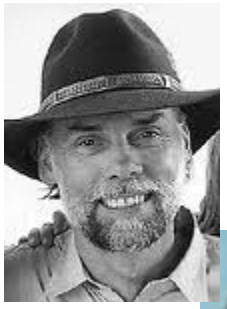
UiO : Kjemisk institutt

SMN NAFUMA
SENTER FOR MATERIALVITENSKAP OG NANOTEKNOLOGI

NAFUMA Research group 2011



Professors

- Helmer Fjellvåg
- Anja Olafsen Sjåstad
- Serena Margadonna

Ass. professors

- Ola Nilsen

Adjunct professors

- Reinhard Nesper (ETH Zürich)
- Spyros Diplas (SINTEF)
- Suzanne McEnroe (NGU, Trondheim)

Engineers

- Per Fostervoll

Administration

- NN (Jan.2012→)

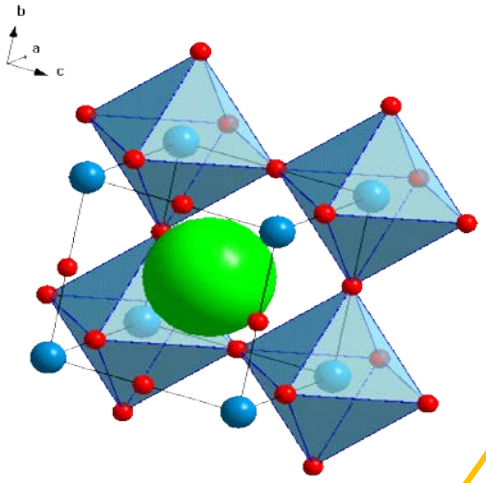
2011: 2 project students; 6 master students
13 PhD students; 11 postdoc/researchers

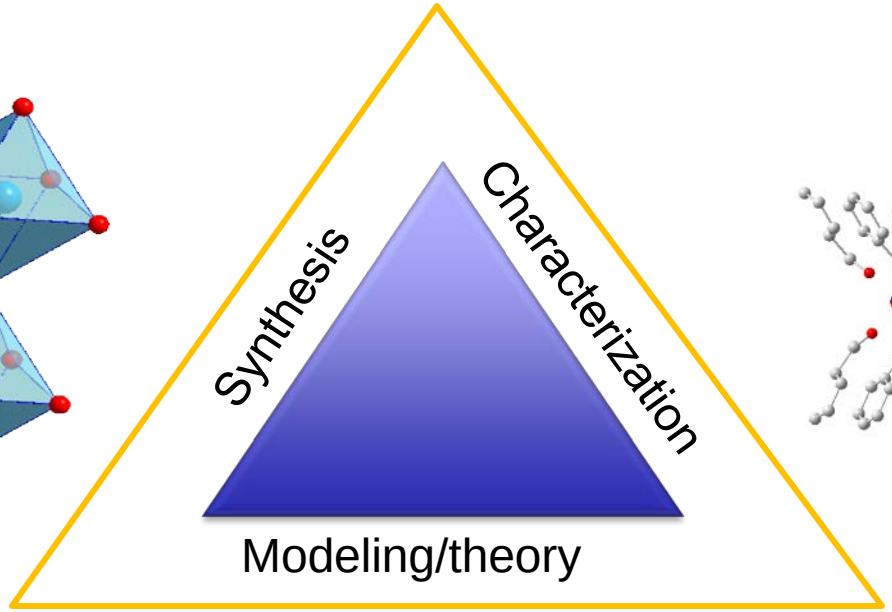
UiO : Kjemisk institutt

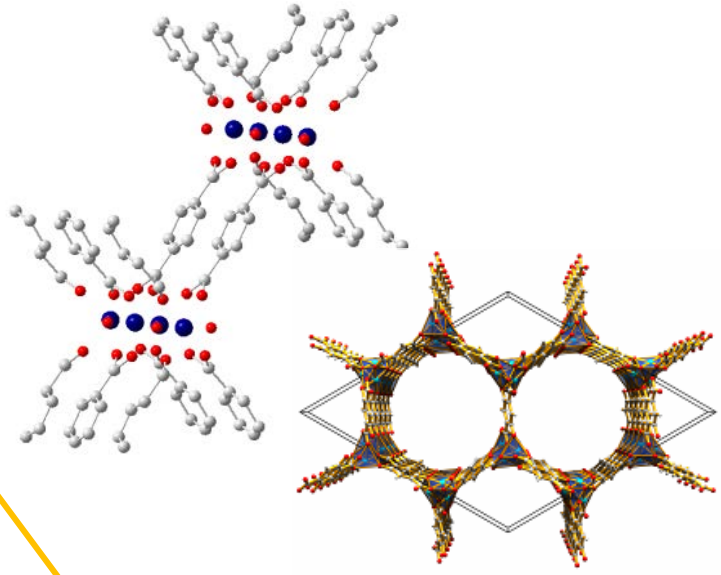
SMN NAFUMA
SENTER FOR MATERIALVITENSKAP OG NANOTEKNOLOGI

NAnostructures and FUnctional MAteriales

An integrated approach

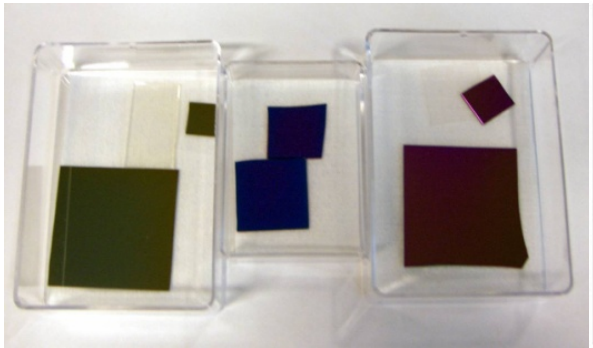




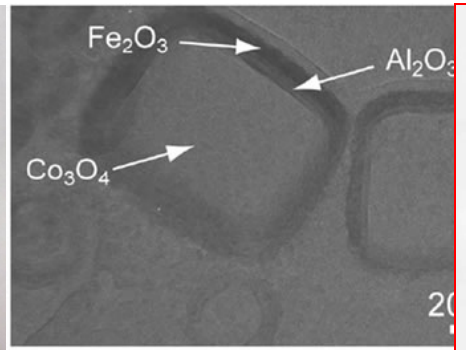


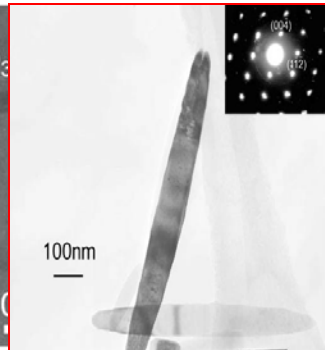
Bulk/solids

Thin films & coatings



(Nano)particles





Laboratories; international collaborations

Synthesis

Bulk:	Ceramic methods, sol-gel, hydro/solvothermal
Crystals:	Transport reactions; flux methods
Thin film:	ALD, spin-coating, MOCVD, PLD, sputtering
Nanoparticles:	Hydrothermal, reverse micelles, sol-gel, electrospinning

Characterization

Structure:	(S)XRD, ND, FTIR, UV-Vis, Ellipsometry, XRR, RAMAN
Composition:	XRF, ICP, EDAX, XPS, SIMS, TOF-ERDA
Shape:	AFM, SEM
Size:	AFM, TEM/SEM, SANS/SAXS, DLS
Phys. prop.:	PPMS, MPMS, Nanoscratch

National/international partners

SWATCH GROUP

ETH

saft

IFE

PAUL SCHERRER INSTITUT PSI

ESRF

++

Approach / activity

abilty to make, study and understand….

Inorganic chemistry / materials chemistry / solid state chemistry

Synthesize novel inorganic compounds/materials

Derive thin films, nanostructures, nanoparticles

Investigate structure – property relations

Study model/real materials at working conditions

Integrate experiments with computational modeling

With applications in mind…..

