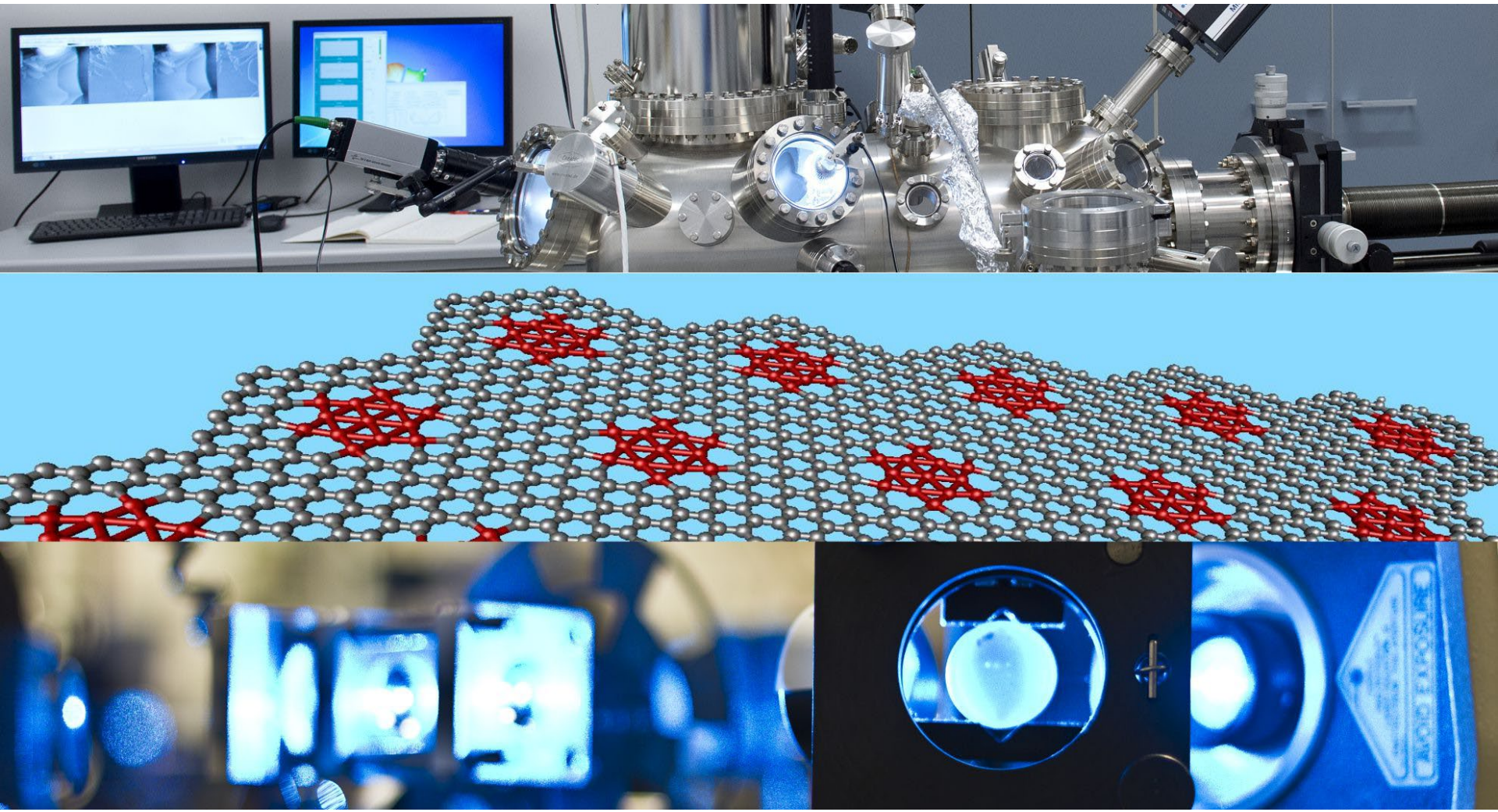
Physics @ AAU



Fundamental science and applications

Fysiklærerdag på Aalborg Universitet

Program

11.30-12.00: intro til forskning og uddannelser på Fysik/AAU, Lars Diekhöner

12.00-12.45: Materialer til Grøn Energi, Kjeld Pedersen

12.45-13.45: Laboratorierundvisning

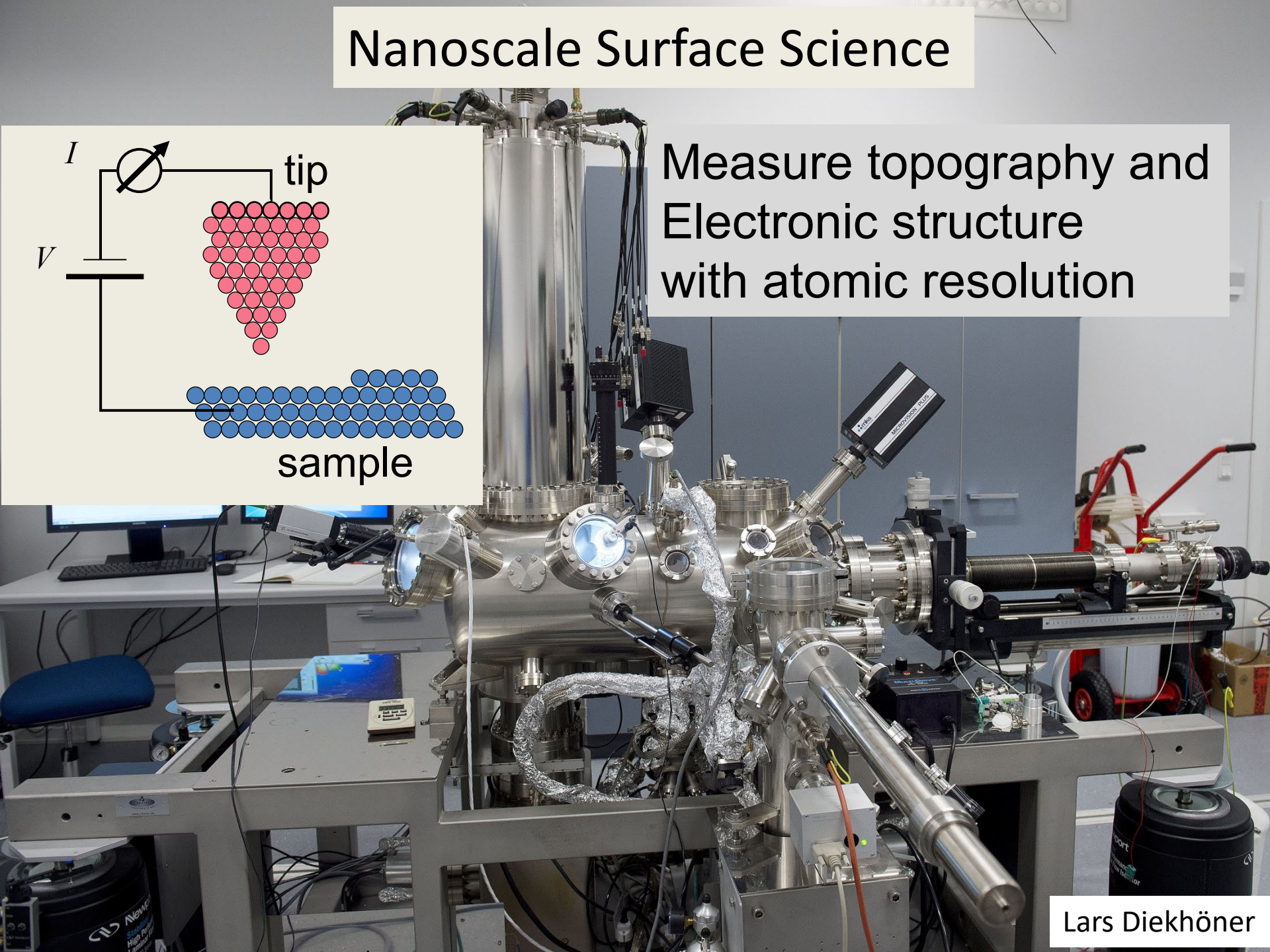
13.45-14.00: Kaffepause

14.00-14.45: Studenteroplæg, Kasper Porsborg Andersen

14.45-15.00: Afrunding og evaluering

Evaluering Gymnasielærerdagen 2025

Nanoscale Surface Science



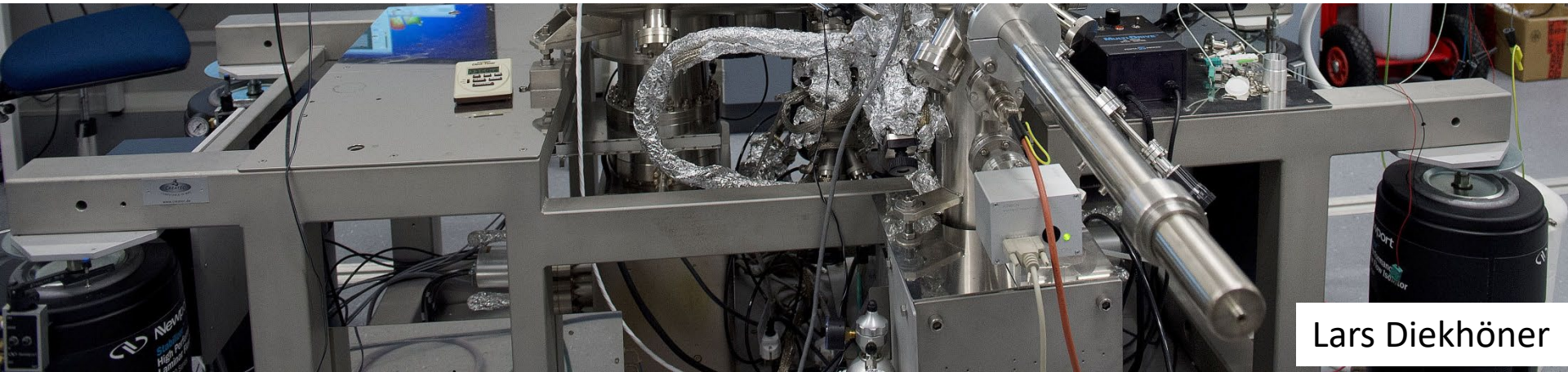
Measure topography and
