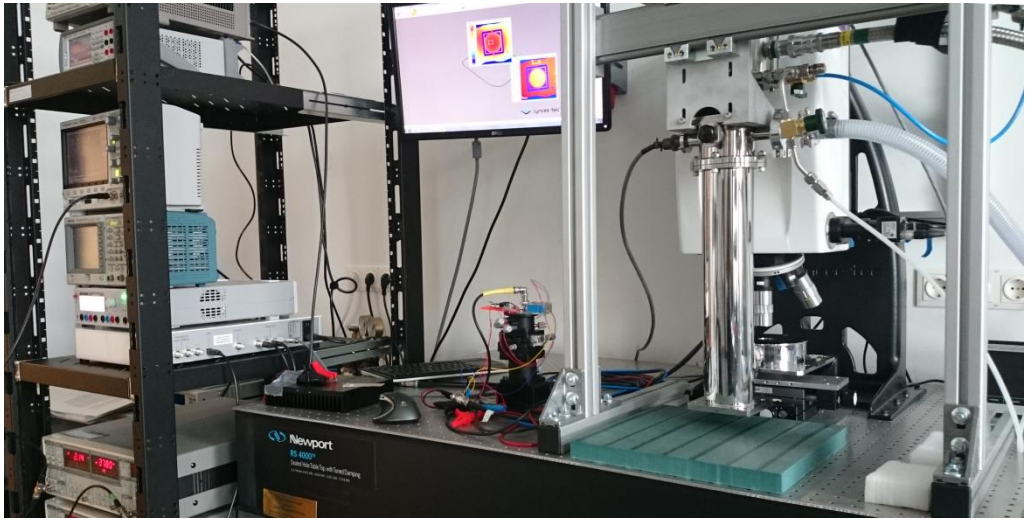


3D vibration analysis

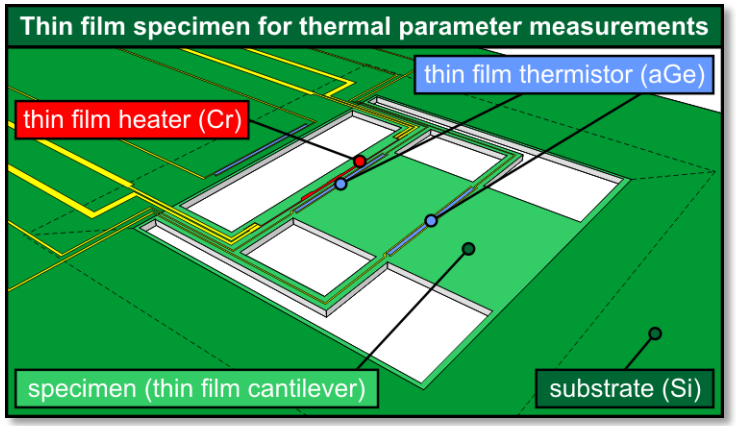
- Measurements over the entire field of view without scanning the XYZ coordinates.
- In-plane vibration resolution of 1nm and an out-of-plane vibration resolution of up to 5 pm.