Energy (batteries, solar cells, hydrogen technology)

Process industry (catalysts and absorbents)

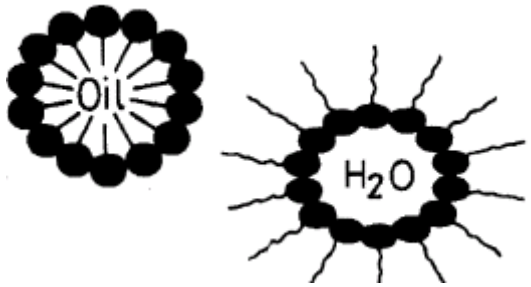
Electronics (sensors and actuators)

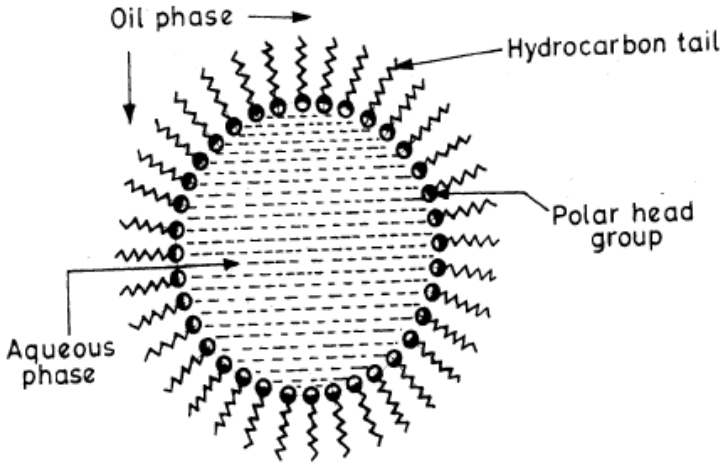
Nanomedicine (particles, coatings, scaffolds)

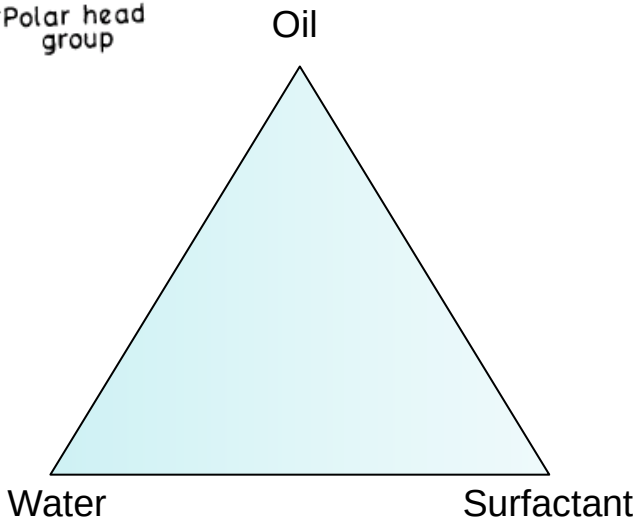
Examples of activities

Nanomaterials - Preparation

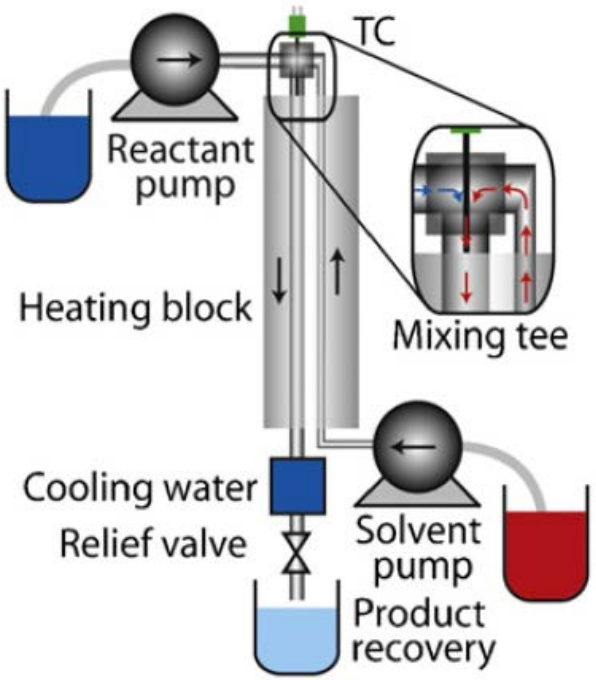
Micelles Routes







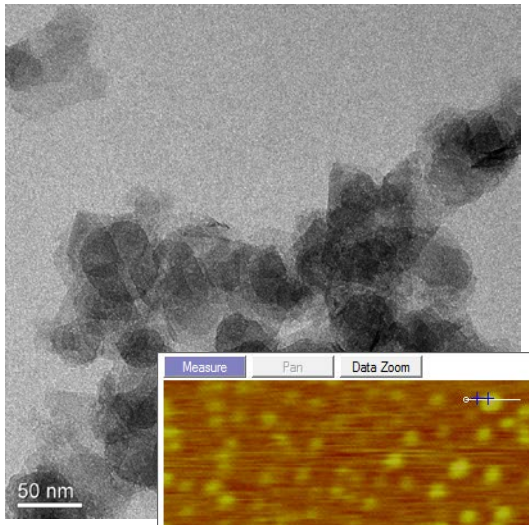
Continues flow
Pressure - Temperature

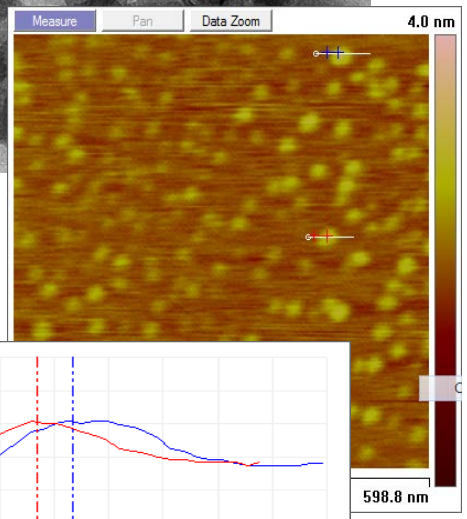


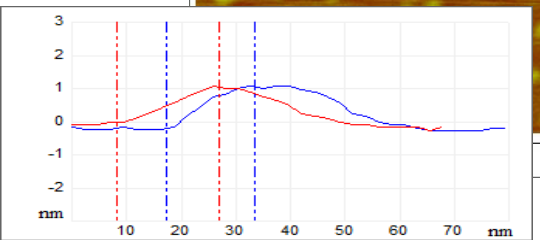
UiO : Kjemisk institutt

Nanomaterials – Characterization
In-situ studies at working conditions

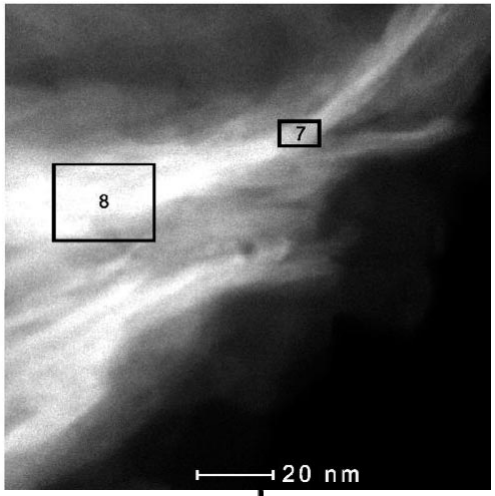
Morphology – size
(TEM/AFM/DLS/SAXS/SANS)