Electronic structure
with atomic resolution

Lars Diekhöner

Nanoscale Surface Science

Properties of materials under well-controlled conditions

- single crystal surfaces: metals and semi-conductors
- thin films
- nanostructures
- clusters
- molecules (self assembly), magnetic, solar cells
- atoms



Lars Diekhöner

Nanoscale Surface Science

Properties of materials under well-controlled conditions

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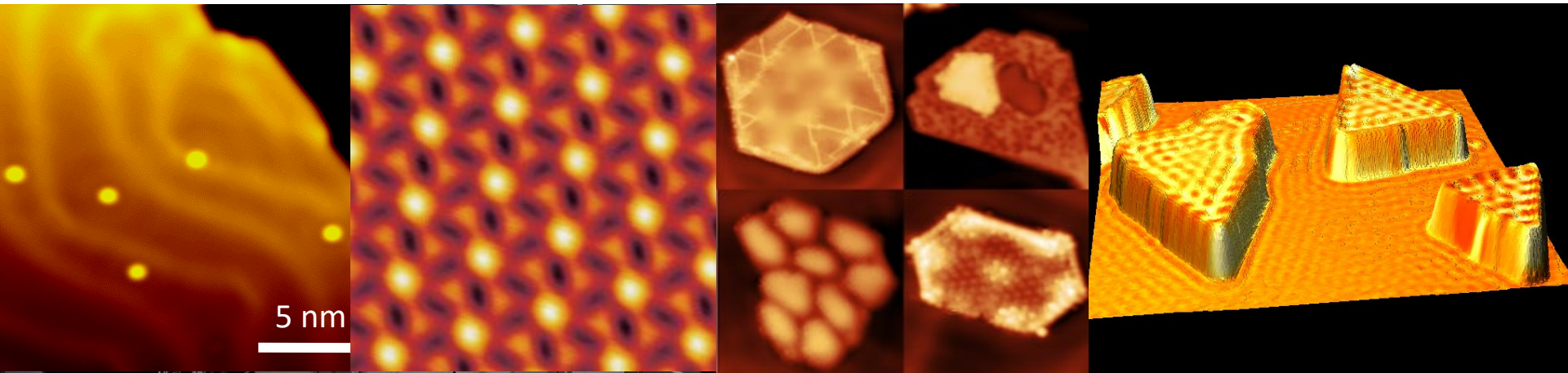
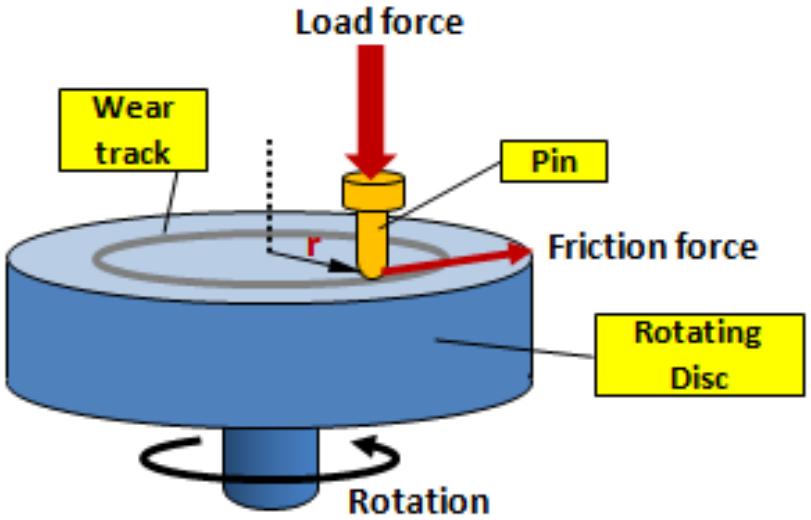
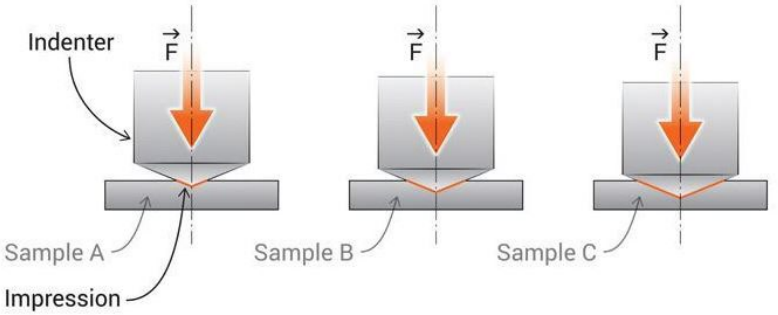