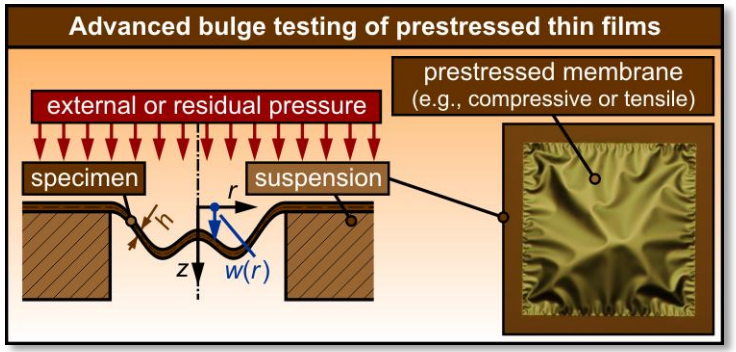
Dynamic live 3D topography

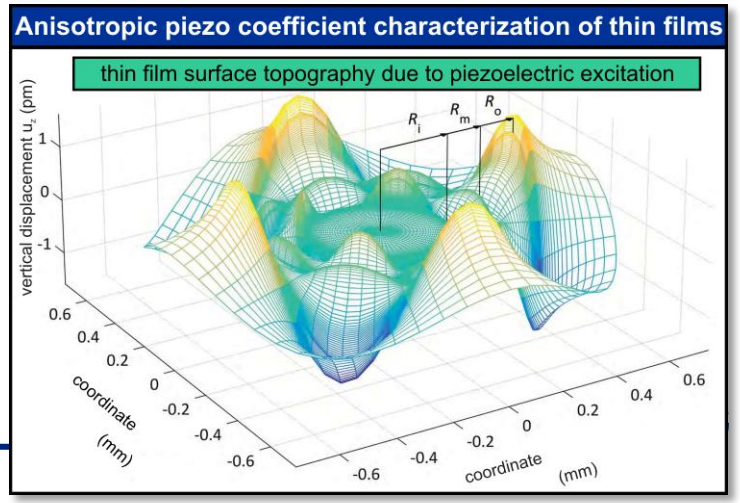
- Bandwidth from DC to 25 MHz
- Measurement of vertical velocities up to 10 m/s

Thin Film Material Characterization

- **Microfabrication facility characterization**
  - Physical parameters of thin films are in general process dependent!
  - Accurate knowledge for design/optimization
  - Custom-tailored specimens for measurement
- **Physical parameters of interest**
  - Young's modulus
  - Residual (tensile or compressive) stress
  - Thermal parameters (conductivity, diffusivity, heat capacities)
  - Piezoelectric tensor components
  - Selected stiffness tensor components
- **Measurements and data extraction**
  - Electrical, vibrometry, AFM, SEM, TEM, EBSD, nanoindentation
  - Highly sophisticated analytical and semi-analytical models
  - Fast, reliable, accurate techniques