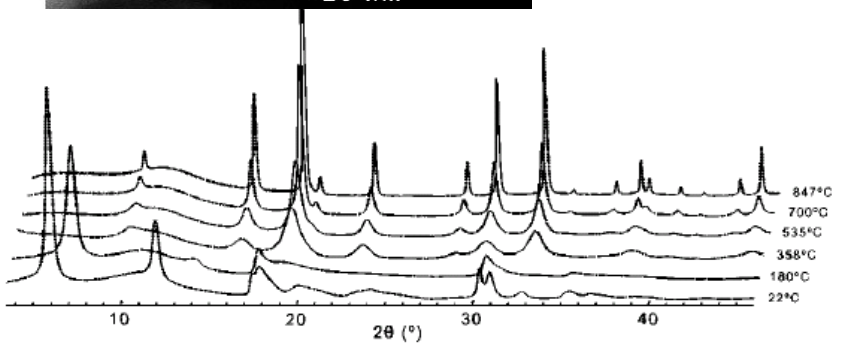




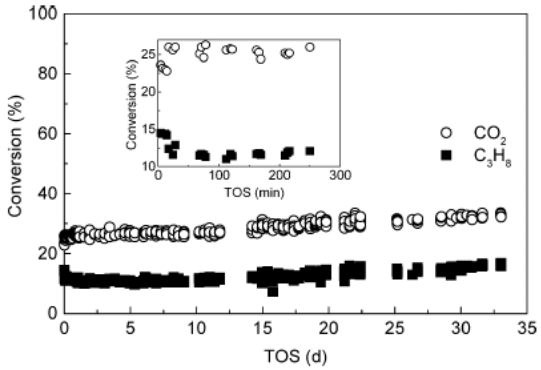


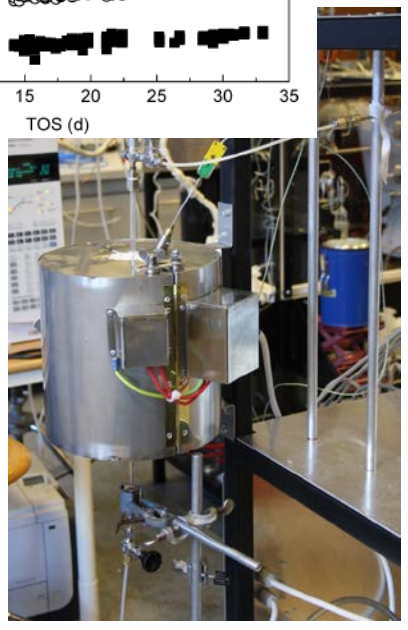
Chemical composition
Atomic arrangement
(ICP/STEM-EDXS/XPS/
XRD/PN/XAS**)**





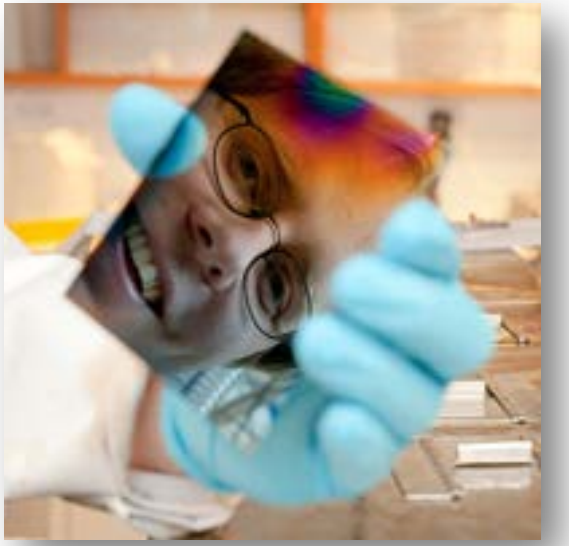
Properties
Catalytic performance
Magnetic properties





UiO : Kjemisk institutt

Thin films & coatings



ALD (Atomic Layer Deposition)
Sol-gel/spin-coating
Electrospinning

Oxides with interesting physical properties

Multistructures with novel properties (nanostructures; interfaces)

Novel inorganic – organic hybridmaterials

Model materials for heterogeneous catalysts

Applications: solar conversion, transparent conductive layers, batteries, imaging, photocatalysis
sensors, photocatalysis, scaffolds,….

Spin-off company; Baldur Coating AS

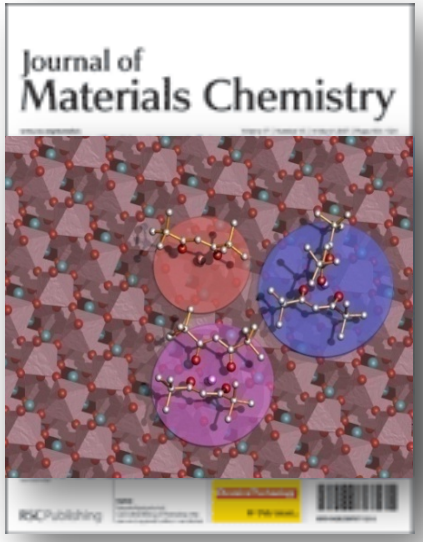
baldur
BALDUR COATINGS AS

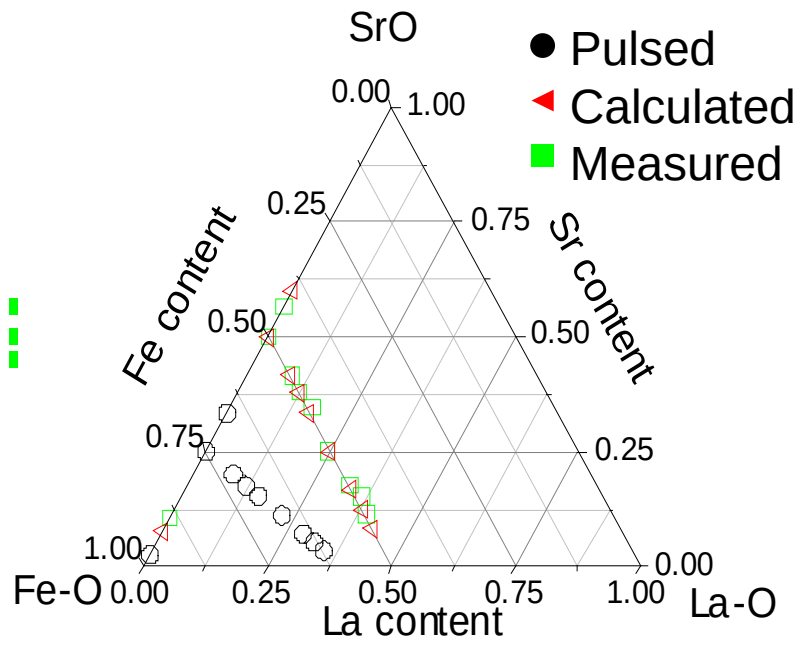
UiO : Kjemisk institutt

Oxides and hybrid thin films

$Ca_xLa_{1-x}MnO_3$ $(Co_xFe_{1-x})_3O_4$ Zn(M)O $CoMoO_4$

Unique possibilities to control stoichiometry at atomic level





Model materials for catalysis
(collaboration Haldor Topsoe, Denmark)

Magnetic nanomaterials
(collaboration NGU, Trondheim + Münster)

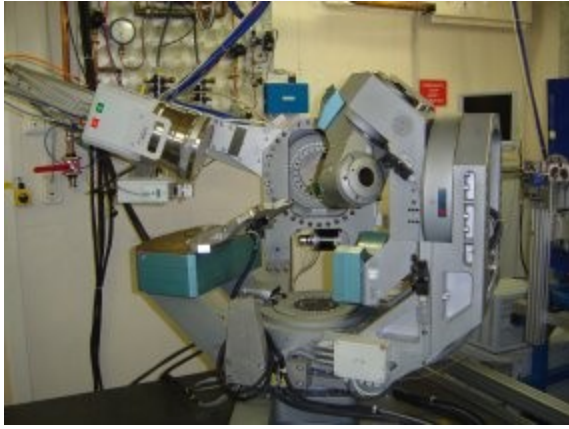
Surfaces and multilayers
Synchrotron and neutron based studies
(collaboration SNBL, ESRF, Grenoble + IFE)