Mechanical testing of thin films

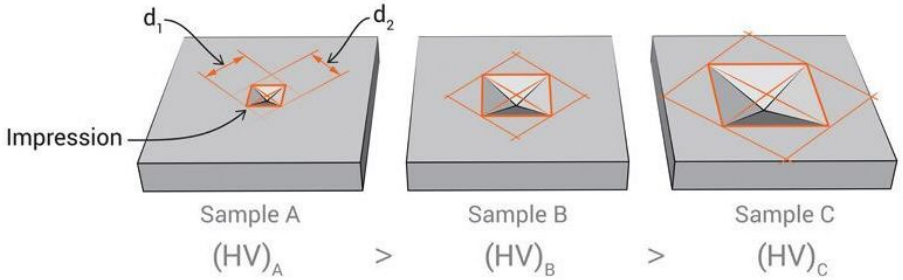
Wear test



Hardness

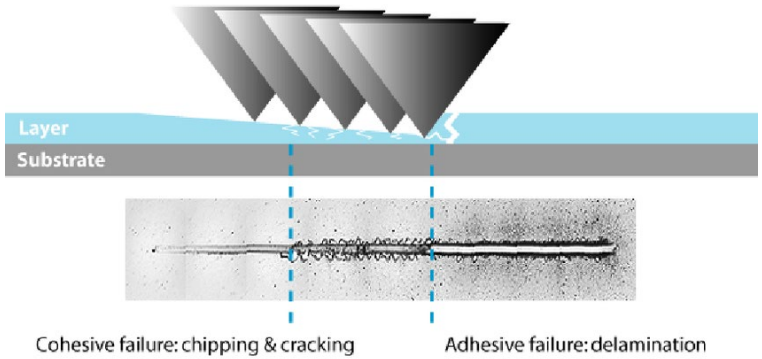


Measurement of impression diagonals



Adhesion

Progressive load measuring depth, friction & acoustic emission



Collaboration with Industry

- Cr-based coatings

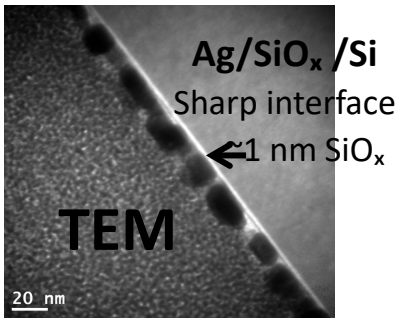
Lars Diekhöner

Materials for energy technology

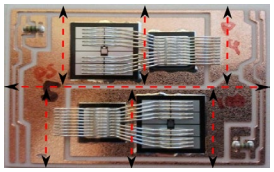
- Solar energy
  - PV cells (Light harvesting)
    - Metal particles
    - Structured contacts
  - Concentrated Solar Power
    - Absorber coatings
- Electrodes for catalysis
  - Structured substrates
  - Ferroelectric electrodes
- Power electronic devices
  - Packaging (Electrical connections)
  - Semiconductors (GaN,..)
- Degradation of Li-ion battery electrodes
- Nanoscale energy generation
  - Energy generation in the body
  - Piezoelectric nanostructures

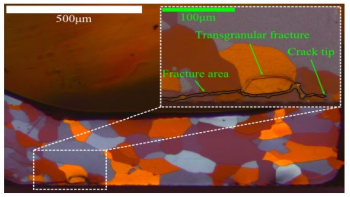
Coated absorber tube (Polyteknik)

Solar Energy, **118**, 410-418 (2015)



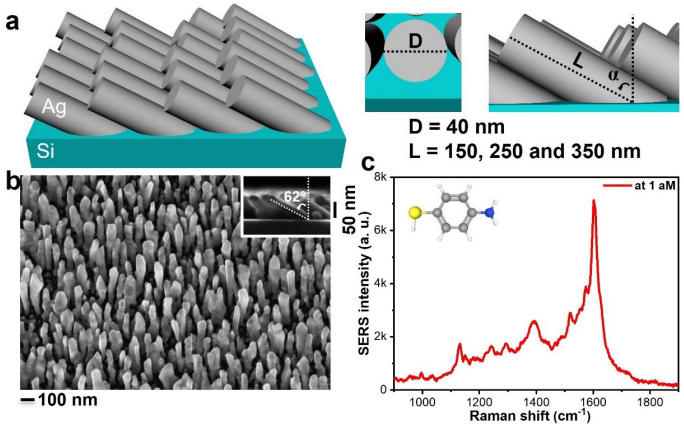
J. Appl. Phys. **120**, 235307 (2016).





IEEE Transactions on Power Electronics ***31****, 975 (2016)*

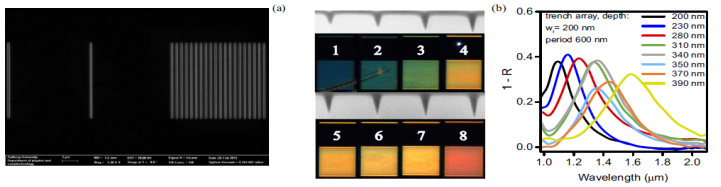
Glancing angle deposition



Kjeld Pedersen

Optical characterization of thin films and nanostructures

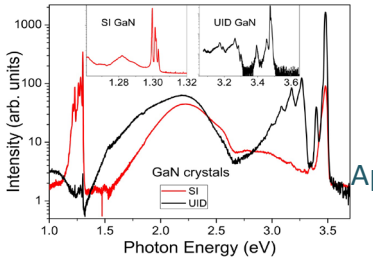
- Linear reflection spectroscopy
  - Plasmonic structures – design of optical properties
  - SERS



3 (2016).

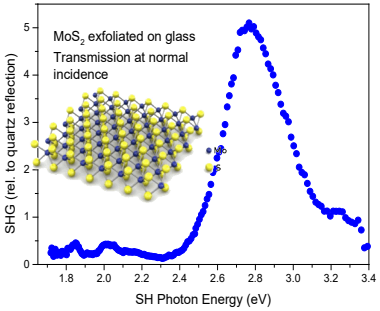
Nature Commun. **3**, 969 (2012).

- Photoluminescence
  - Semiconductor nanostructures
  - Organic nanowires

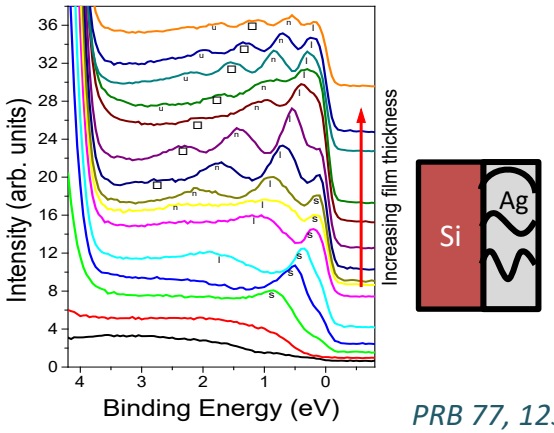


Appl. Phys. B (2017) 123:270

- Nonlinear optical spectroscopy – Harmonic generation
  - SHG spectroscopy and microscopy
  - SHG of surfaces and interfaces
  - IR – VIS sum frequency generation
  - Metal quantum wells
  - Semiconductor quantum dots



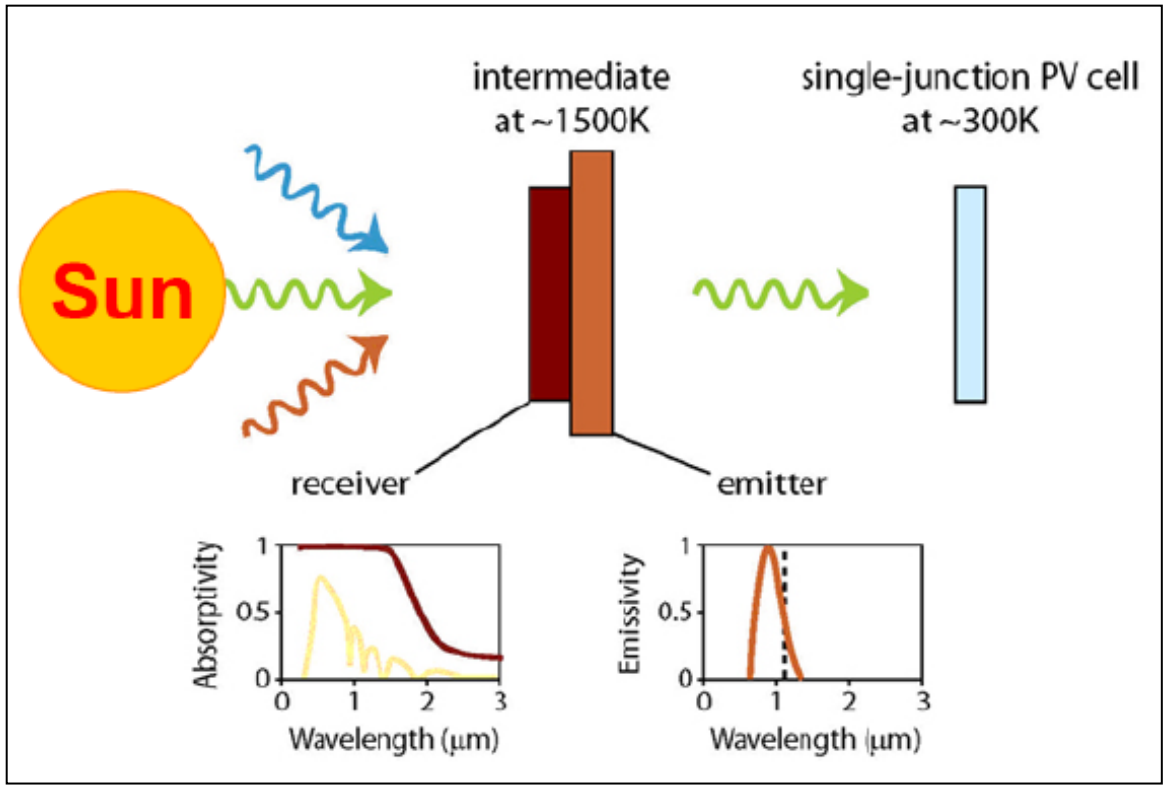
PRB ***92****,* 161409 (2015)



