

Måletekniske dage 2012

*Teknologisk Institut, Tåstrup
31 maj 2012*

Medicotekniske målinger Sensorer, partikler og mikroflow



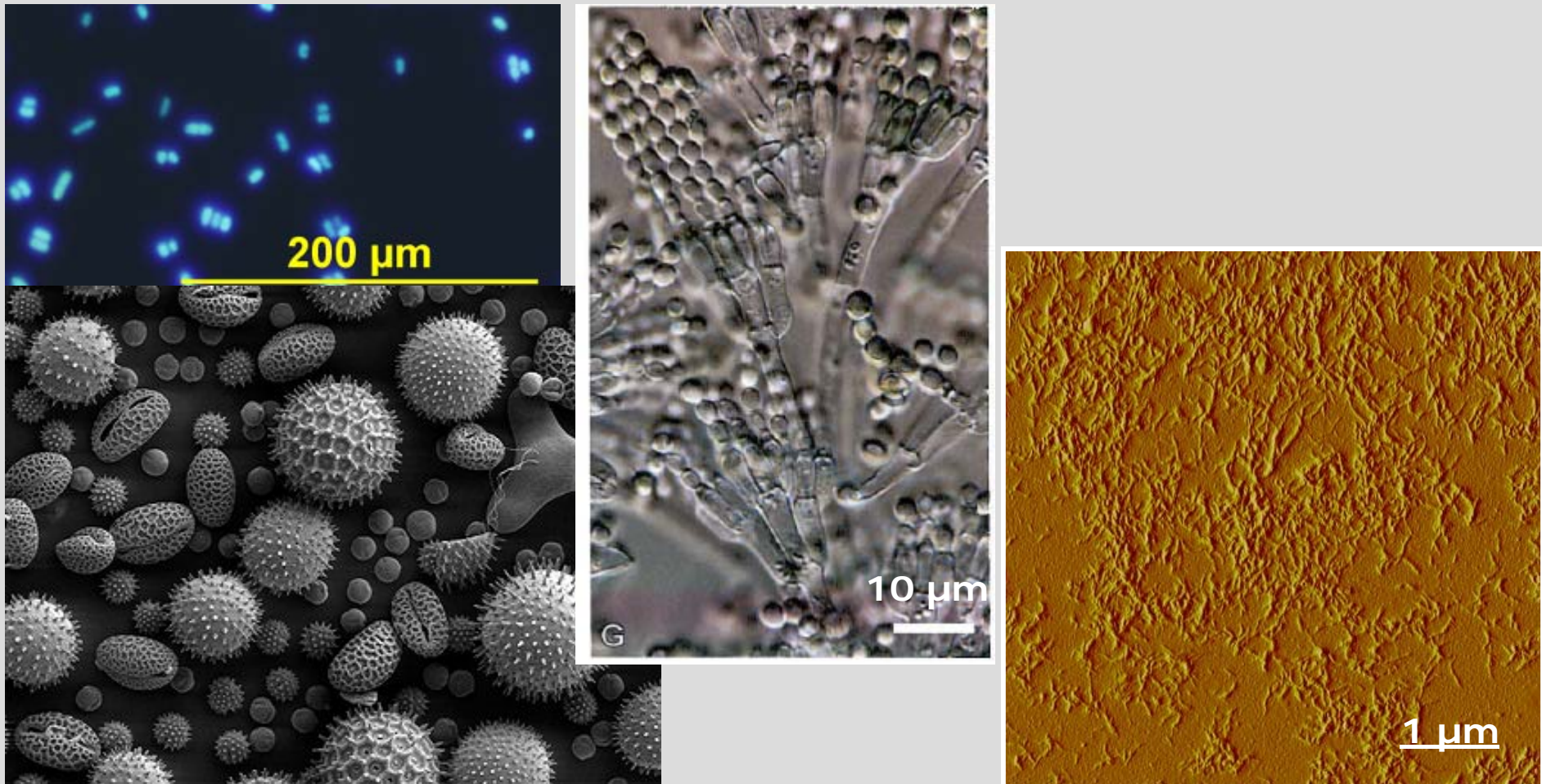
Kai Dirscherl
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2800 Kgs. Lyngby

kdi@dfm.dtu.dk

Tel.: 4525 5878

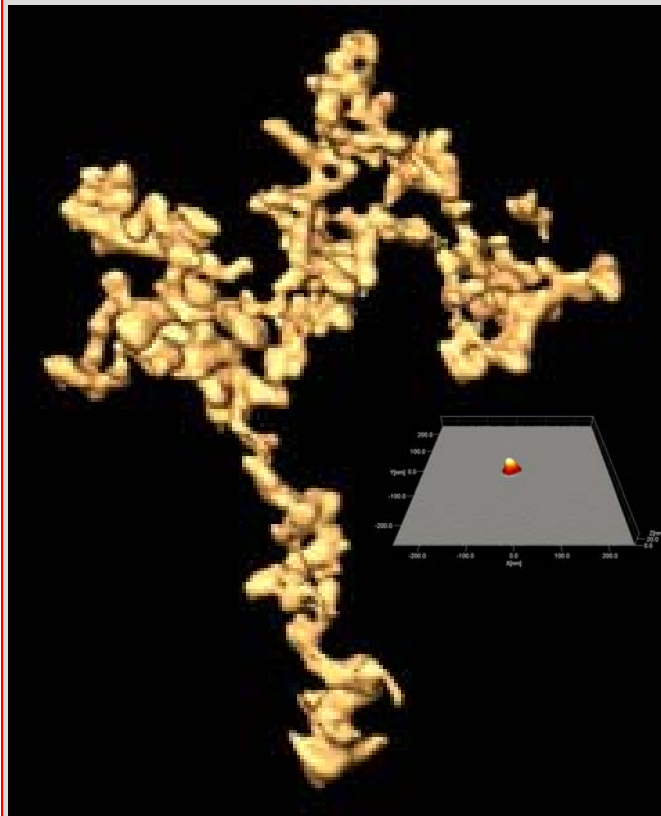
- Eksempler for partikeltyper
- Fra meter til nanometer
- Partikelmorfologi med optiske mikroskoper
- Partikelstørrelse i suspensioner
- Partikelantal i rumluft

Partiklernes mange ansigter – biologiske partikler



Bakterier (1-3 μm), pollen (5-50 μm), svampesporer (2-10 μm), pektiner (0.1 μm)

Partiklernes mange ansigter – forbrændingspartikler

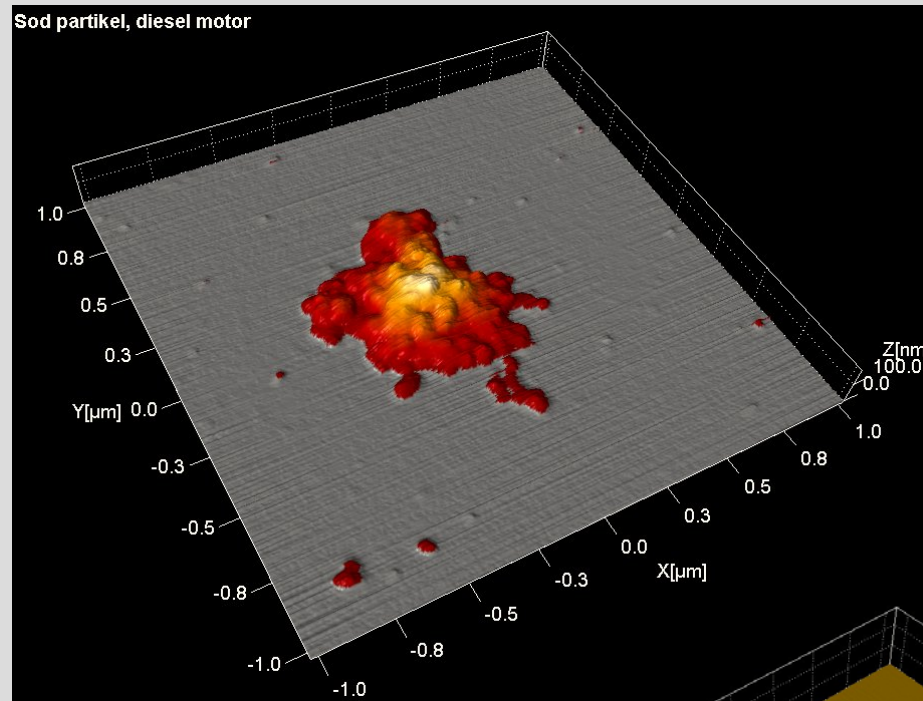


← 500 nm →

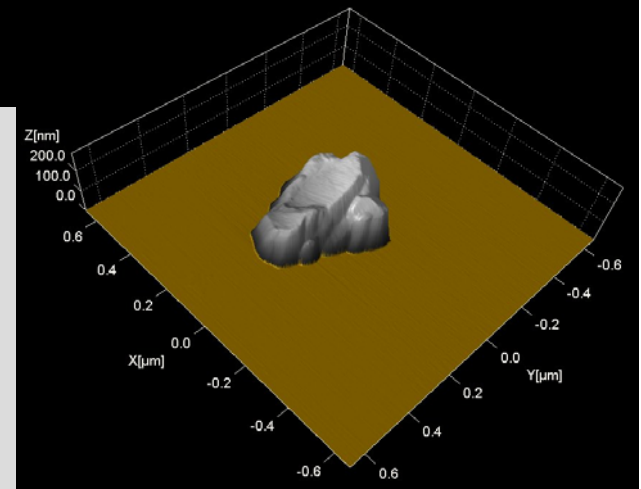
Dieselpartikler ($\sim 1 \mu\text{m}$) består af primærpartikel af ren kulstof (30 nm)