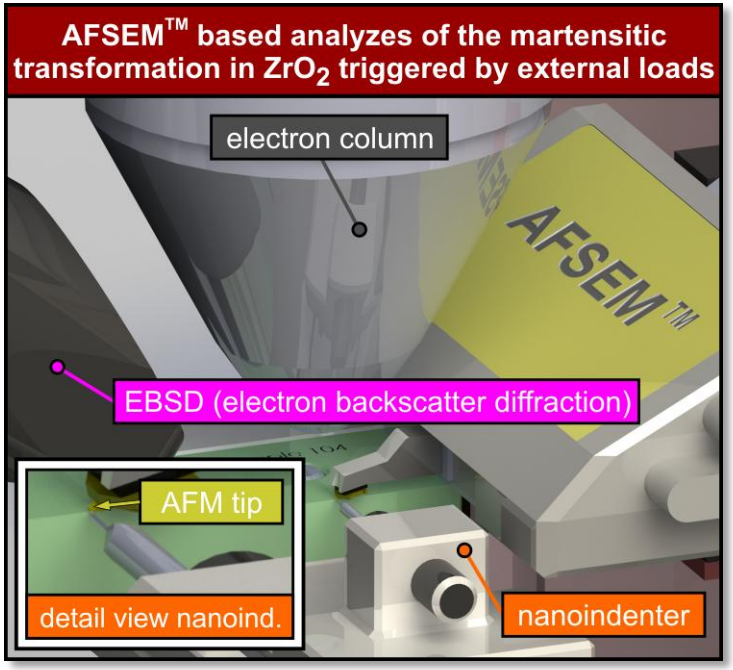


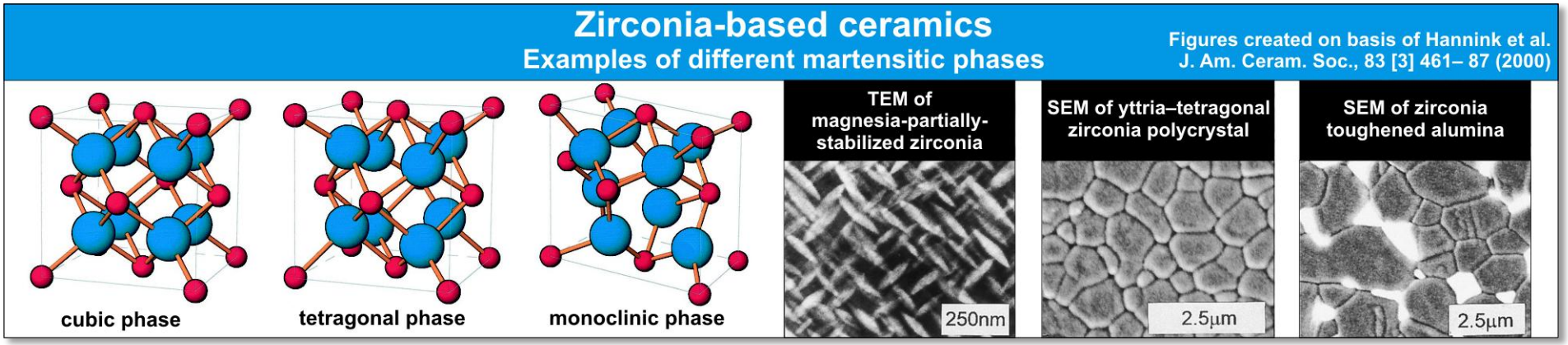




Bilateral Project: ICON

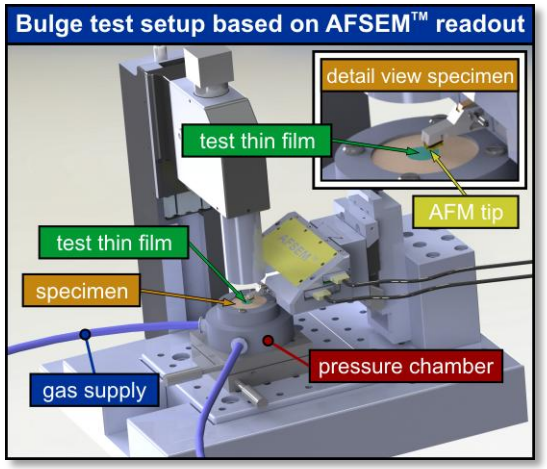
- **Bilateral project** between **Austria** and **China**
- **ICON =** Improvement of ZrO_2 hard coatings by novel characterization tools
- **Partner**
  - GETec Microscopy GmbH
  - Shanghai Inst. of Ceramics, Chin. Academy of Sciences
- **Project goals and potential applications**
  - Development of novel characterization tools for
    - accurate *in situ* correlative analysis of martensic transform in nano films for studying ceramic toughening,
    - highly accurate AFM-based bulge testing of ultra thin (elastically anisotropic) films
  - Improve zirconia-based hard coatings for applications in femoral implants, thermal barrier coatings, etc.

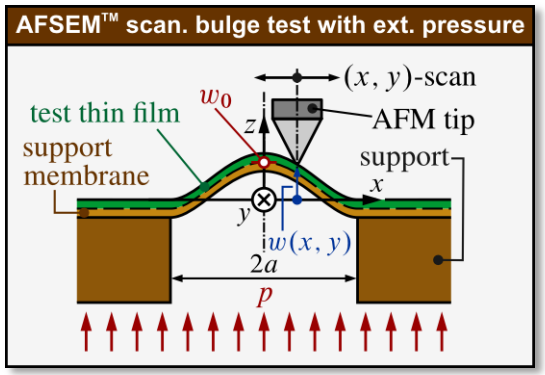


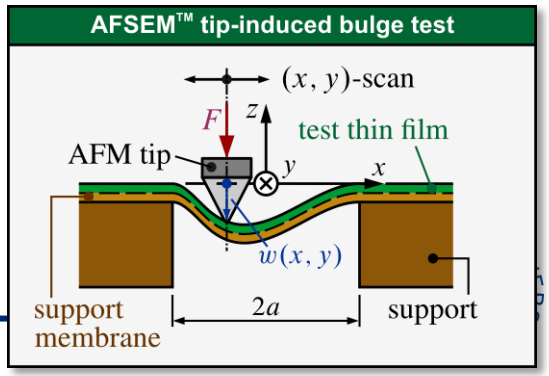


AFSEM™-based bulge testing

- **Standard bulge test technique**
  - Optical measurement of the load-deflection (LD) characteristics, i.e., the center deflection w_0 of a membrane in response to an external load (e.g., a differential gas pressure) p
  - Fit of a theoretical LD model to the measured $p(w_0)$ characteristics in order to determine the Young's modulus and residual stress
- **Drawbacks of the standard bulge test technique**
  - Only the center deflection is taken into account
  - Inaccurate because of the generally unknown clamping and overall bending characteristics
  - Not applicable to gas permeable membranes
  - Not applicable to optically transparent membranes
  - Not applicable to membranes with highly anisotropic elastic behavior
- **AFSEM™ scanning bulge test with external pressure**
  - Incorporation in a novel and highly accurate LD characteristics
  - Applicable to elastically anisotropic membranes
- **AFSEM™ tip-induced bulge test**
  - Applicable to ultra-thin membranes (e.g., graphene monolayers, MoS_2 sheets, etc.), translucent and gas permeable nano films, etc.