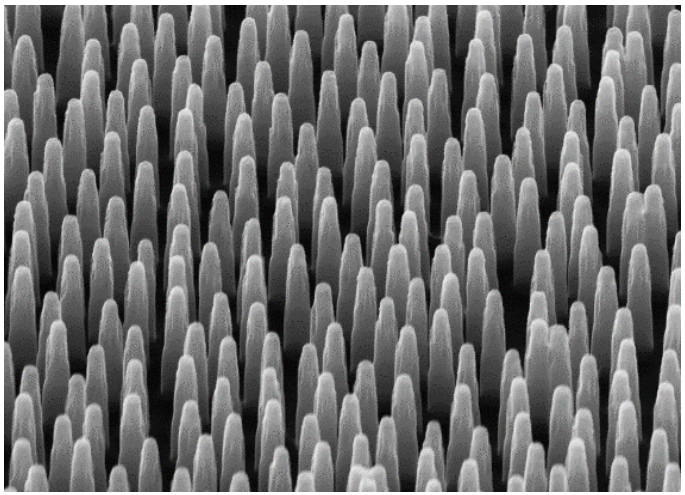
PRB 77, 125440 (2006)

THERMOPHOTOVOLTAICS

Solceller, problem: udnytter kun en begrænset del af sollyset



Titanium-Nitrid



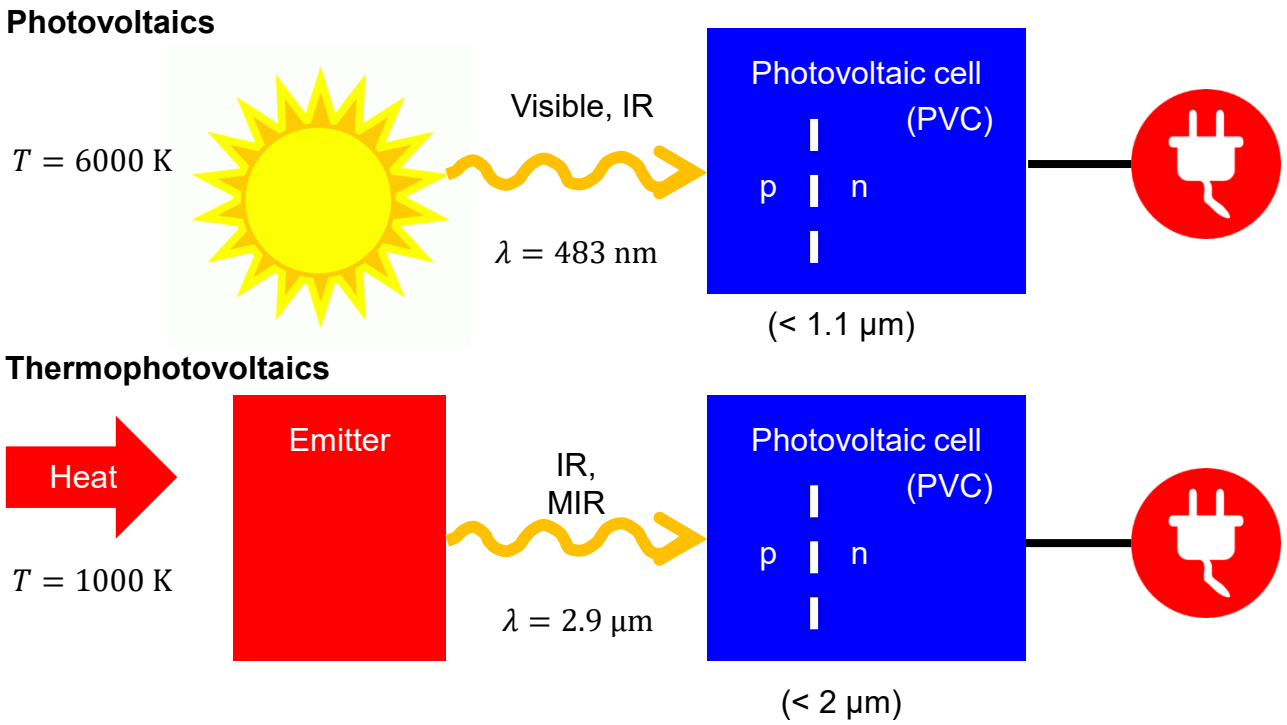
- Nanostrukturer: TiN nanosøjler absorberer effektivt solens lys
- Emitter som udsender lys svarende til solcellens båndgab
- Effektiv konvertering af solenergi til elektrisk energi

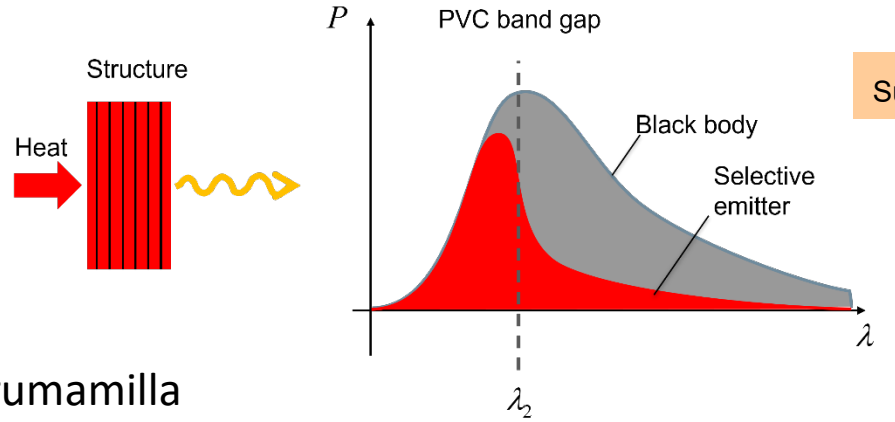
Manohar Chirumamilla

Thermophotovoltaics

generate power from heat source

AALBORG UNIVERSITY





Suppression of long wavelength radiation

Significant increase in efficiency

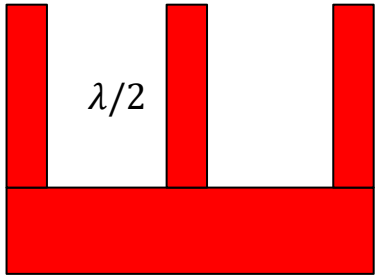
Manohar Chirumamilla

Department of
Materials and Production

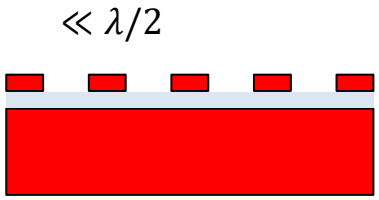
Several concepts with structured metals were proposed to provide selective emission/absorption at high T