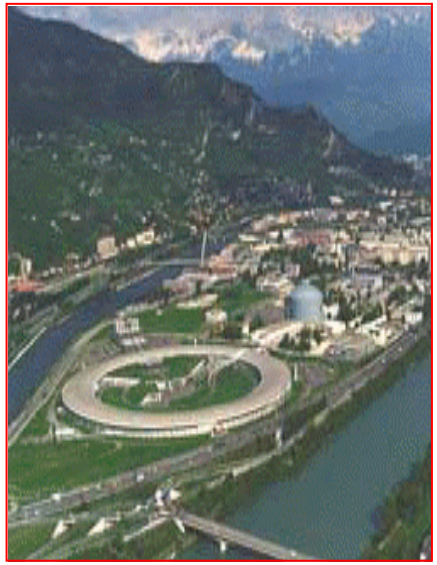
Coatings for solar cells
(collaboration UiO; FME-solar united,…)

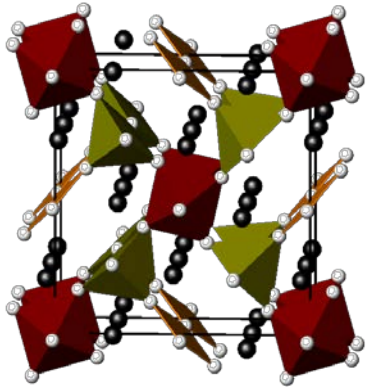
O. Nilsen et al. J. Mater. Chem. 17 (2007) 1466

UiO : Kjemisk institutt

Advanced characterization of nanoparticles and surfaces







Synchrotron based tools – in addition to ”home lab”

Particles:

- Total scattering studies (Bragg + diffuse)
- Modulated studies to enhance surface effects
- Information on size, shape, atomic arrangement
- Average and local structure
- XANES – oxidation states

Surfaces, thin films and multilayers:

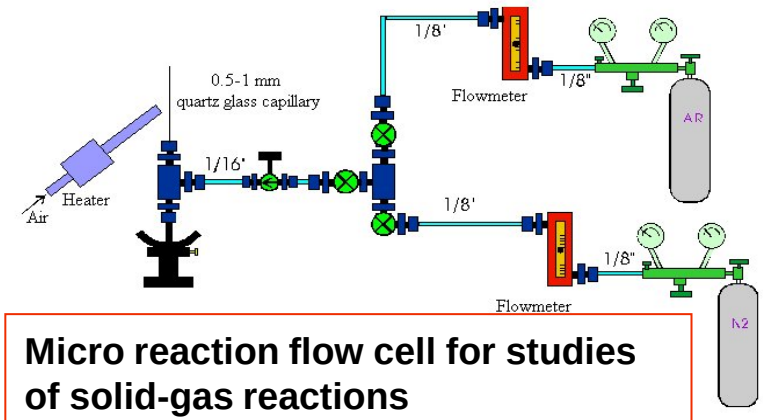
- Single crystal diffraction
- Surface sensitive techniques
- Reflectometry

Collaboration with staff at SNBL and ESRF, Grenoble (European Synchrotron Radiation Facility)

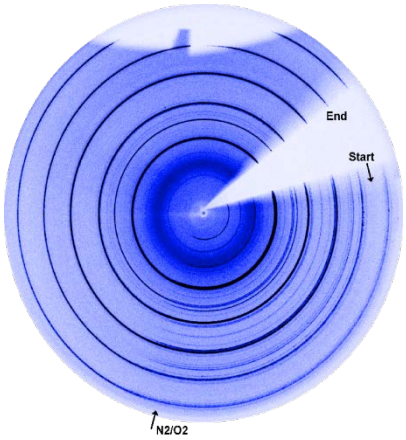
UiO : Kjemisk institutt

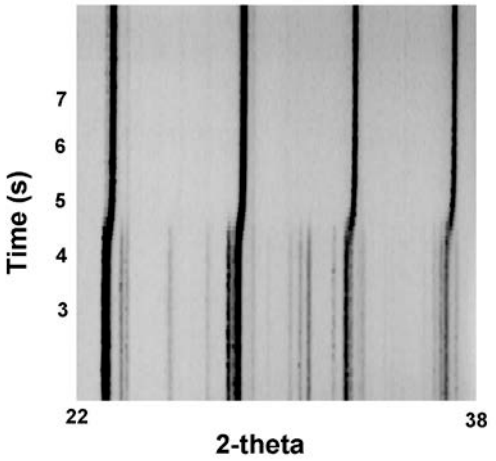
In-situ/time resolved studies at working conditions

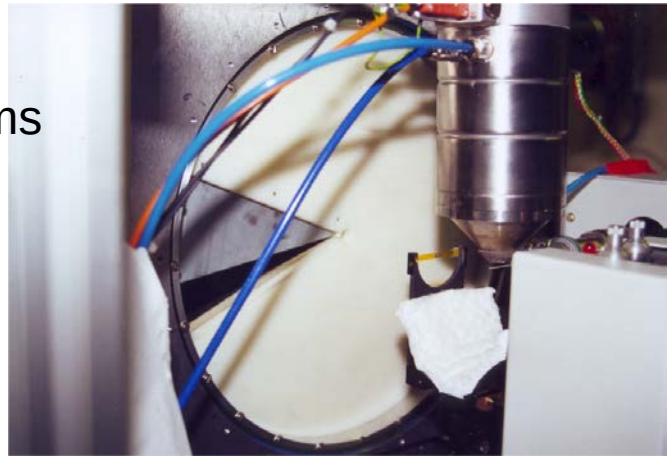
What: Methods providing insight at realistic atmosphere-P-T conditions
Focus: Reducible oxides; catalysts; absorbents; fast reactions
Why: Insight in species/defects/structures that provides a certain function



Micro reaction flow cell for studies of solid-gas reactions





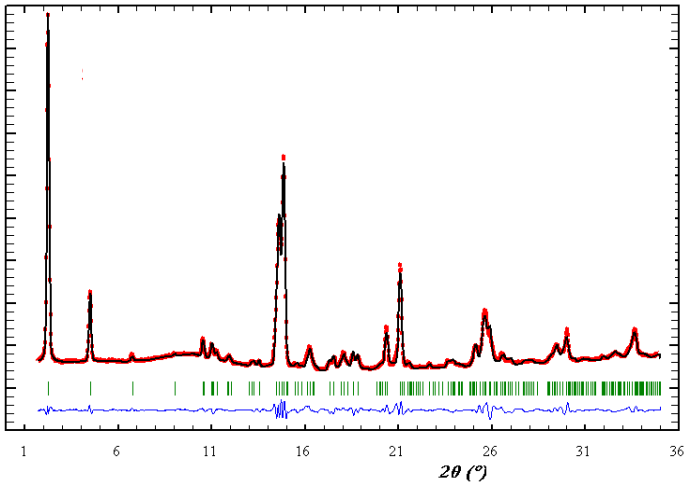


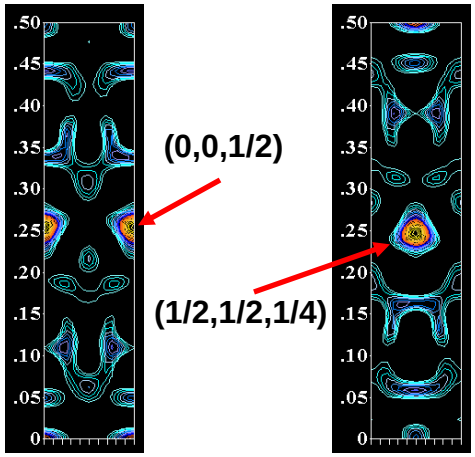
Key to progress: State-of-the-art tools & model systems
Our approaches: Model surfaces for catalysts (ALD); Selective absorbents – MOFs;
Partners: SNBL/ESRF; Utrecht (AFM;RAMAN); Haldor Topsoe (ETEM)

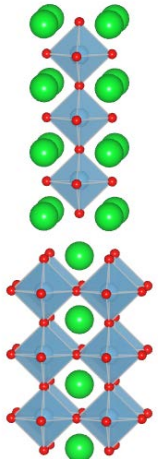
Structure analysis: synchrotron + neutron