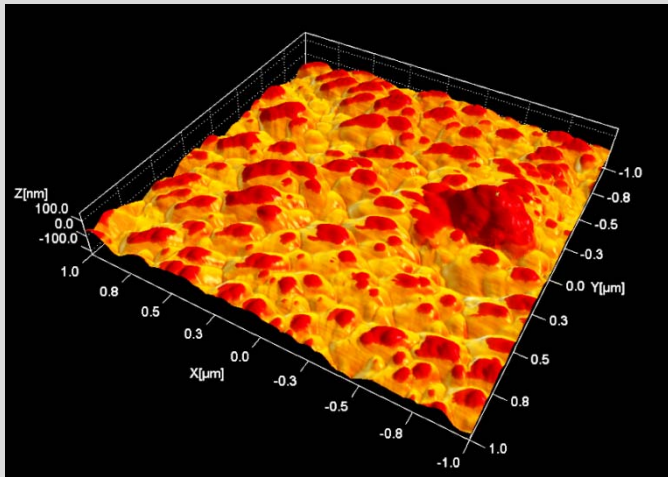
800 nm



Vulkanaske
Eyjafjallajökull
(400 nm)



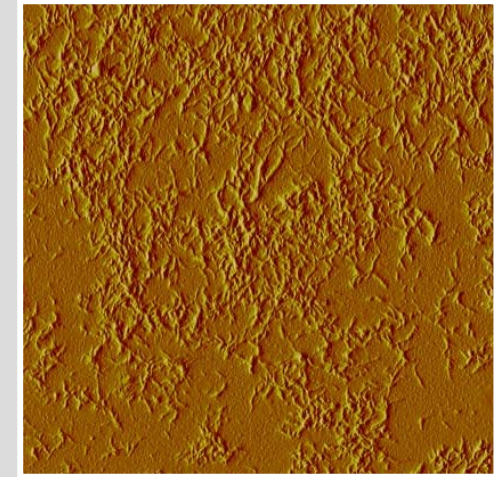
Partiklernes mange ansigter – funktionaliserede partikler



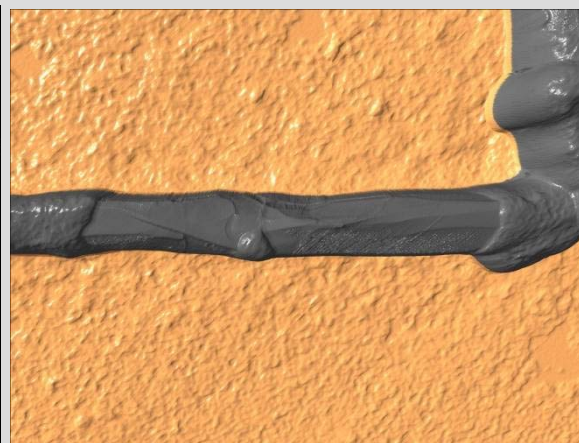
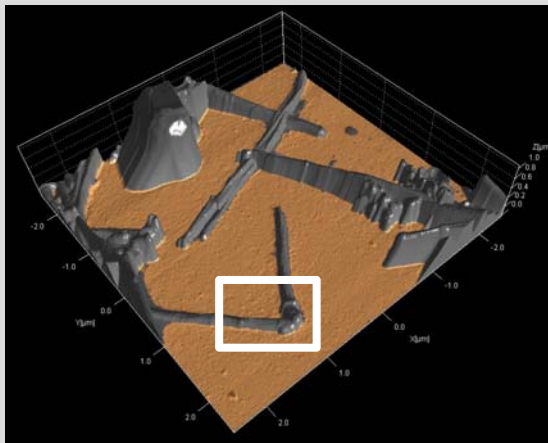
Titandioxid partikler (100nm)
Maling, selvrensede vinduer



Glasfibre (500 μm x 10 μm)
Varmedæmning

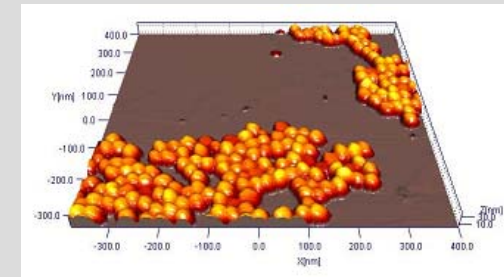
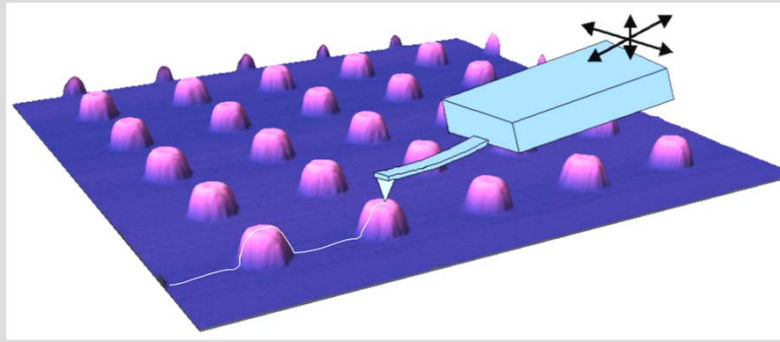
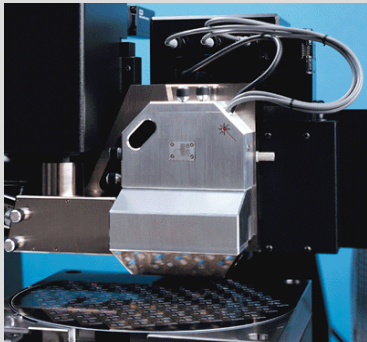


Pektiner (100 nm)
Fremmer benvækst

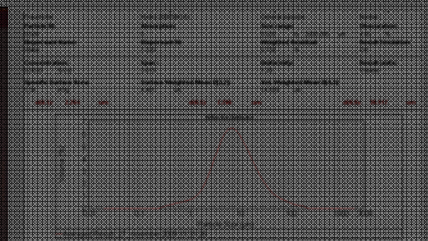
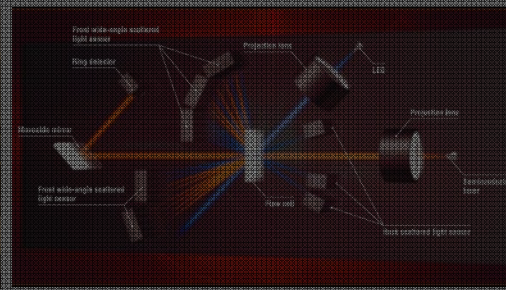
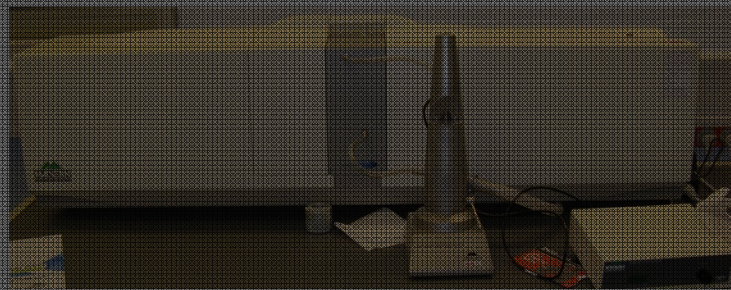


Kulstofnanorør (4 μm x 0.1 μm)
Vindmøllevinger, racercykler,
tennisketcher ...