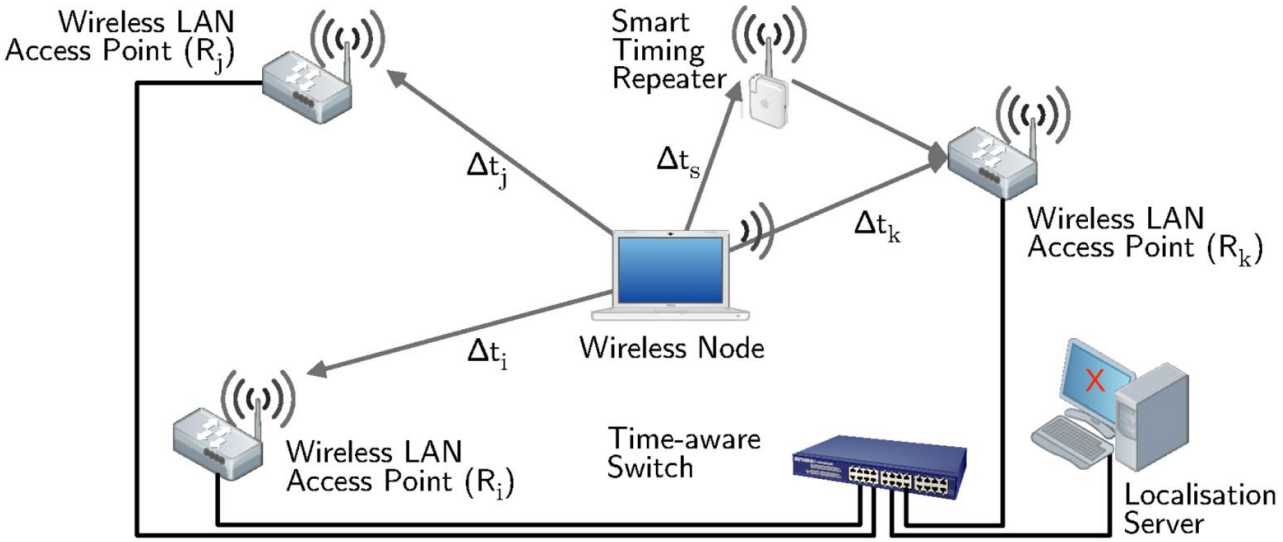


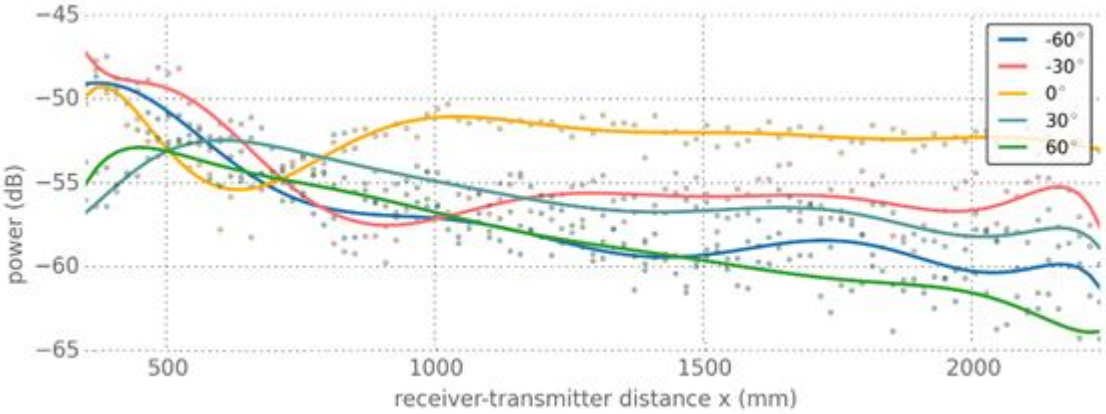




Localization of Wireless Devices

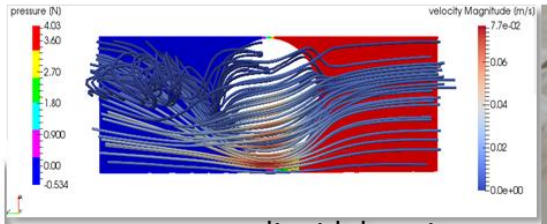
- **WLAN**
  - TDoA
  - high precision up to10cm
- **Bluetooth**
  - Novel RSS & AoA
  - Directional antenna
- **COTS nodes in both cases**