SELECTIVE EMITTERS WITH STRUCTURED METAL

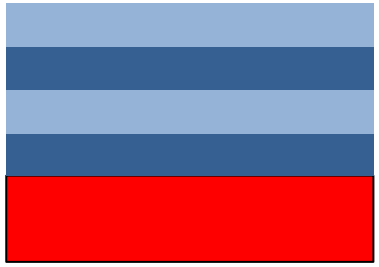
Cavity



Metamaterial / surface

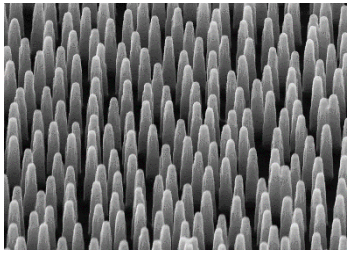


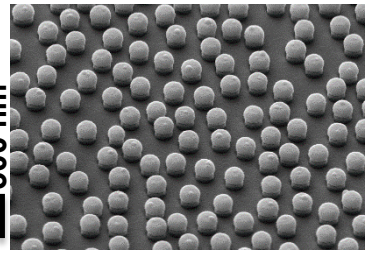
Metal + filter

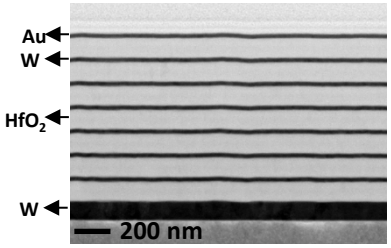


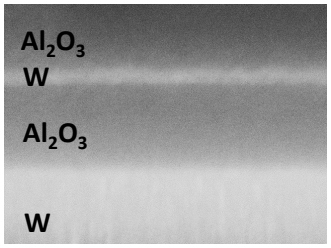
- Low temperature stability (metal diffusion at sharp edges)
- Difficult to manufacture (2D metal structuring required)
- Residual absorption in MIR (electric fields orthogonal to metal surface)

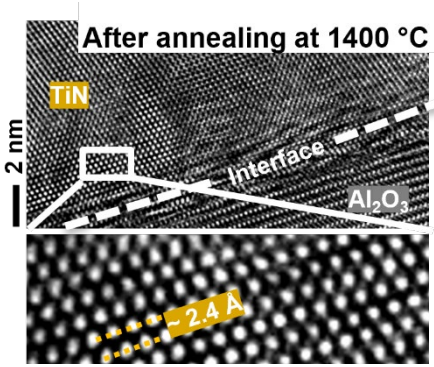
- Thermal stresses (thick coatings)
- Low emissivity above bandgap







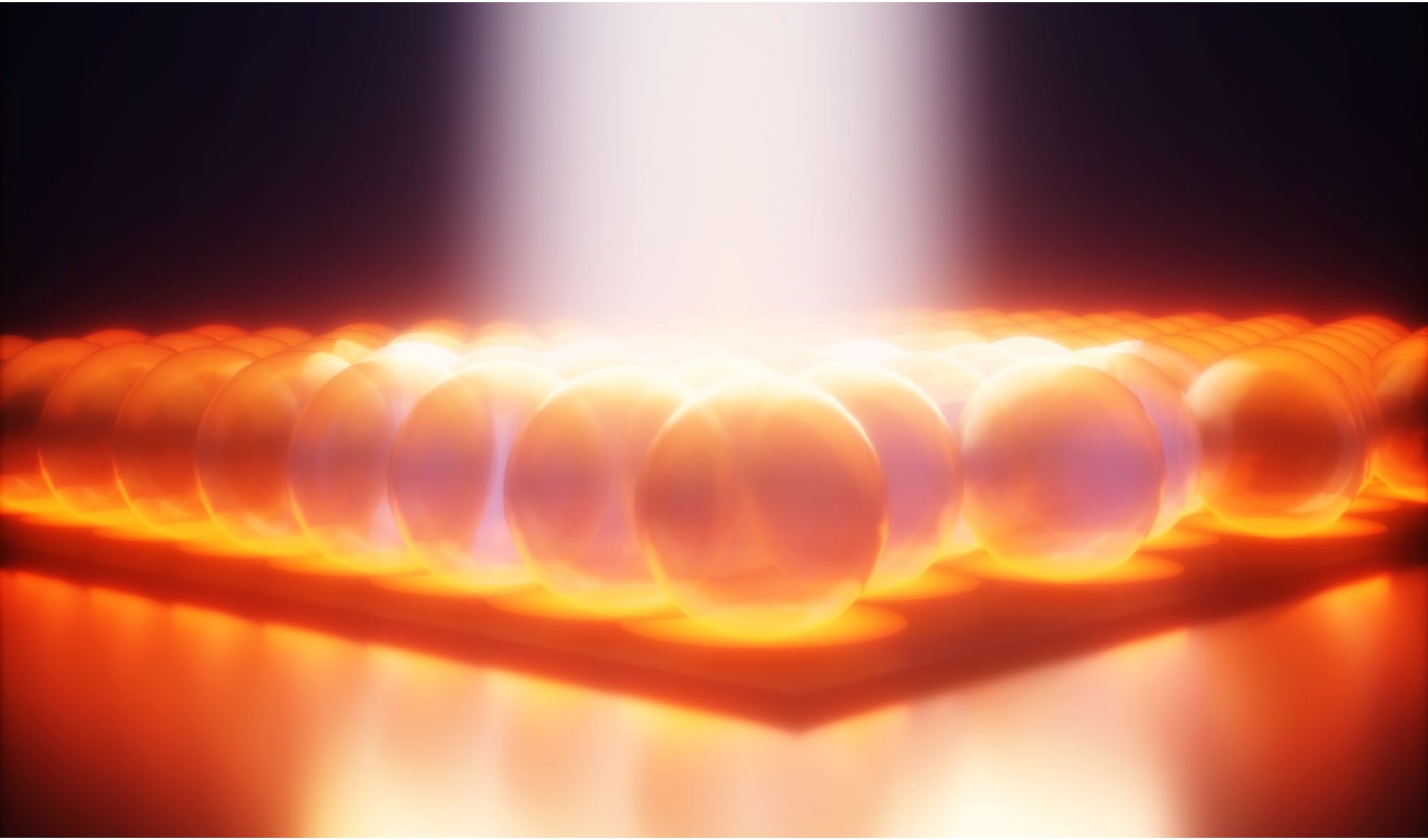




T. Kerkeler, et al., Adv. Opt. Mat. 9 (2021) 2100323;
M. Chirumamilla, et al., Adv. Opt. Mat. 5 (2017) 1700552;
M. Chirumamilla, et al., Scientific Reports 9 (2019) 7241;

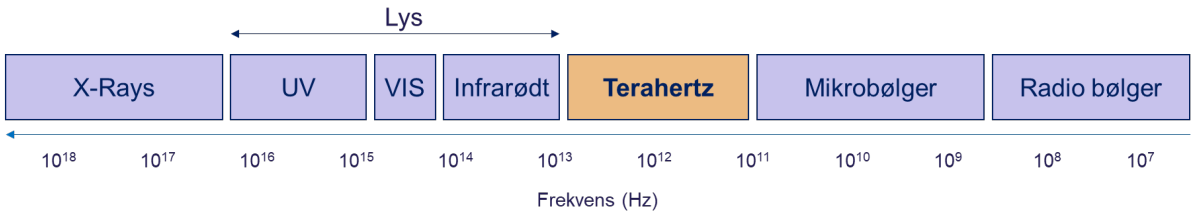
A. Chirumamilla, et al, Mat. Today Phys. 21 (2021) 100503;
M. Chirumamilla, et al., Opt. Mat. Exp. 6 (2016) 2704