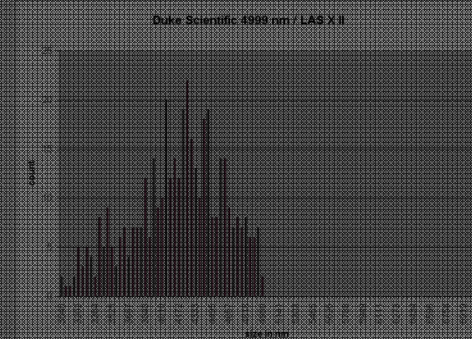
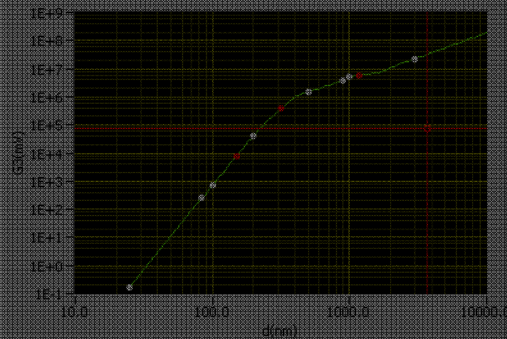
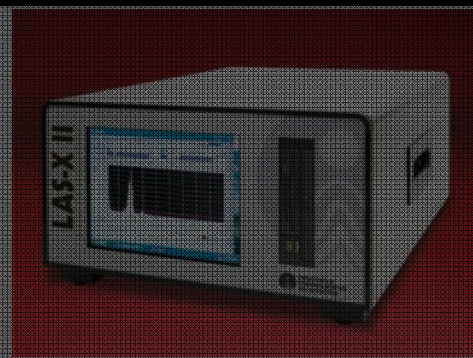
Particle measuring instruments



e.g. 30 nm gold particles



*Suspended particles:
20 nm – 2 mm*

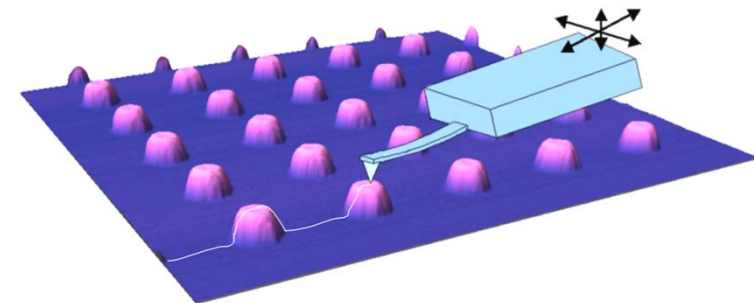
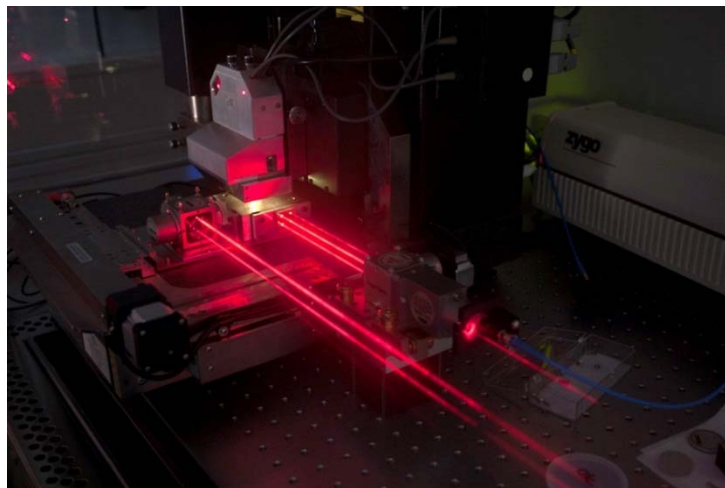
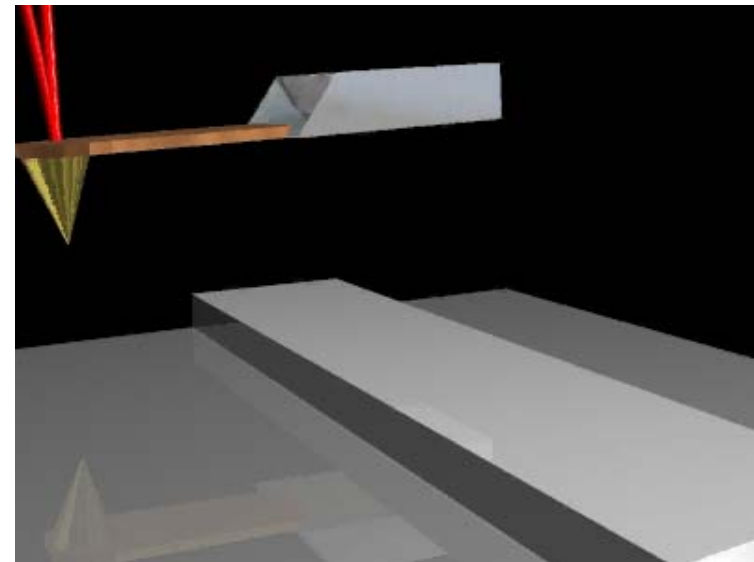


*Counting and sizing of
airborne particles.
100 nm – 7.5 µm*

Nanopartikler – hvordan kan man få dem synlige ?



Atomar kraftmikroskop



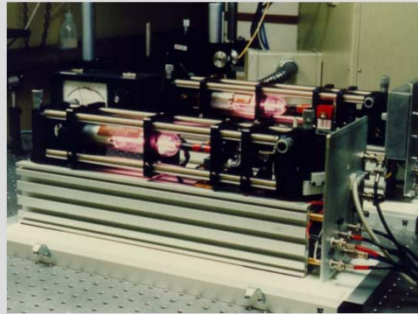
Nanometrology – The science of measuring at the nanometre scale



+ Definition of measurements units

+ Realization

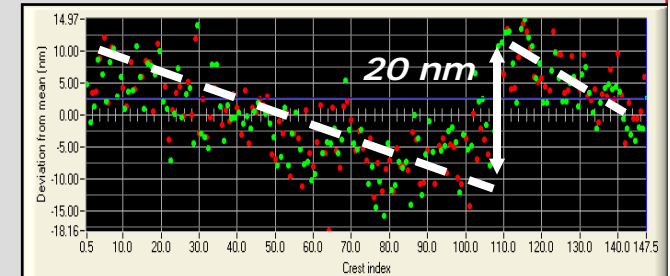
DFMs laser
(wavelength)



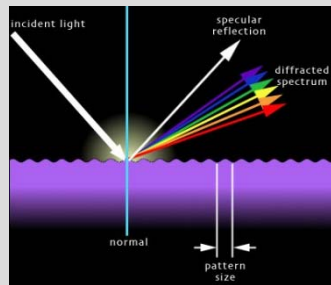
632,991 398 22 ± 0.000 000 02 nm



Stitching error of an e-beam writer

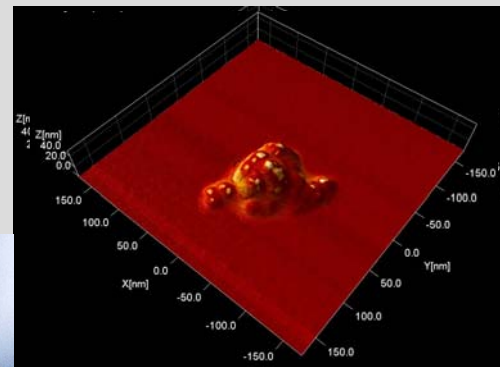
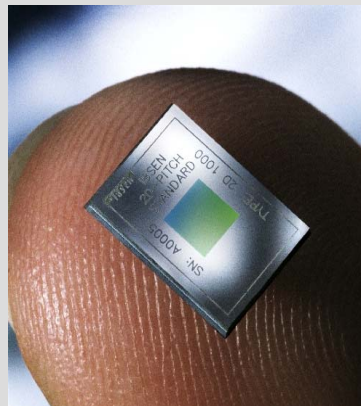


400 nm roughness polished aluminum
400 μm x 200 μm scan



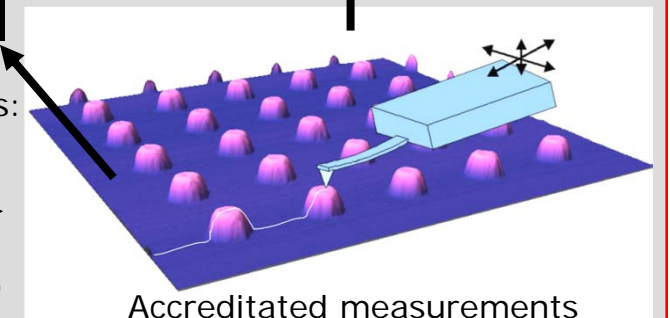
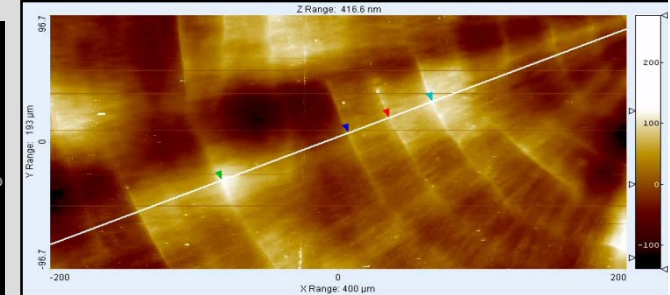
Optical diffraction