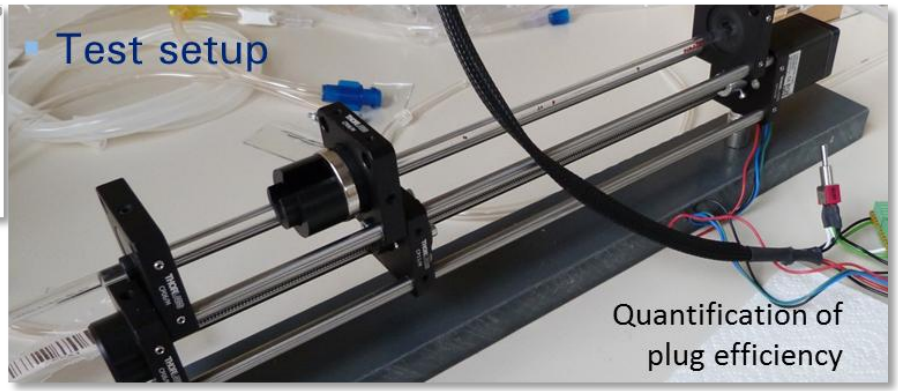


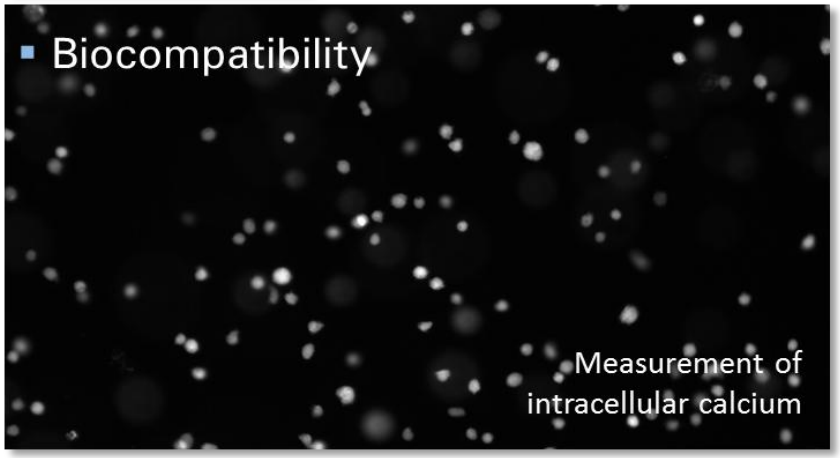
Gentle Pump

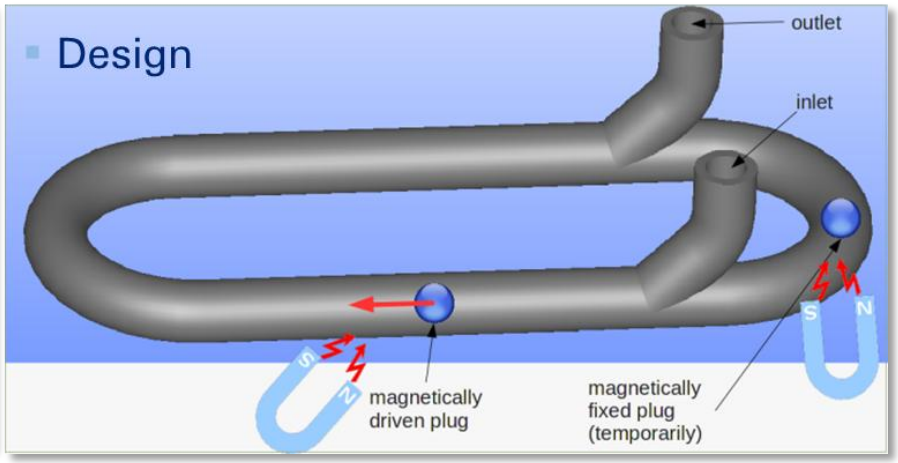
- Pumping system for the perfusion of cellular suspensions