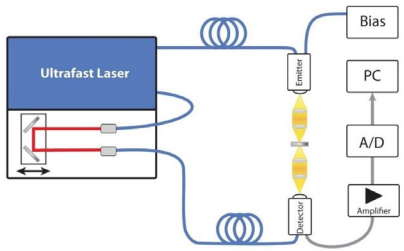
Selective emission at temperatures up to 1400 ºC



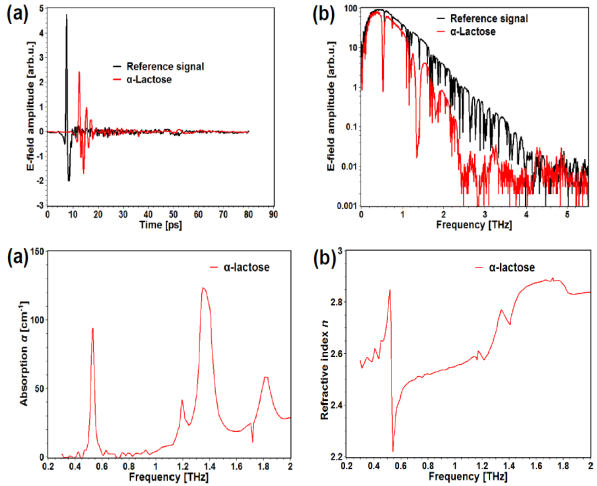
M. Chirumamilla, et al., Cell Reports Physical Science 6 (2025) 102850

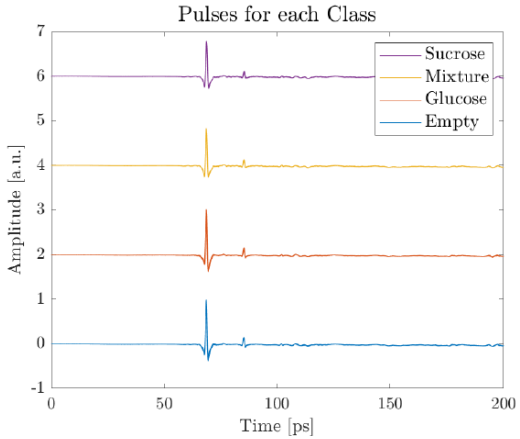
AI-assisterede terahertz sensorer

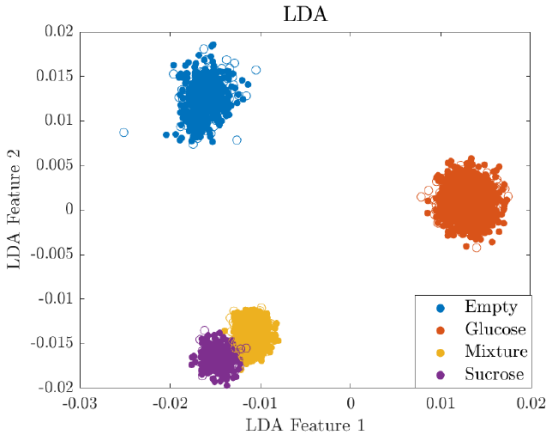




Fourier transform

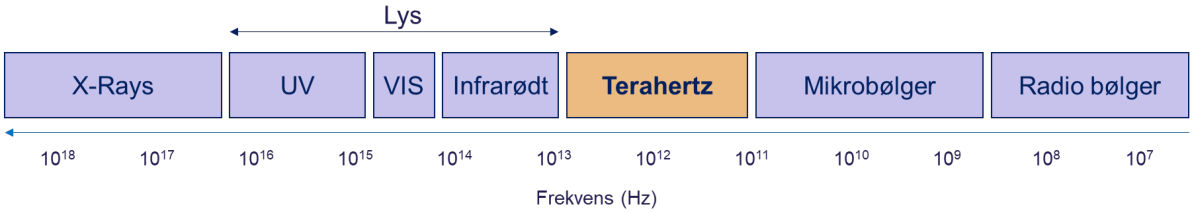


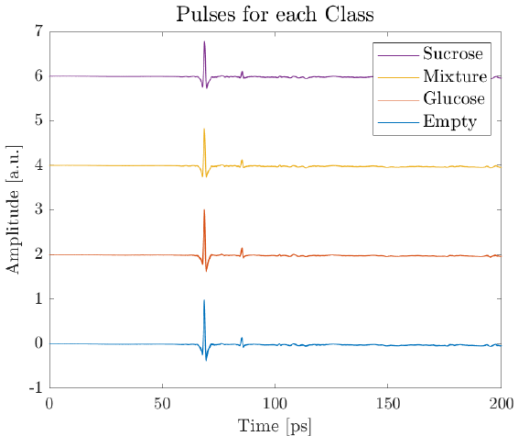


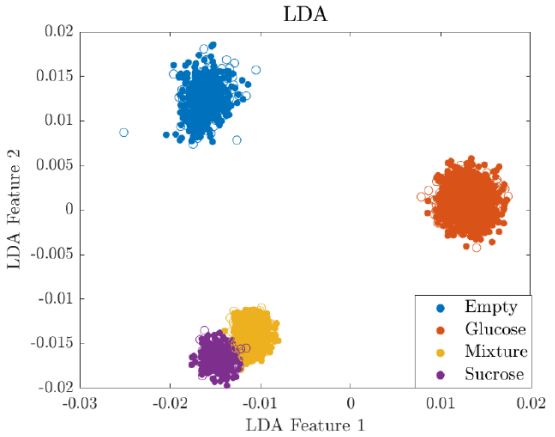


Esben Skovsen

AI-assisterede terahertz sensorer



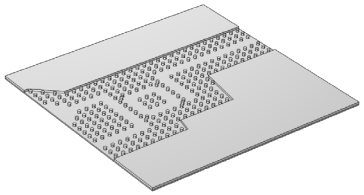


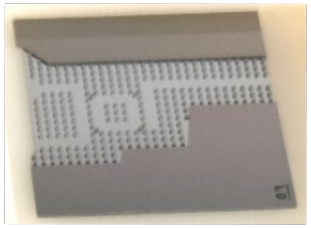


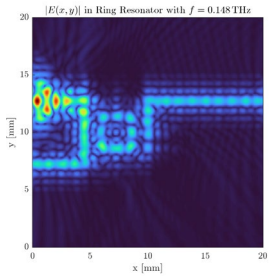
- Terahertz (THz) stråling er elektromagnetiske bølger i frekvens-området mellem infrarødt lys og mikrobølger
- Absorptions resonanser i THz området svarer til intra- eller inter-molekylære vibrationer, samt gitter vibrationer (fononer) i krystaller
- THz spektroskopi kan bruges til at genkende specifikke materialer med ”fingeraftryk i THz området, fx narkotika og sprængstoffer mm.
- AI-algoritmer kan trænes til at skelne mellem spektre fra forskellige materialer, selvom de er næsten ens.
- AI-assisterede sensorer er suveræne til at genkende specifikke materialer som de er blevet trænet til at finde.