DFMs NANO normal:
Grating with period
1 000.519 ± 0.017 nm

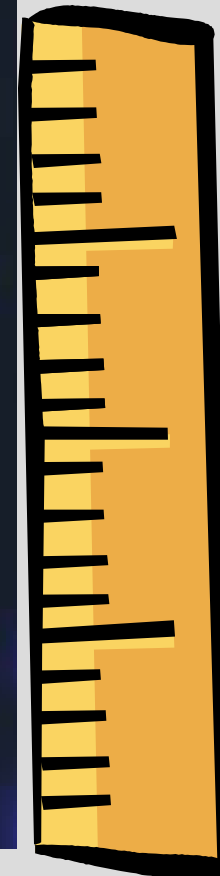
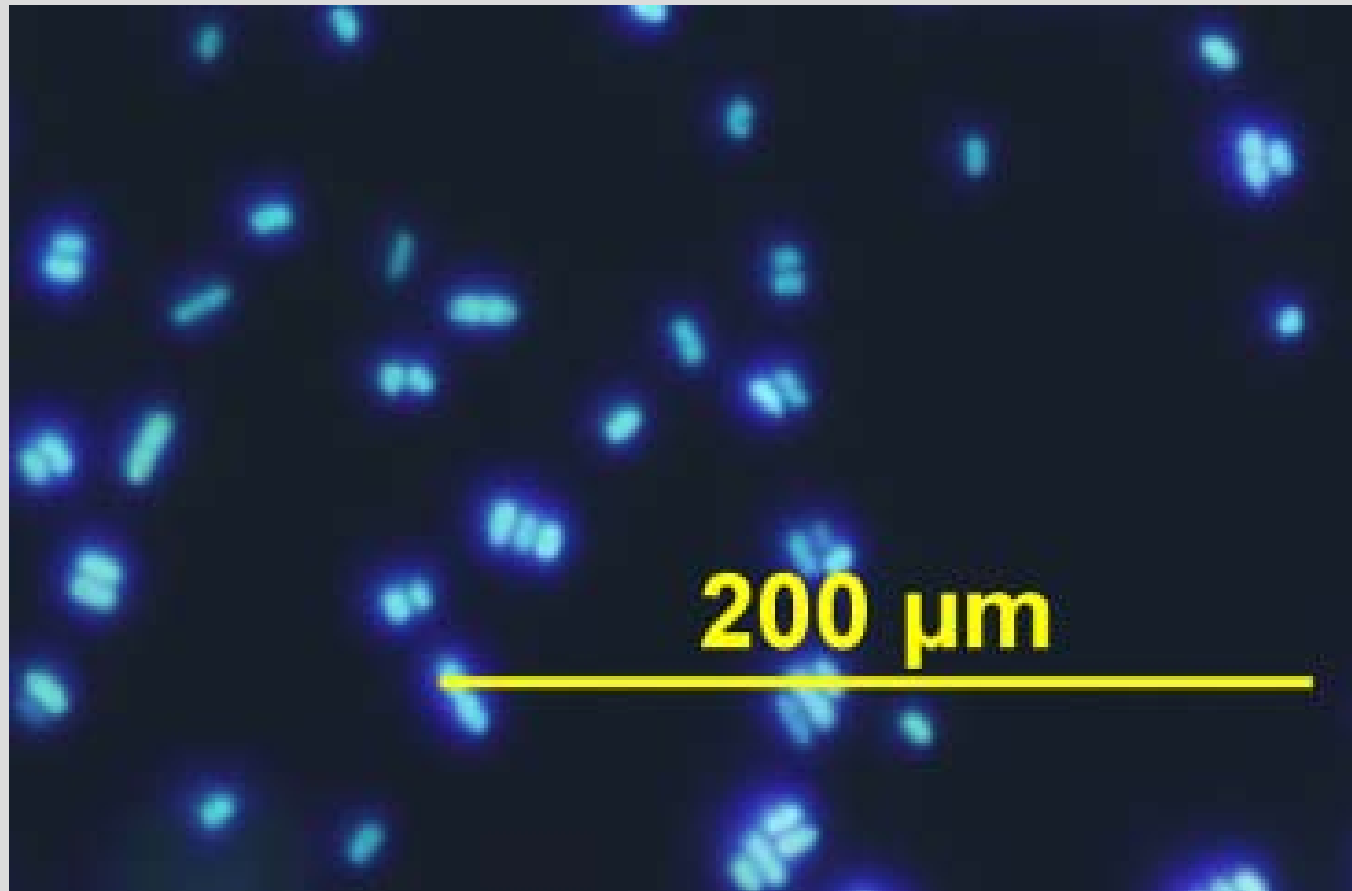


Soot particle
local morphologic variations:
solid primary particles

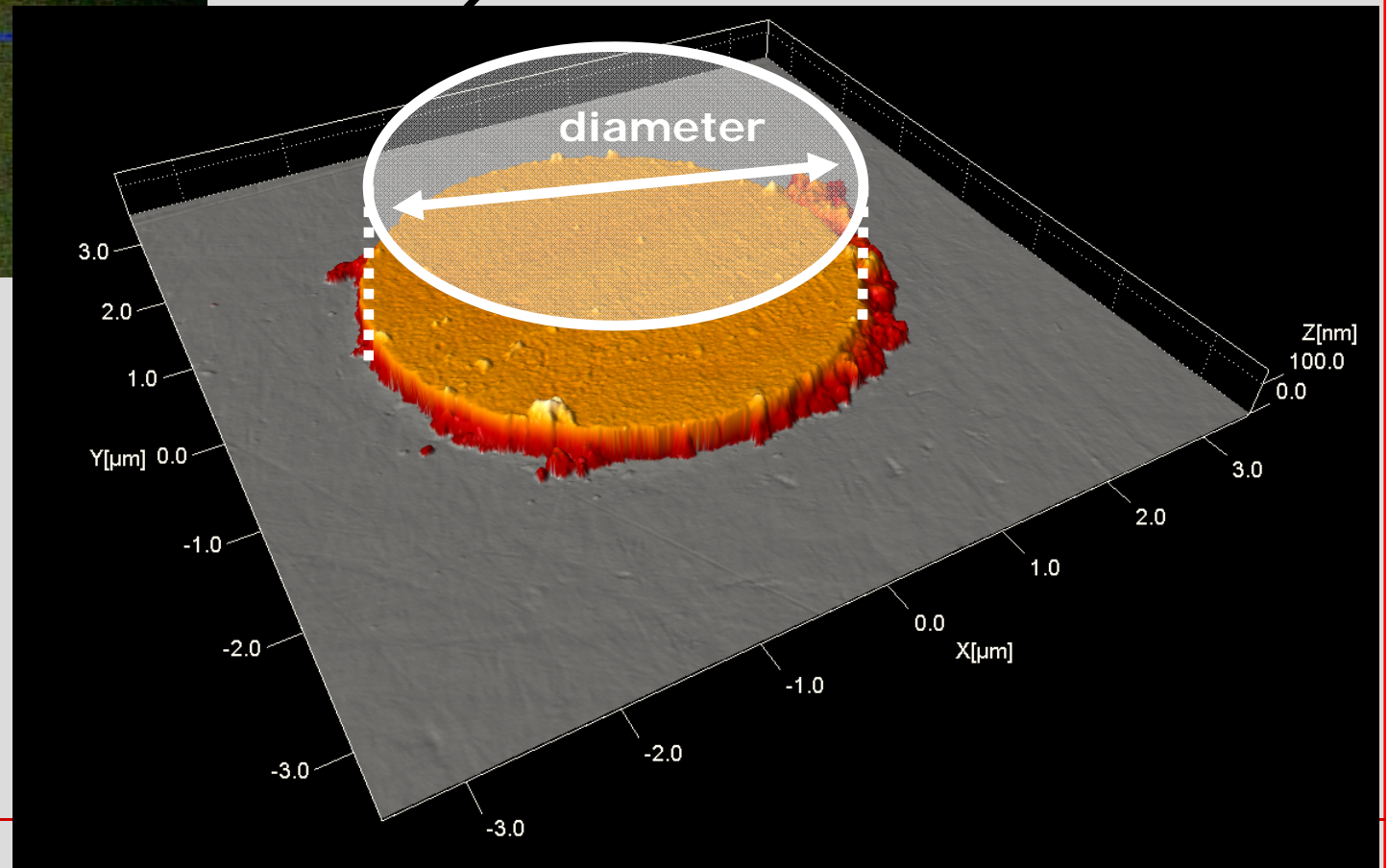
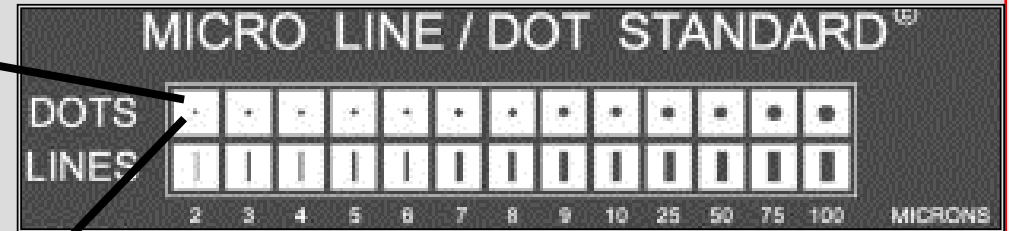
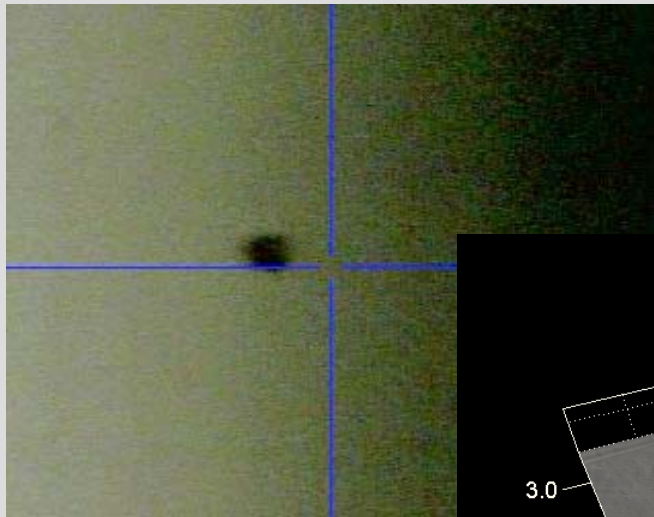
Atomic Force Microscopy
Nanometer accuracy in 3D