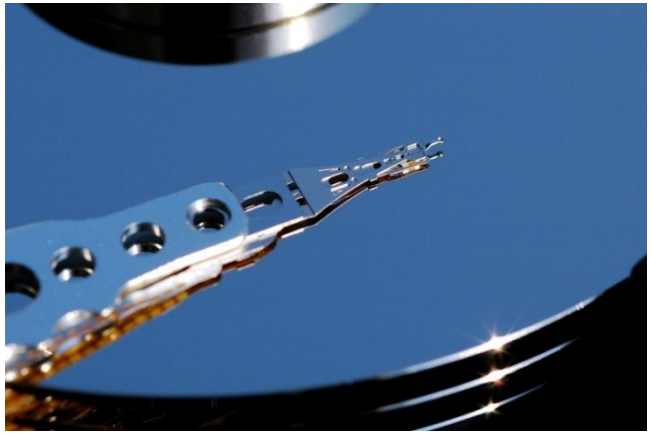
liquid domain
and
cell membrane

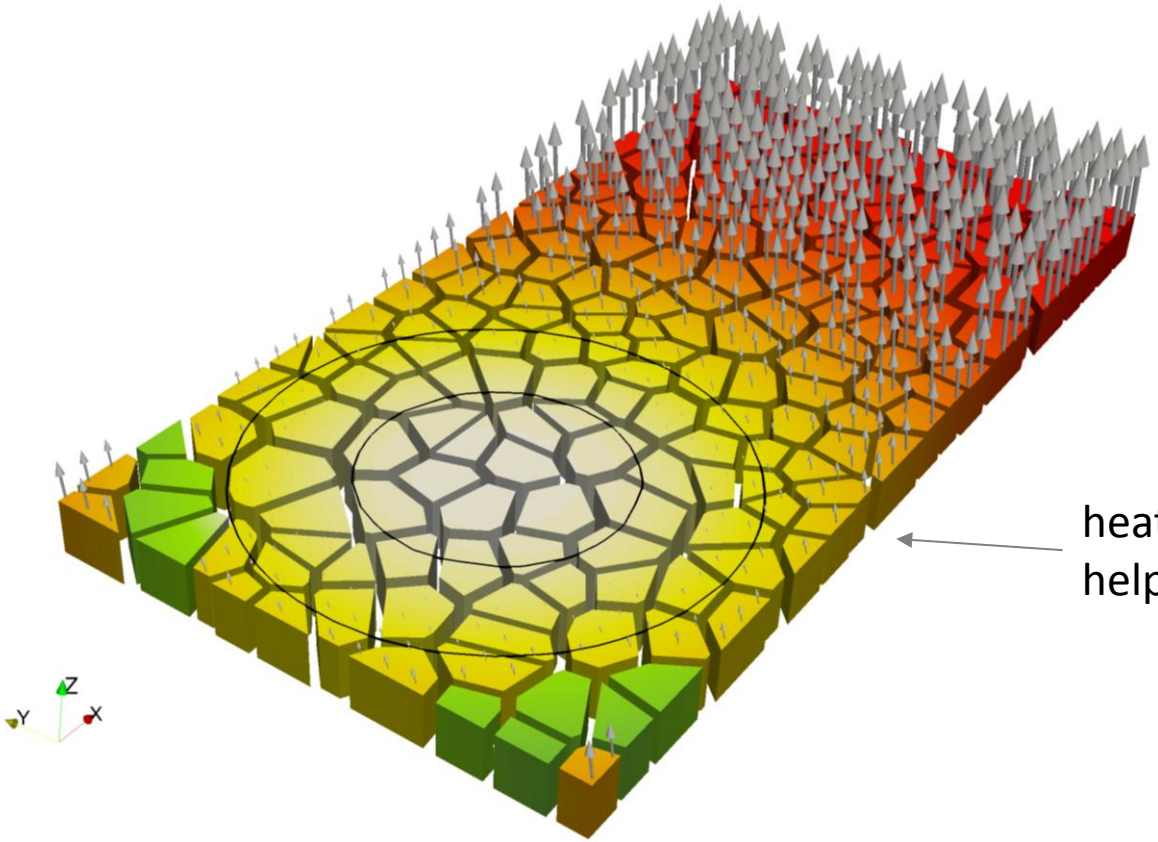






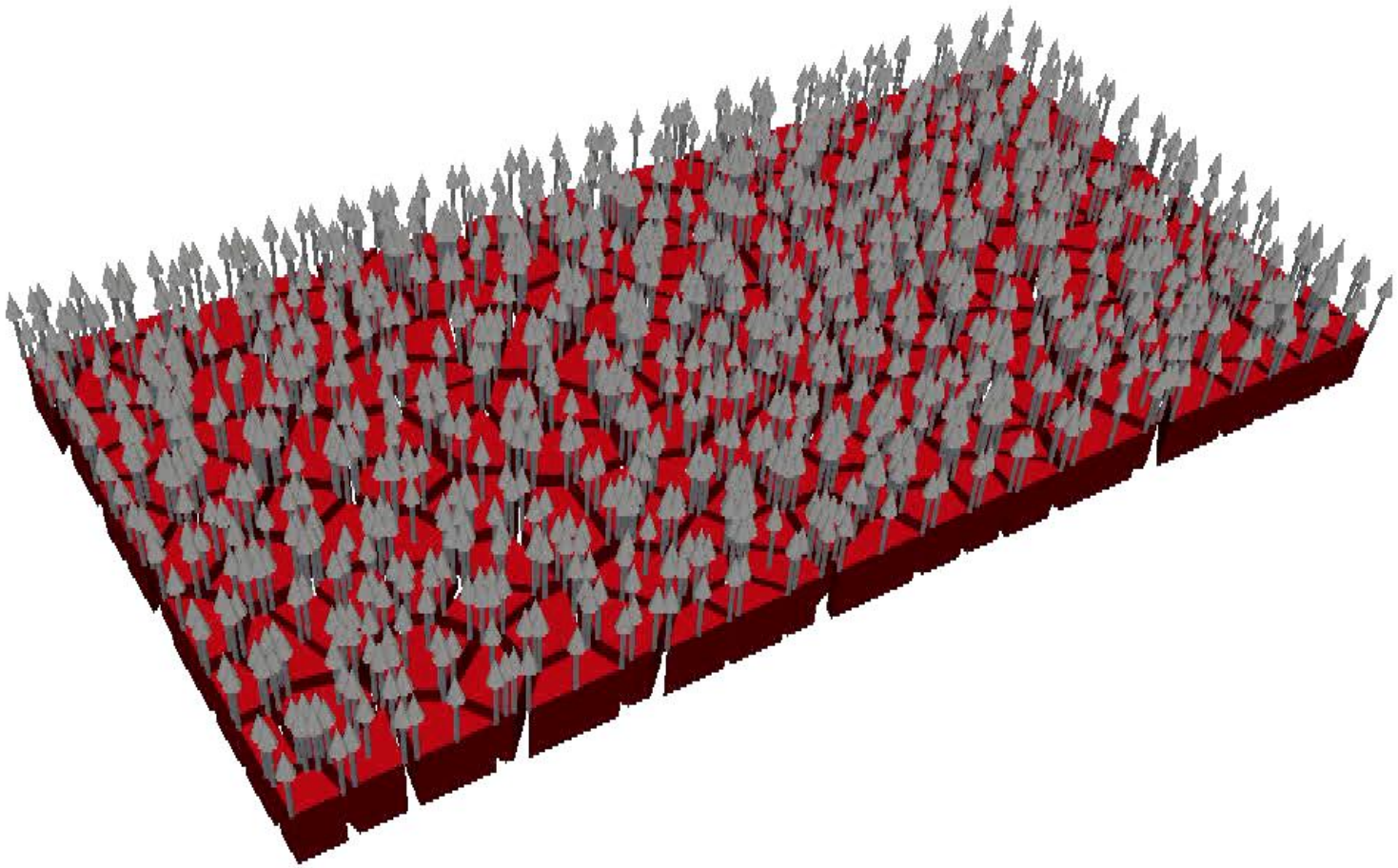
Heat assisted magnetic recording





heat spot (~50nm) by a laser pulse helps to write data

Heat assisted magnetic recording



Thank you for your attention !!

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