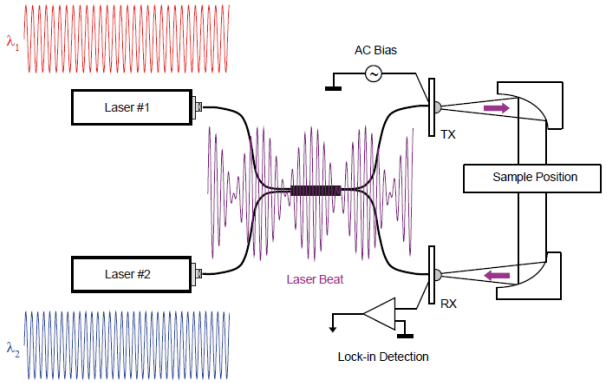
Esben Skovsen

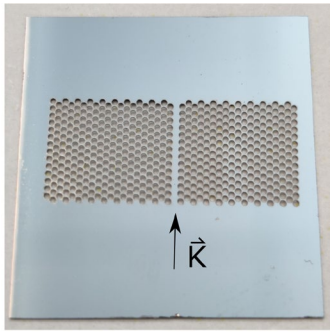
Terahertz fotoniske krystaller

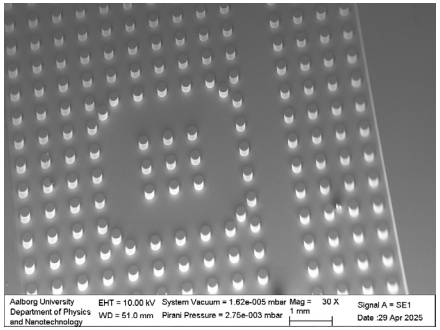


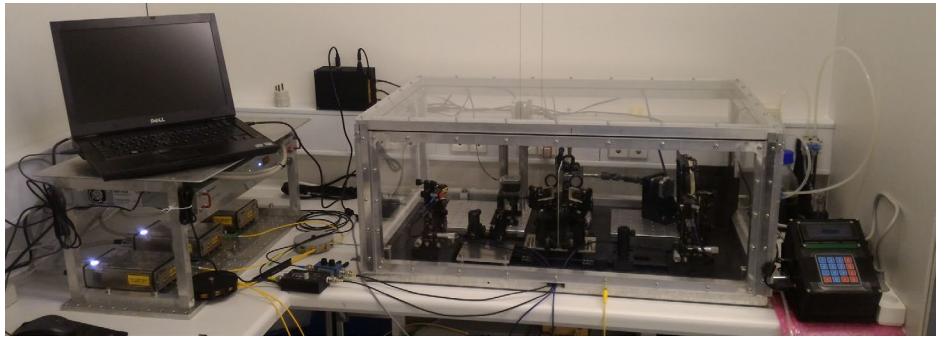








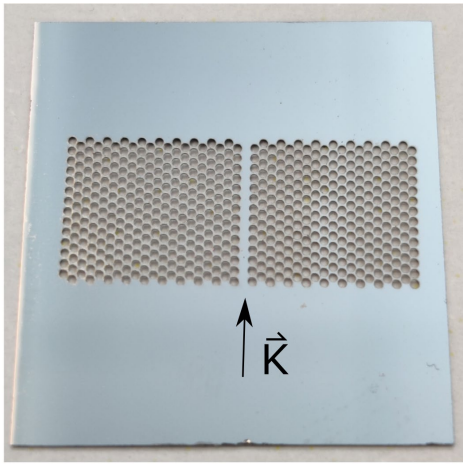


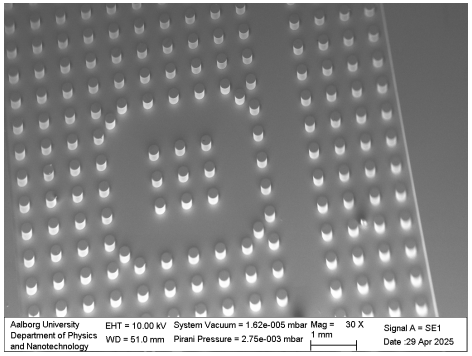


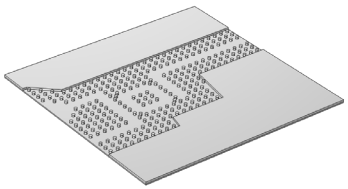
Esben Skovsen

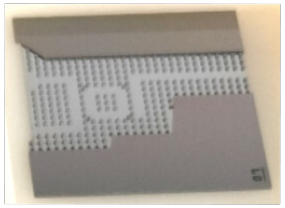
Terahertz fotoniske krystaller

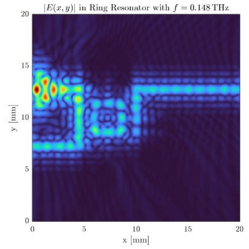
- Ved hjælp af mikro- og nanofabrication kan man lave Materialer med et periodisk varierende brydningsindeks i 1D, 2D, eller 3D.
- En fotoniske krystal er et materiale, hvor denne periodicitet gør det umuligt for nogle frekvenser at propagere gennem materialet.
- Dette kræver, at variationen foregår på en skala mindre end bølgelængden, som fx ved 1 THz er 300 μm.
- Ved at lave defekter i en fotonisk krystal kan man lave integrerede fotoniske komponenter som bølgeledere, kaviteter, filtre mm.
- Da næste generation trådløs kommunikation (6G) forventes at operere i THz området er det vigtigt at udvikle komponenter til det