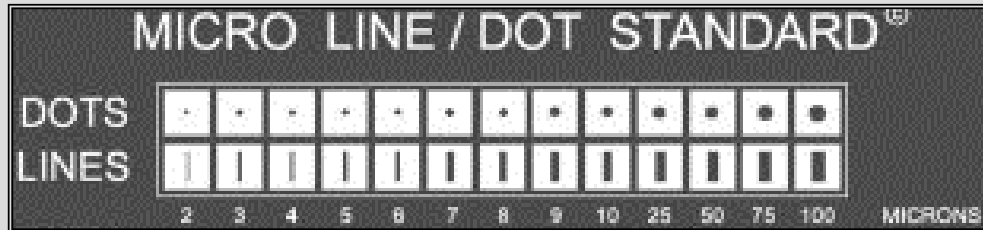
Opgave: Nøjagtig udmåling af partikelmorfologi med optiske mikroskoper



Optisk graticule En reference til partikel morfologi



Kalibrering for kvalitetssikring og målinger med større nøjagtighed



Kalibreringsydelse:

Cirkel ækvivalent diameter

Diametre : 1 μm to 50 μm

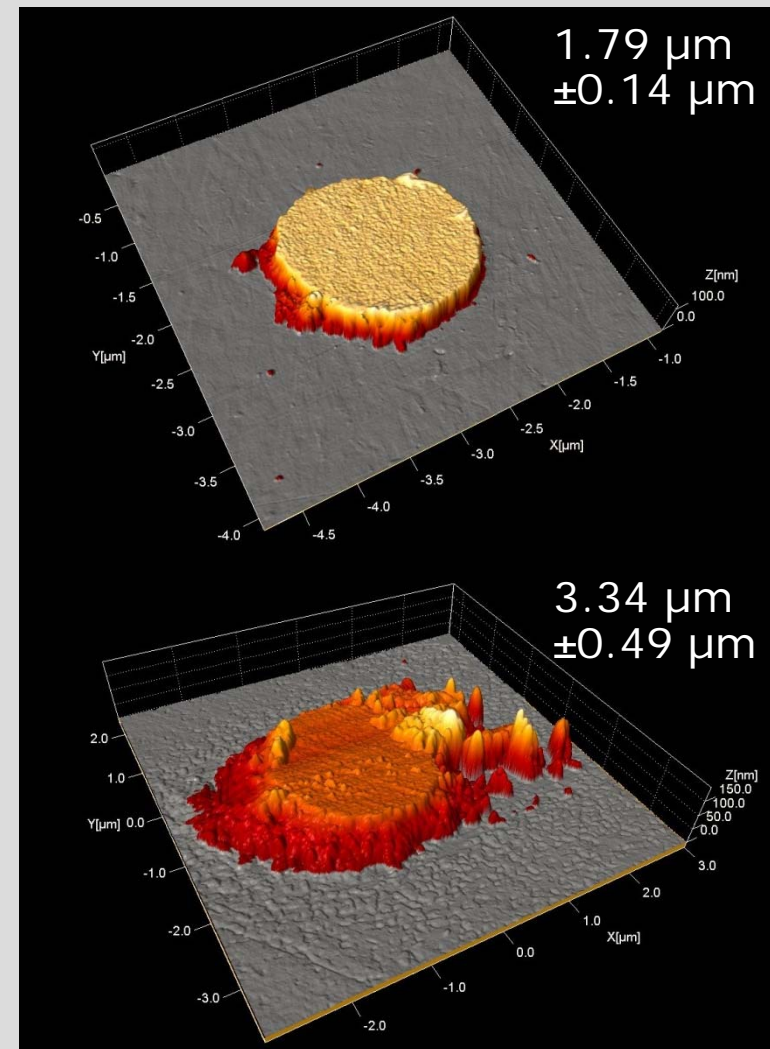
Exp. usikkerheder : 0.1 μm to 1 μm



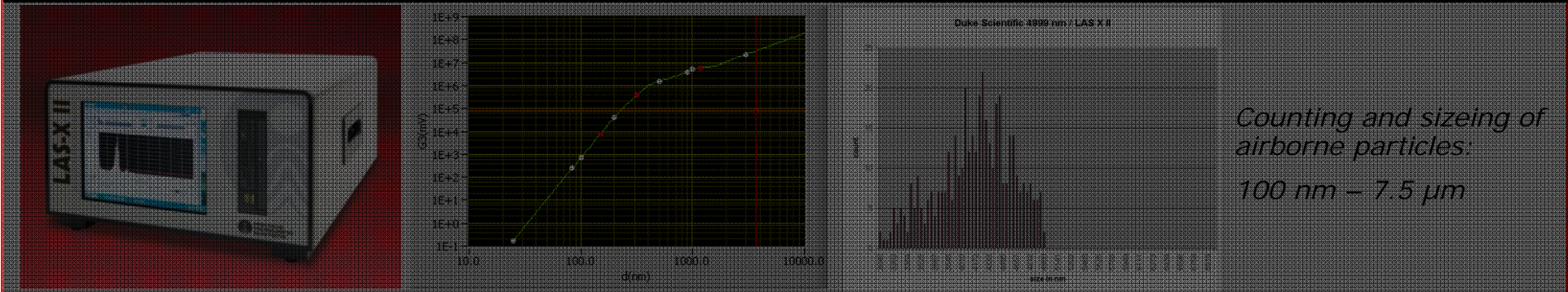
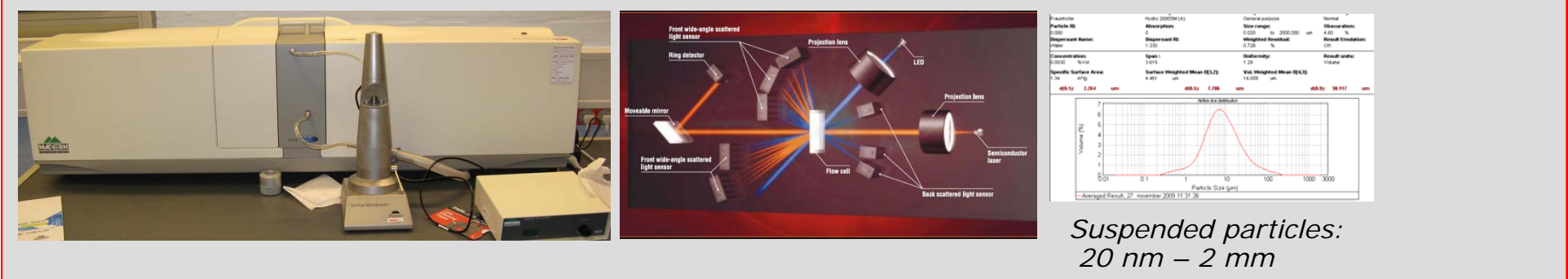
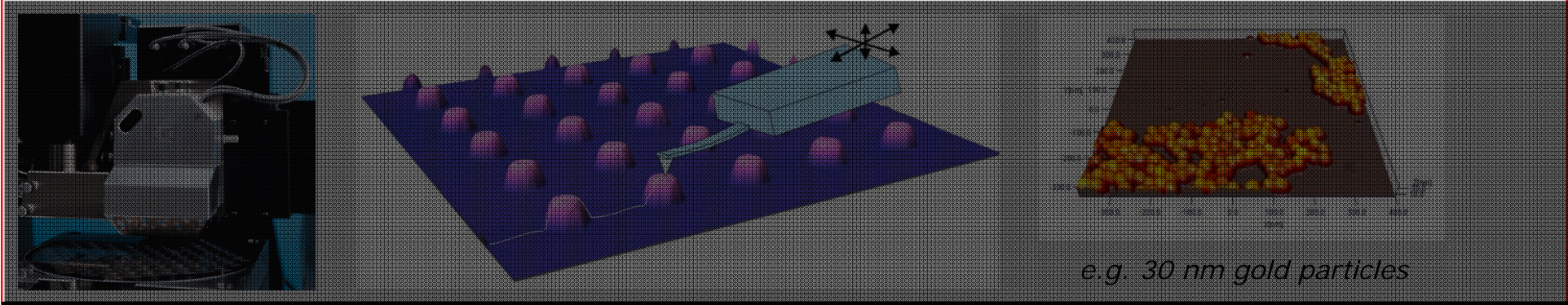
Danish Fundamental Metrology Ltd.
Matematiktorvet 307
DK-2800 Kgs. Lyngby, Denmark