Purpose: To understand structure and bonding ←→ properties

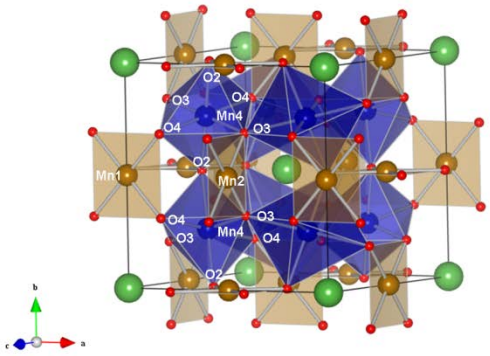
- **Hydrated oxidehydroxide $(Pr,Sr)_4(Fe,Co)_3O_7(OH)_2$-$yH_2O$**

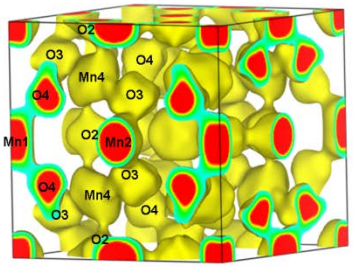


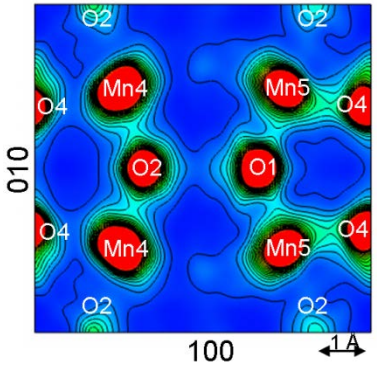




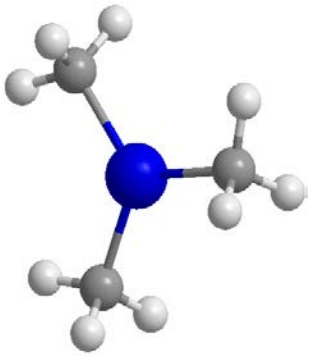
- **Hybridization of Mn3*d*-O2*p* orbitals in $BiMn_7O_{12}$**



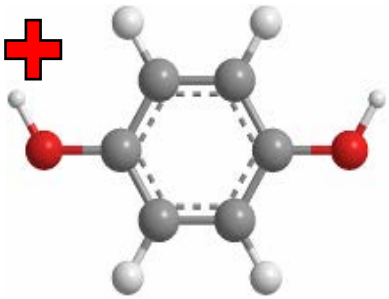




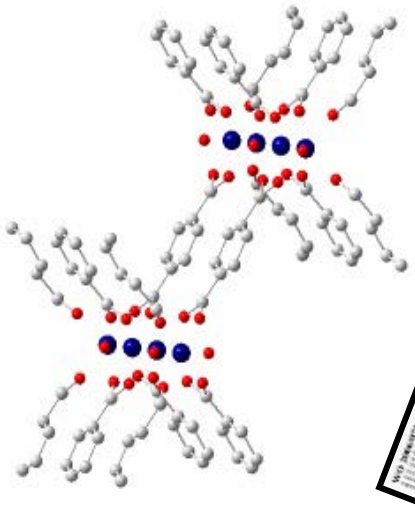
Organic– inorganic hybrid films



$Al(CH_3)_3$

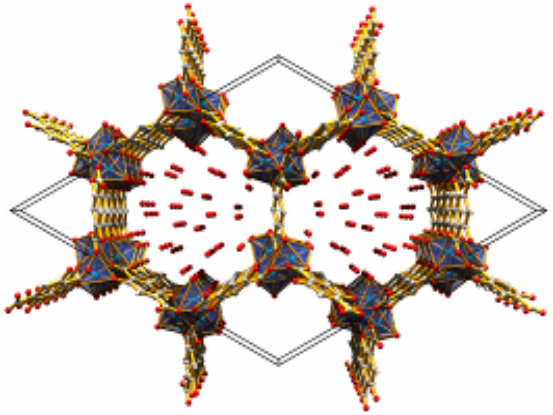


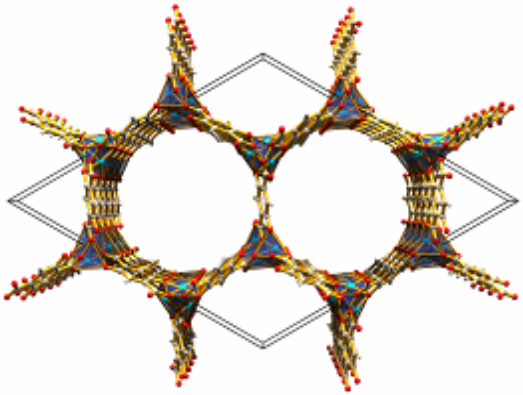
Hydroquinone



$Al_2(Hq)_3$

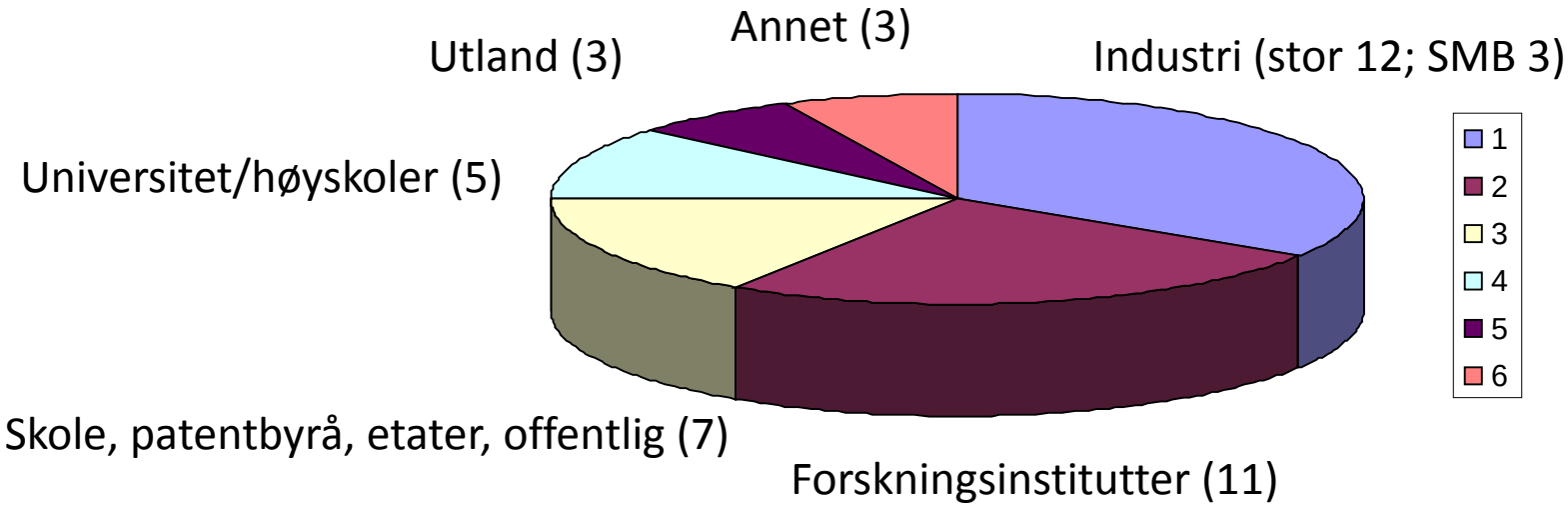
Novel microporous MOF materials; Coordinatively unsaturated metal sites





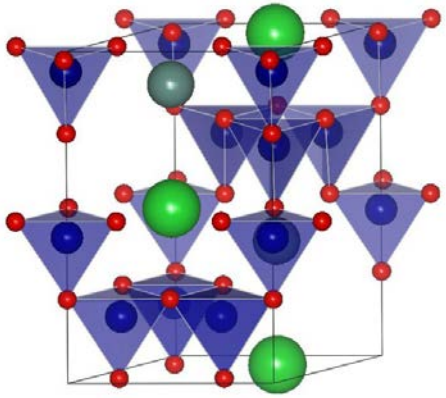
Arbeidssted etter avsluttet studium/forskertrening ved UiO