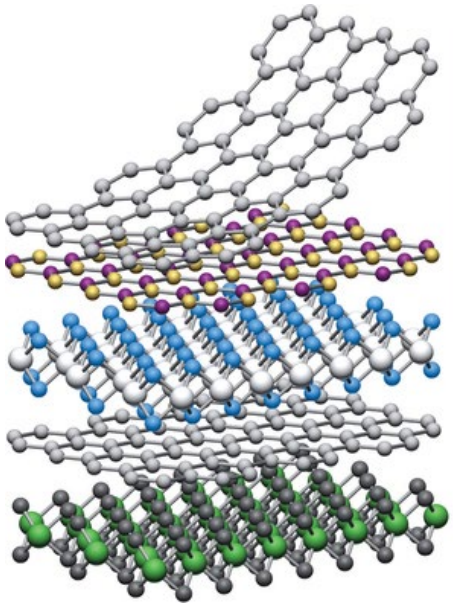


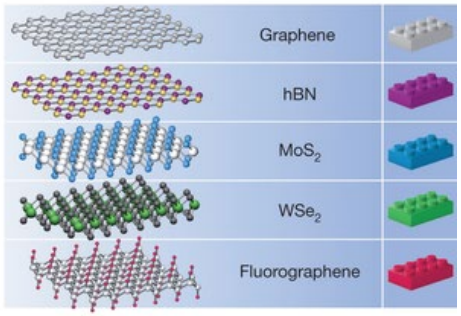


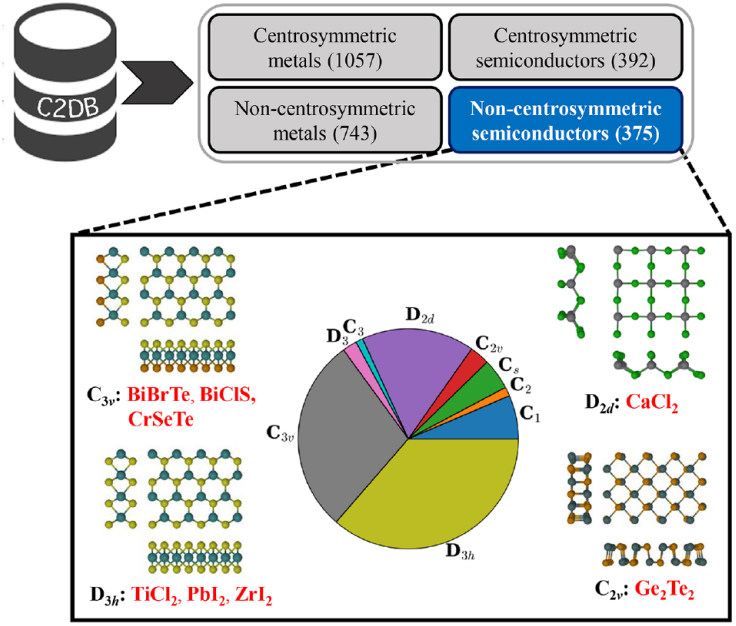


Esben Skovsen

Kvantemekanik og komponenter



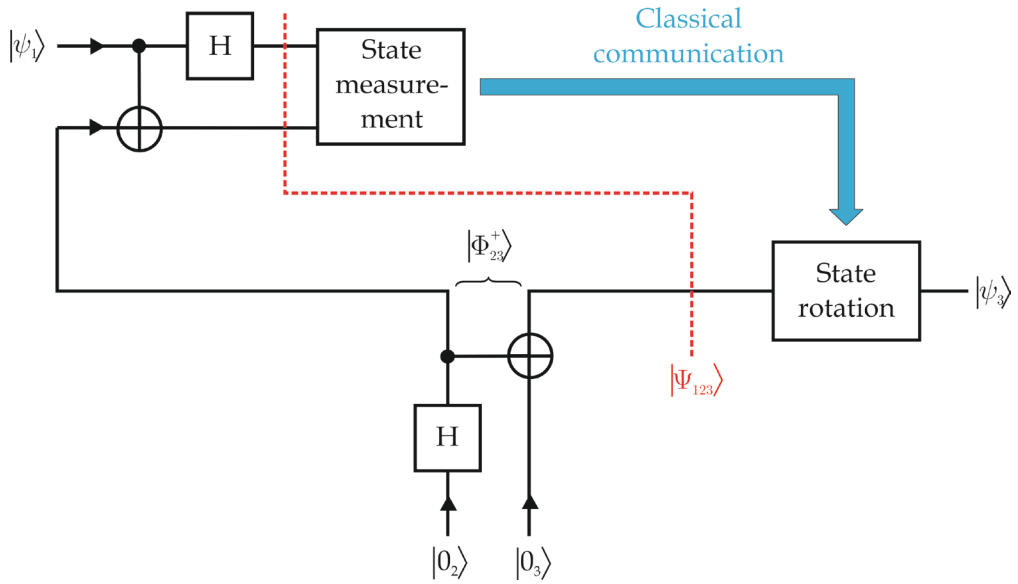


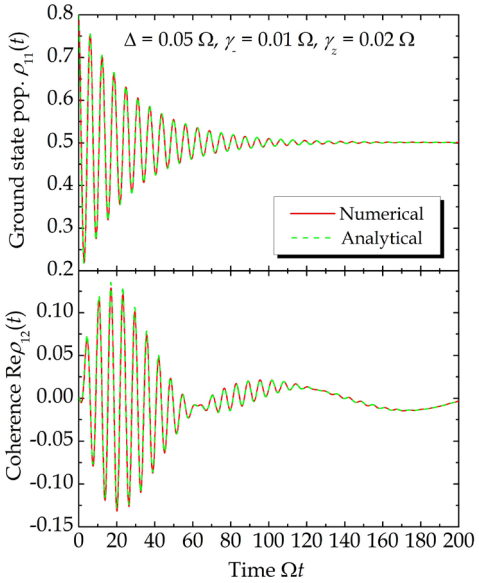


Kvantemekaniske simuleringer af materialer og deres egenskaber:
Elektrisk ledningsevne, optisk absorption, ulineære optiske egenskaber

Thomas Garm Pedersen

Kvantemekanik og komponenter

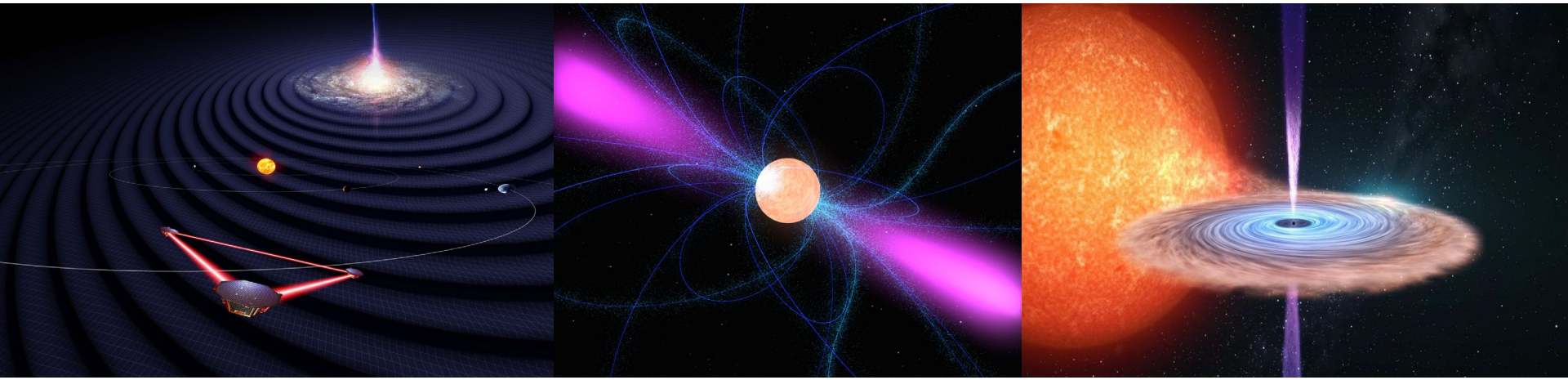




Modeller for komponenter i kvante-kommunikation: qubits og gates. Simuleringer af ”dekohærens”: henfald af kvantemekaniske superpositioner pga. støj og kobling til omgivelser

Thomas Garm Pedersen

ASTROFYSIK

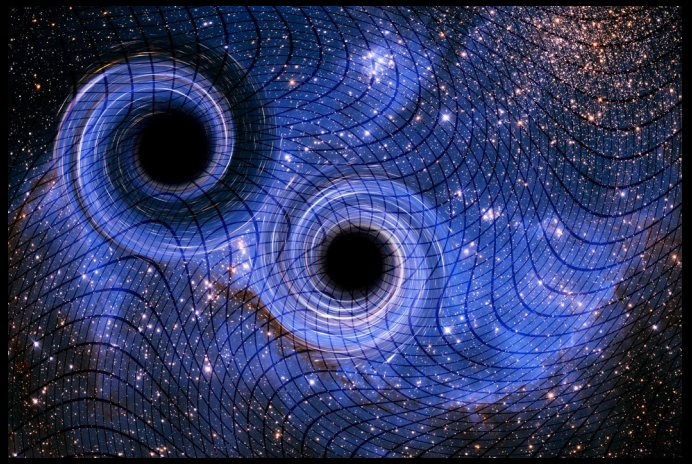


- Fokusområde: **kompakte objekters fysik**
  (neutronstjerner, sorte huller og hvidedværge)
- Projektarbejde: teoretiske beregninger
- Metoder: numeriske beregninger og simuleringer (Monte Carlo)

Binære røntgensystemer

Supernovaer

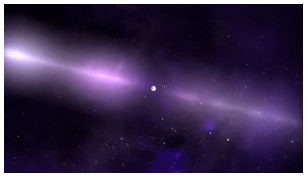
Radiopulsarer



Gravitationsbølgekilder

Centrale spørgsmål: AAU Astrofysik

- **Hvordan dannes systemer med BH+NS ?**
  (binær stjerneudvikling, røntgenkilder, supernovaer, …)
- **Kan vi forstå deres karakteristika ?**
  (fx masse, spin, omløbsperioder, kollosionsrater)
- **Gravitationsbølgespektra for LISA ?**
  (Europæisk gravitationsbølgedetektor, opsendes i 2035)



Inspiration til
gymnasieundervisning:

[Link til AAU Play]

https://www.youtube.com/watch?v=QXKBdIZDSwM

Hvordan ved vi, at SORTE HULLER eksisterer?

De er uendeligt tætte, og meget mystiske. Sorte huller har så kraftig en tyngdekraft, at ikke engang lys kan slippe ud... Men hvordan ved vi overhovedet at de eksisterer, når de ikke udsender lys? Kilder: NASA, ESA, LIGO, Thomas Tauris, AAU Research og manus: Lasse Winther og Martin William Thorning-

www.youtube.com

Thomas Tauris

Physics @ AAU

- Nanoscale Materials Science
- Cluster Beams for Materials Modification on the Nanoscale
- Astro Physics
- Theoretical Nano Physics
- Optics and Spectroscopy
- Theoretical analysis of electromagnetic fields in micro- and nanostructures
- Energy Materials (solar)
- Extensive laboratory facilities: Clean Room, fabrication and characterization

- Fundamental Science and applied research