Calibration certificate

**Circle equivalent diameter
of specific dots on a graticule**



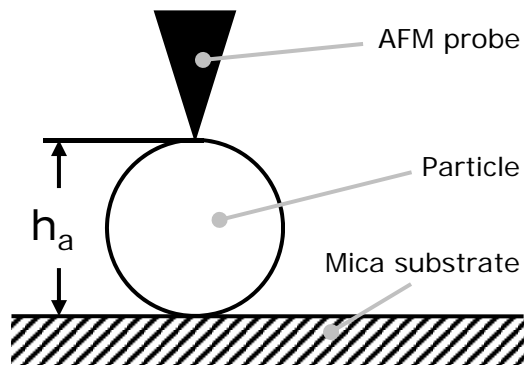
Particle measuring instruments



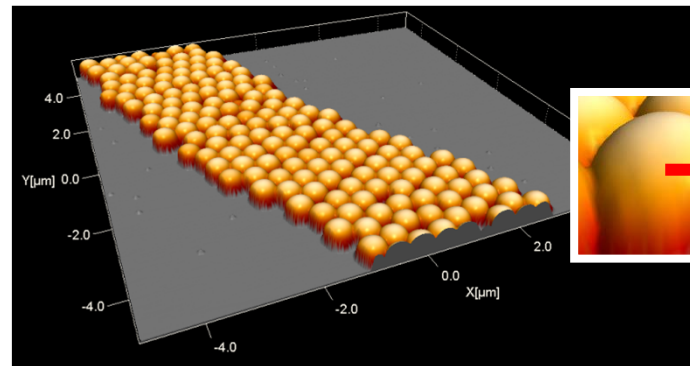
Size-certified nanometer particles traceable to the meter with a metrology Atomic Force Microscope



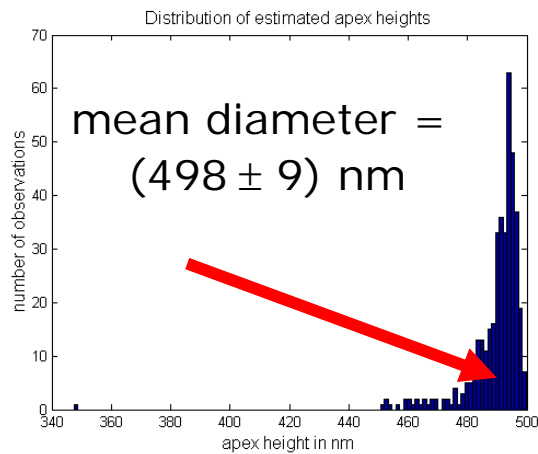
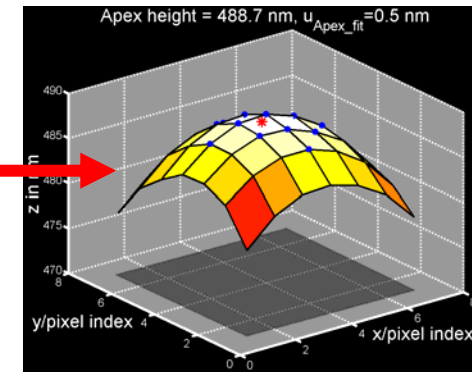
Measurement method



AFM image of particle sample



Data analysis



Result: diameter distribution



Certification

Certified dispersions (15 ml) available at DFM



Diameter ranges:

from 100 nm
to 5 000 nm

Uncertainties:

from 5 nm
to 50 nm

Partikler i suspensioner

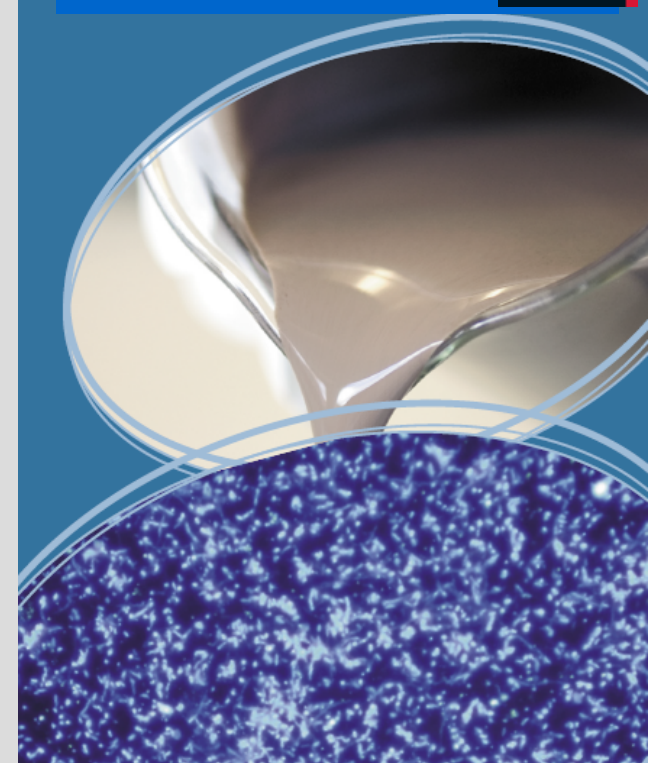


- Kalk (til beton)
- Maling
- Mejeri produkter
- Farmaceutiske partikler

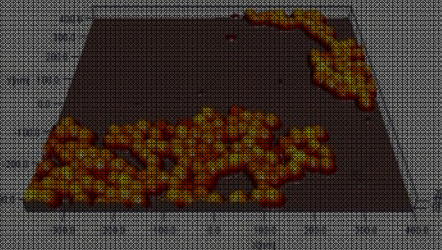
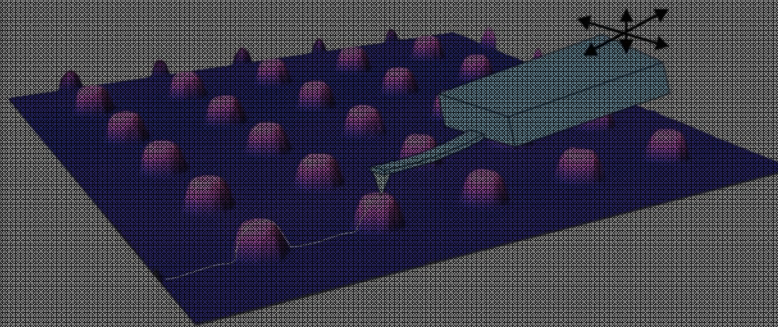


Introduktionskursus
til industriel
partikelanalyse

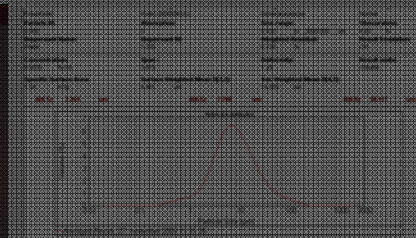
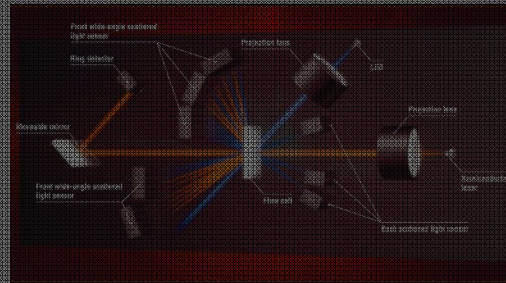
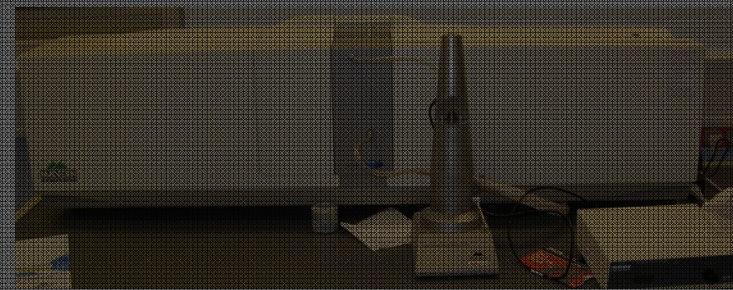
4. September 2012
4. Oktober 2012