Statistikk basert på 44 medarbeidere (master, PhD, post doc)
Innen uorganisk materialkjemi; gruppen til prof. Fjellvåg
1990-2007



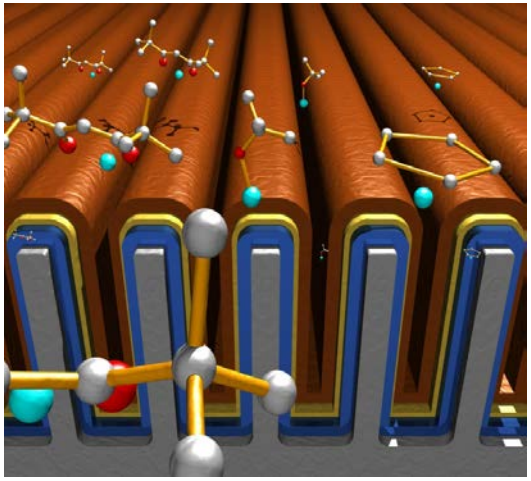
Master 2012 – (nano)materials

- Surfaces, multilayers and nanoparticles
  - Characterization of monodisperse nanoparticles
  - Characterization of surfaces and multilayers
  - Modeling of reactions and properties



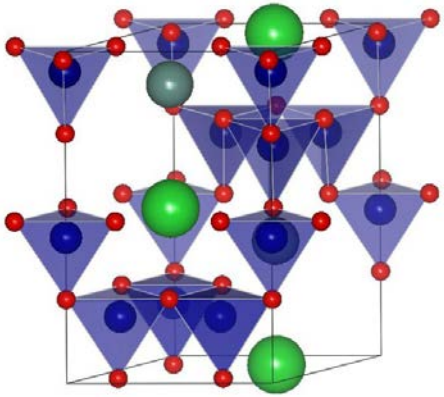
- Complex oxides – structures and properties
  - Synthesis; crystal structure, physical properties

- Thin films and coatings
  - Organic-inorganic hybrid films for cell growth



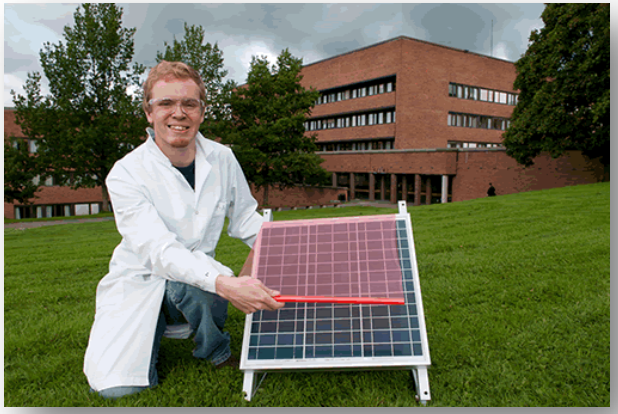
Kjemitunge masteroppgaver – muligheter 2012

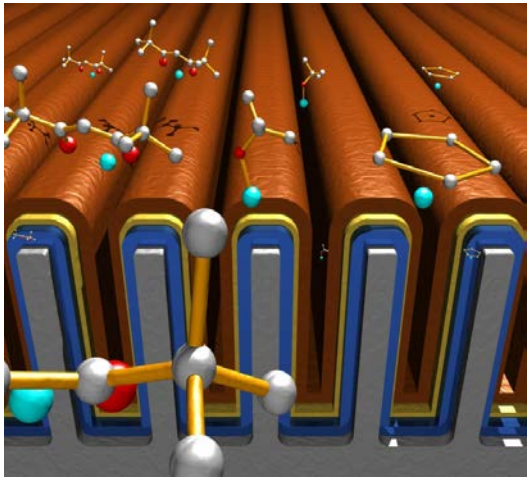
- Complex oxides – structures and properties
  - Bulk – nanoparticles – thin films
  - Experiments or modelling



- Surfaces and nanostructures
  - Monodispersible nanoparticles
  - Model surfaces for catalysis

- Thin films and coatings





Bakgrunnskunnskaper for master

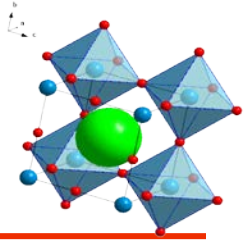
- Oppgaver innen syntese, karakterisering og modellering stiller ulike krav til optimal bakgrunn
- Viktig å vite hva man er mest interessert i (syntese, studier av struktur/fysikalske egenskaper, eller teori/modellering)
- Ulike MENA-kurs kan være nyttig; videre fysikalsk kjemi.
- Kurs 1.semester master bør avtales med veileder(e)
- TA KONTAKT og diskuter dine valg med oss !

A few more examples

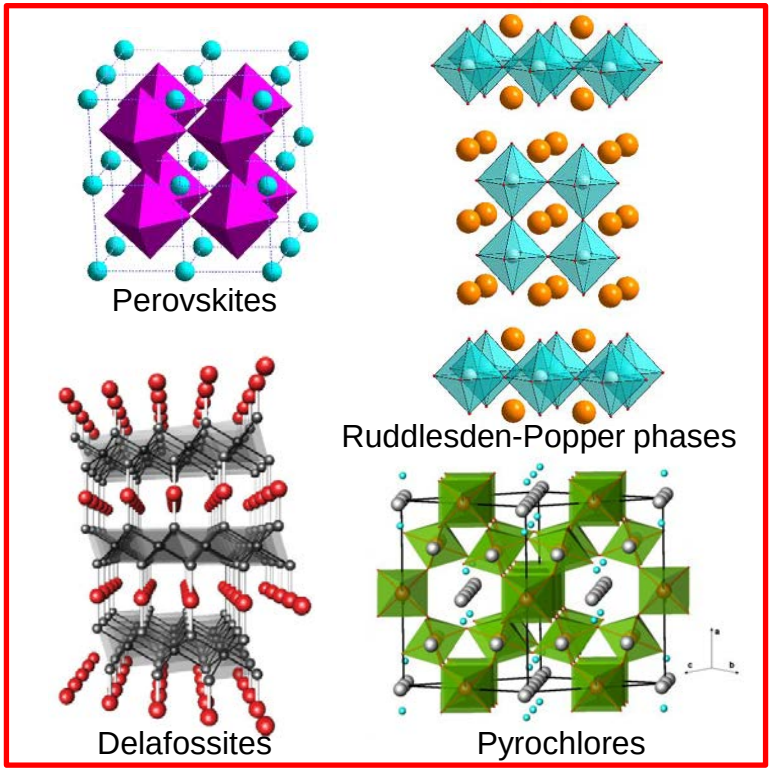
→ ongoing and planned activities

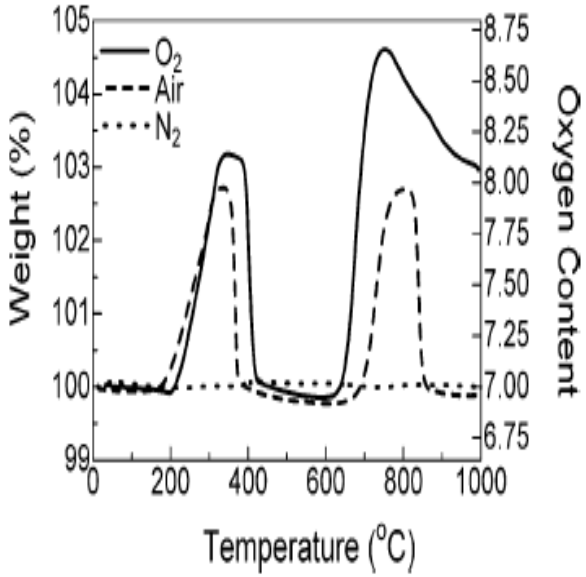
UiO : Kjemisk institutt

Complex oxides



What: Oxides with particular physical properties (phenomena)
Focus: Magnetic/electric/optical properties; oxygen reservoirs; catalysts
Why: Novel phenomena, higher yield, fundamental insight, technology





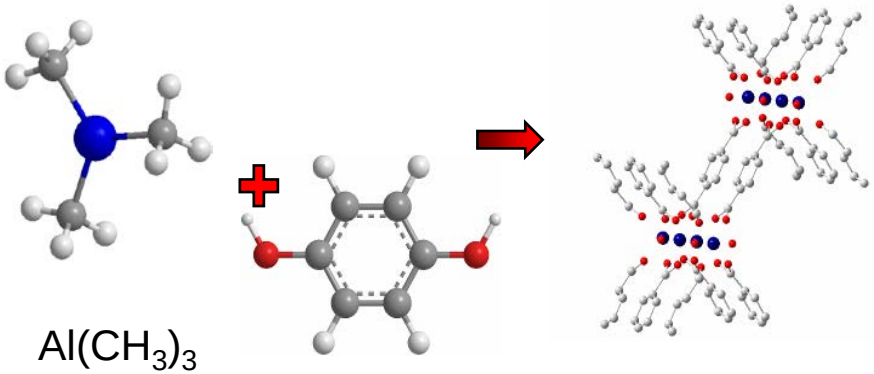
Our approaches: Soft chemical synthesis (pO_2 control); nano/thinfilms/bulk; exp+theory
Partners: Large scale facilties (synchrotron & neutron diffraction);world wide universities

Organic– inorganic hybrid films for cell growth

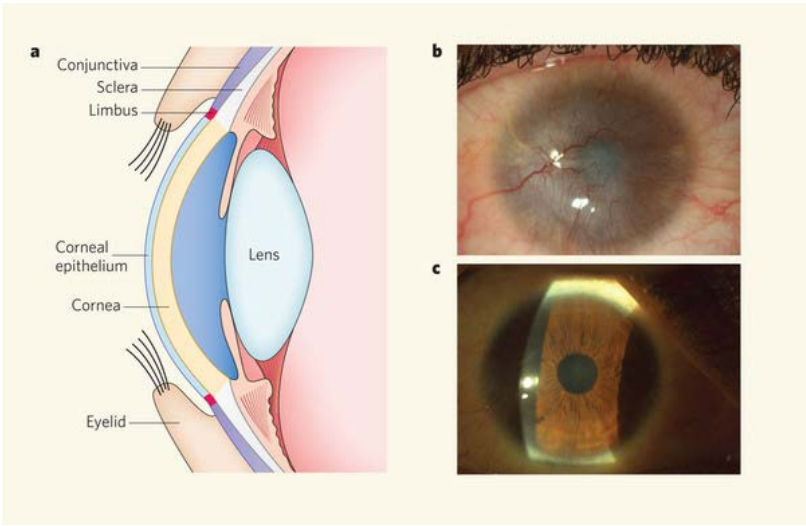
Bionano:
Have unique abilities to functionalize surfaces to become bioactive.
Wish to exploit this through joint project with Ullevål hospital to study cell growth on functionalized surfaces.

Aim:
Regeneration of retinal cells

Requirements:
Some understanding of what a cell is – will be admitted to cell growth laboratory at Ullevål



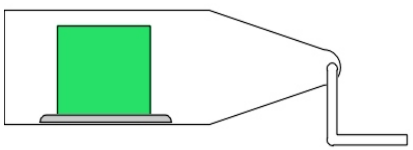
$Al(CH_3)_3$ Hydroquinone $Al_2(Hq)_3$

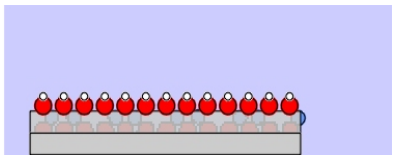


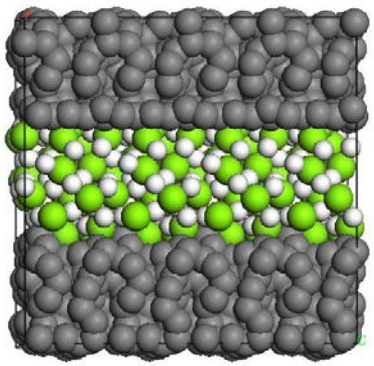
Modeling – computational materials science

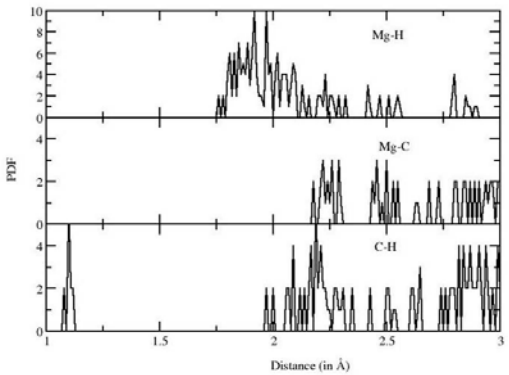
The vision: understanding of electronic properties
feedback to experiments and improved materials

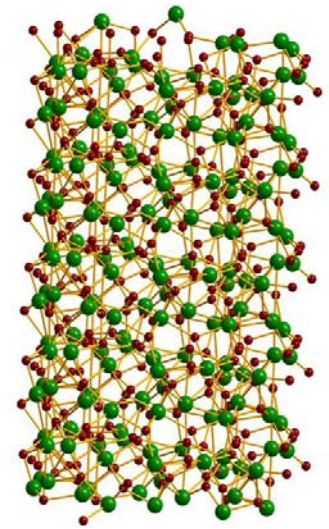
Modeling of the ALD deposition process; surface reactions
Modeling of chemical defects in semiconductors – TCOs
Multiferroics and magnetoelectrics; coupling between structure and properties
Properties of nanoparticles; freestanding and in scaffolds
Prediction of possible novel compounds (hydrogen storage; Li-ion batteries)