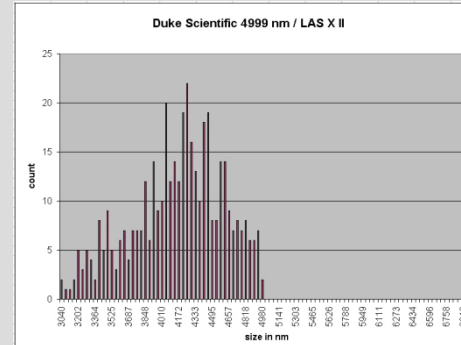
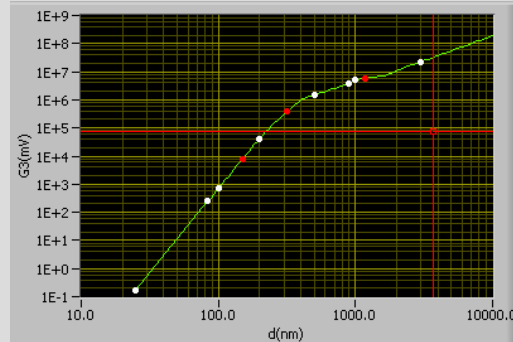
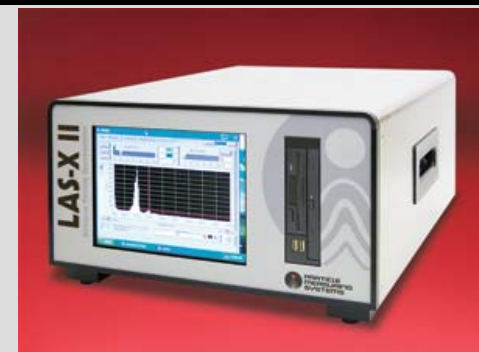
Particle measuring instruments



e.g. 30 nm gold particles



*Suspended particles:
20 nm – 2 mm*



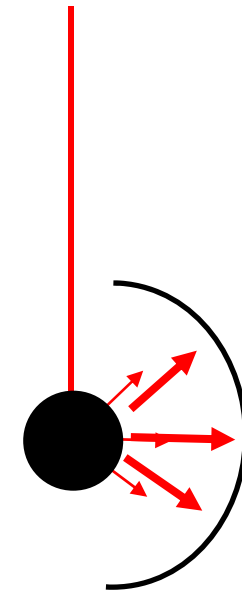
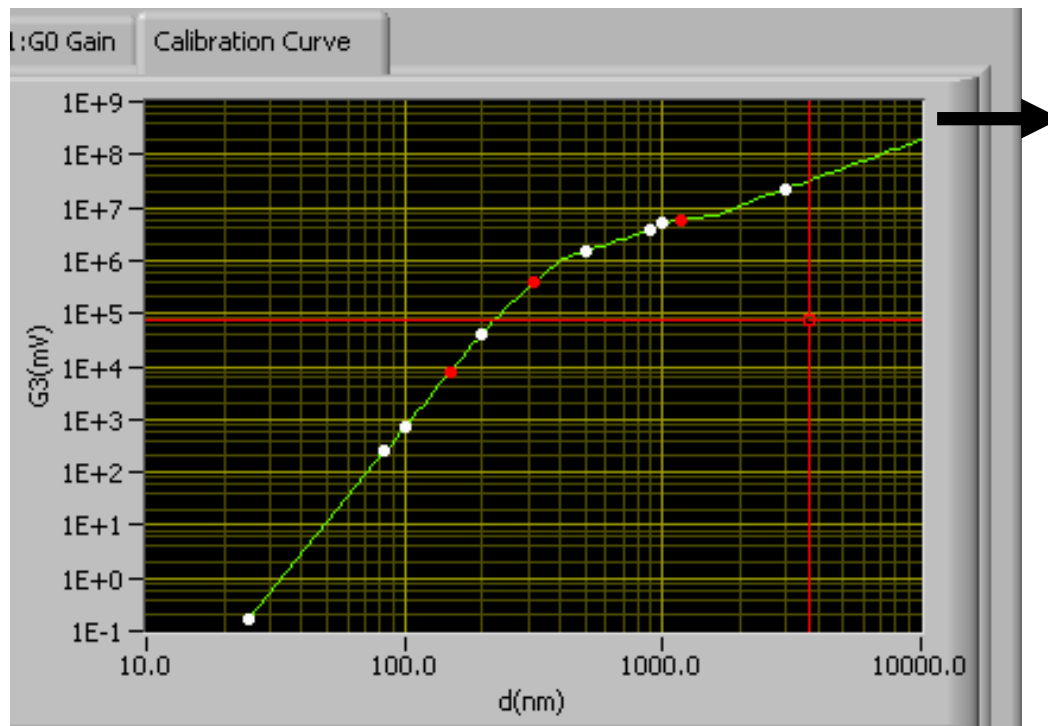
*Counting and sizing of
airborne particles:
100 nm – 7.5 μm*

Partikeltæller baseret på lysspredning: Fysikken sætter begrænsninger for størrelsesmåling



Kalibrering af en look-up-table:

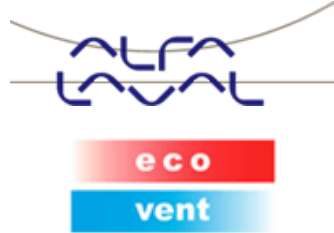
Spændingssignal photodiode → partikel størrelse



Spredningsteorien bestemmer målefølsomheden

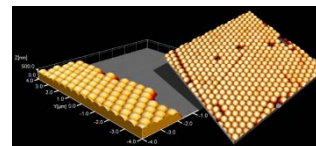
Innovationskonsortium *NaKIM*

Nano- og mikropartikler – karakterisering,
innovative anvendelser og miljørigtig teknologi

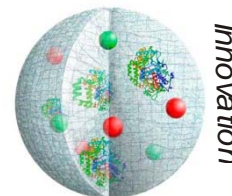


- + *Partikler i væske (mejeri, medicin)*
- + *Aerosoler (sod partikler)*
- + *Renrum (genbrug af luft, medicinale produktion)*