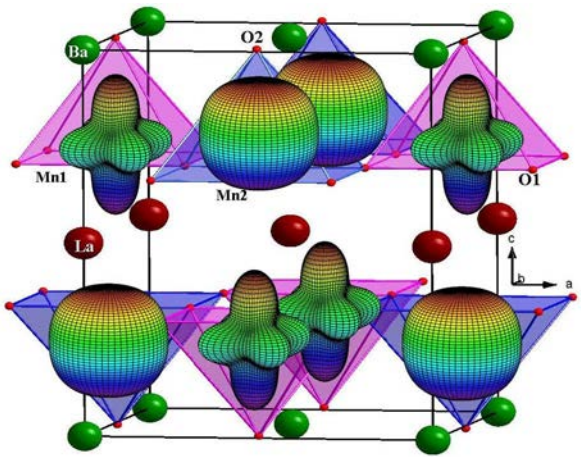






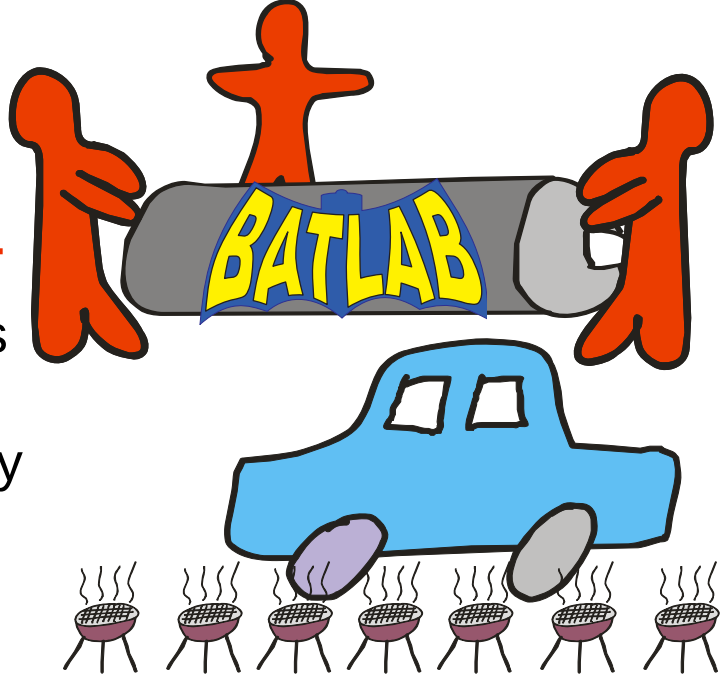




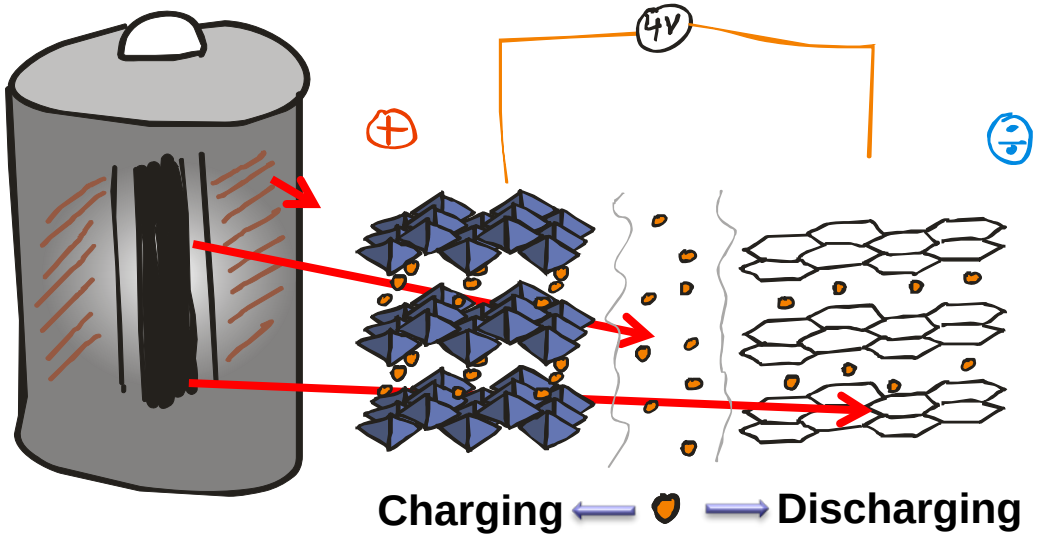


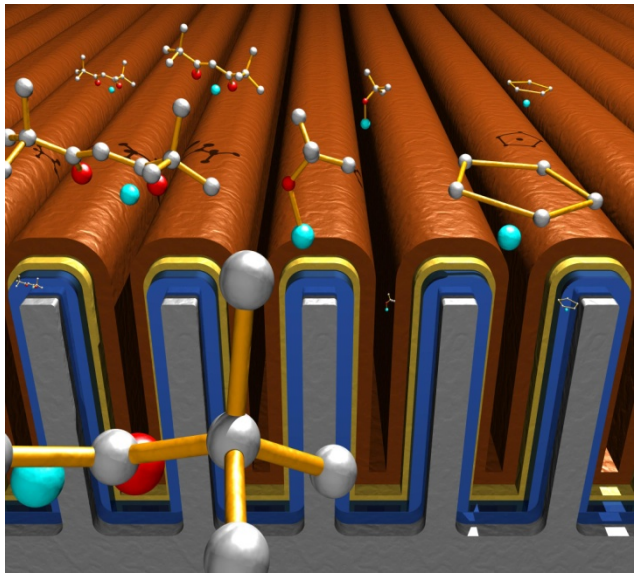
UiO : Kjemisk institutt

Battery materials



What: Cathode, anode and electrolyte materials
Focus: Li-ion batteries; microbatteries
Why: Need for breakthroughs in energy capacity



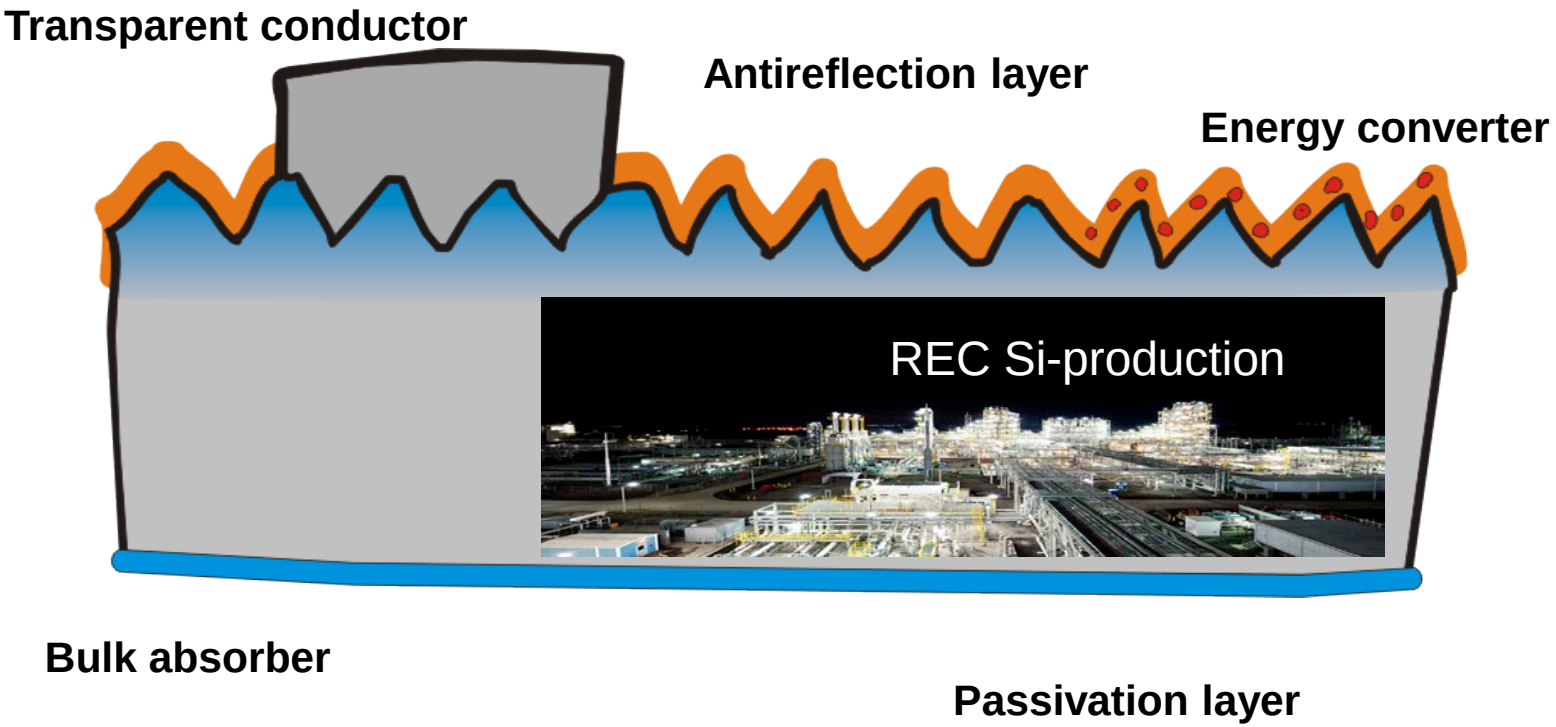


Key to progress: Solid state chemistry/electrochemistry
Our approaches: Novel electrode materials; all-solid-state microbatteries by ALD
Our partners: Key European universities, research centres and leading inductry

UiO : Kjemisk institutt

Solar cell materials

What: Bulk Si-absorber; all means to enhance energy efficiency
Focus: Si-solar cell; bulk absorber, TCOs and conversion materials
Why: Need for improved (cheap) technology with higher energy efficiency



Key to progress: Materials/nanophysics and -chemistry
Our approaches: Tailored TCOs - understanding of defects & chemistry; materials facilitating energy conversion; fundamentals of Si-growth. **Partners**: FME-solar; REC