Miljø



Karakterisering



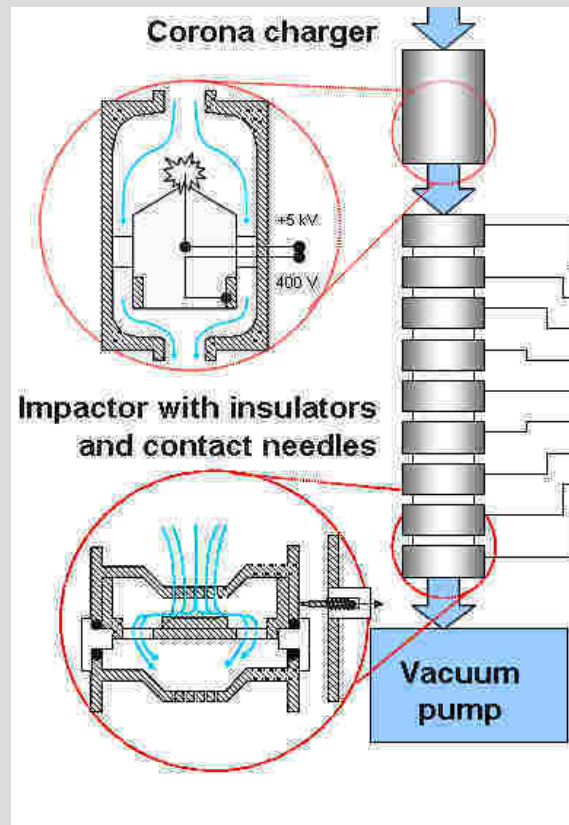
Innovation



Andre ikke-billeddannende partikelmålere

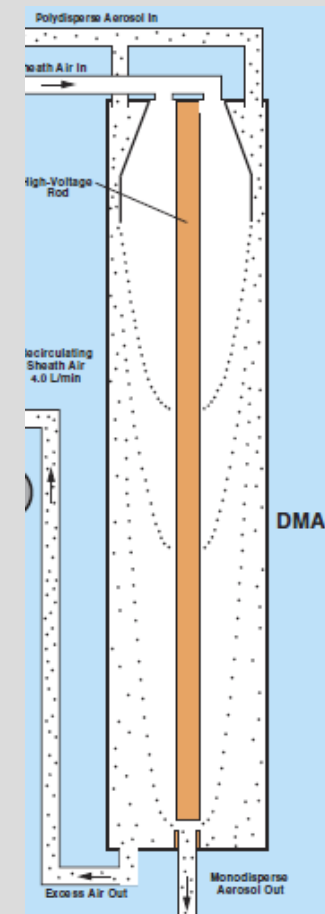


ELPI:
Electric Low Pressure Impactor



aerodynamisk diameter

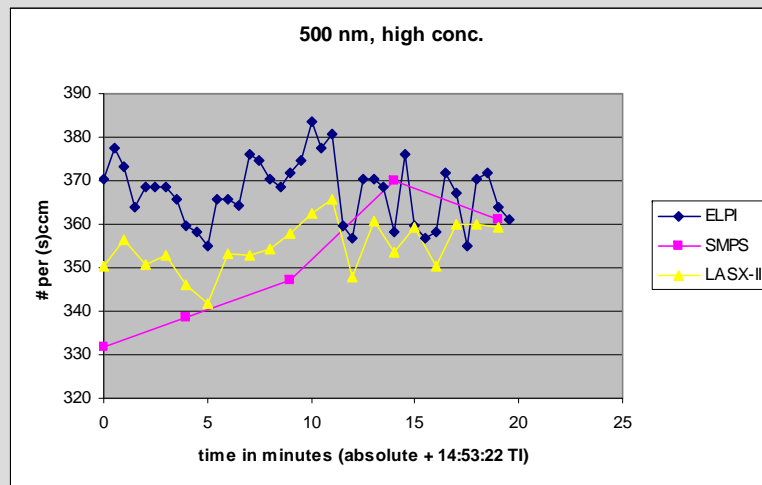
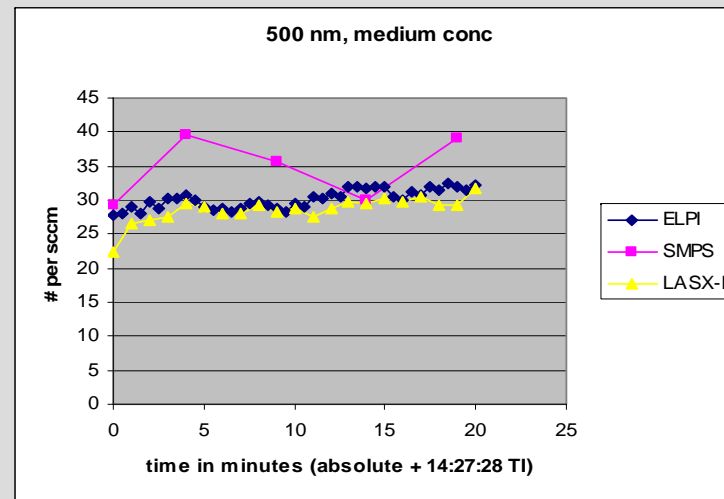
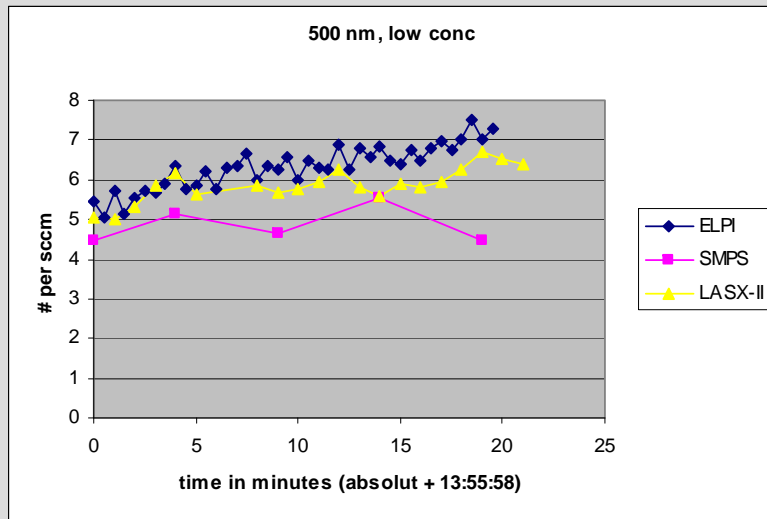
SMPS:
Scanning Mobility Particle Sizer



Forskellige teorier

Elektrisk
mobilitets-
diameter

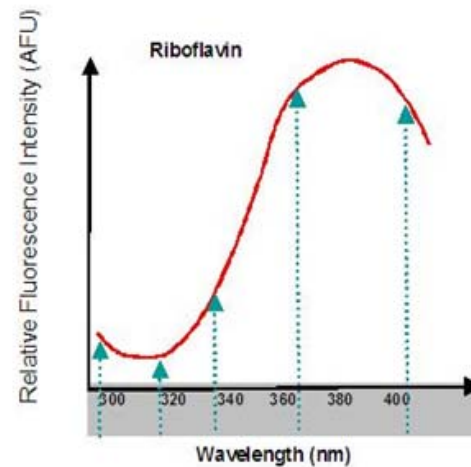
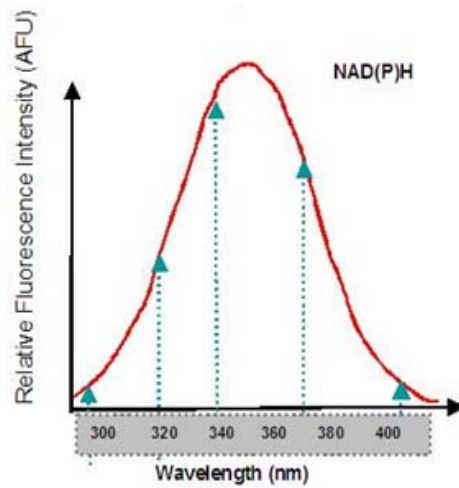
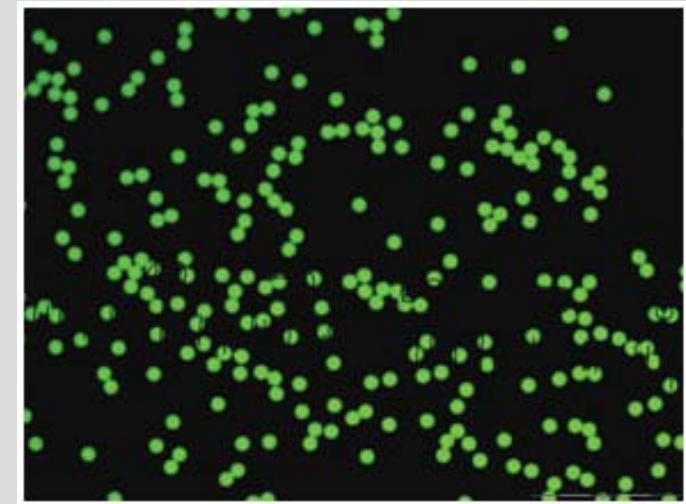
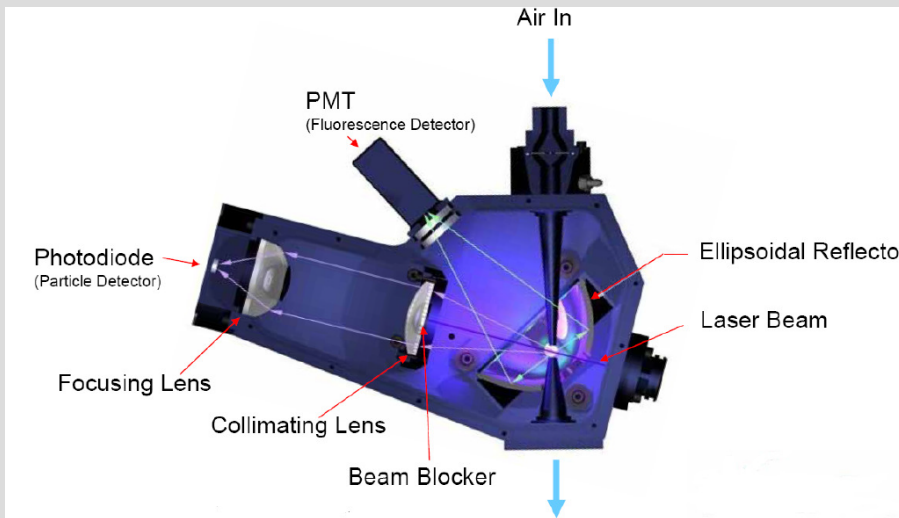
Partikeltællinger er også metodeafhængige



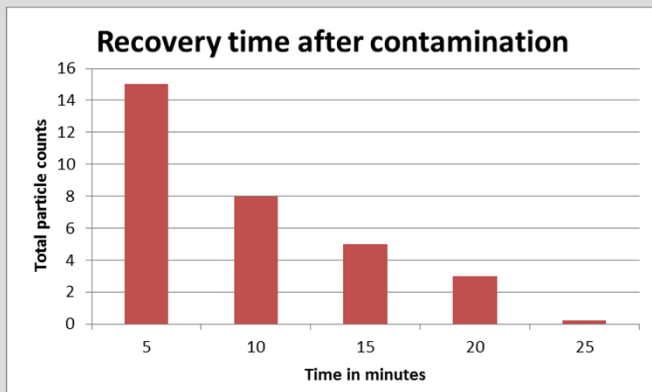
ELPI: Electric Low Pressure Impactor
SMPS: Scanning Mobility Particle Sizer

ELPI tæller ~6% - 10% flere partikler end optiske metoder.

Detektering af biologiske partikler ved hjælp af fluorescens



Zero count



Size setting ved grænsen 1 μm

Biologiske partikler: Mean: 1.33 μm , SD: 0.031 μm

Inerte partikler: Mean: 0.73 μm , SD: 0.016 μm

! Tæller identiske størrelsesforhold i en blanding !

Counting efficiency

Intern luftkoncentrator har størrelsesafhængig effektivitet

0.9 biologic	0.64
1.3 biologic	0.57
3 inert	0.1
5 inert	0.055

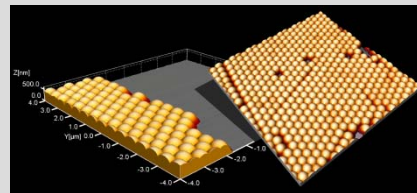


Perspektiver og gavn af partikel metrologi på det højeste niveau



- + *Centre of Excellence* – Partikelmåling (TI, FORCE, Novo Nordisk)
- + *Dansk primærnormal* for partikeltælling ifølge ISO 21501-4
- + **Etablering af umiddelbar sporbarhed**
- + **International anerkendt certificering** (FDA godkendelse ...)
- + **Større nøjagtighed ved måling af partikel kontaminering hjælper med at optimere omkostninger for rene rum** (energiforbrug, filterudstyr, finer følsomhed for hurtigere fejldektering)

Partikelstørrelse
AFM



Partikeltælling
LSAPC

