

# Electrochemistry and electroactive materials

Faculty of Science and Engineering

Johan Bobacka

Laboratory of Molecular Science and Engineering

# Electrochemistry and electroactive materials

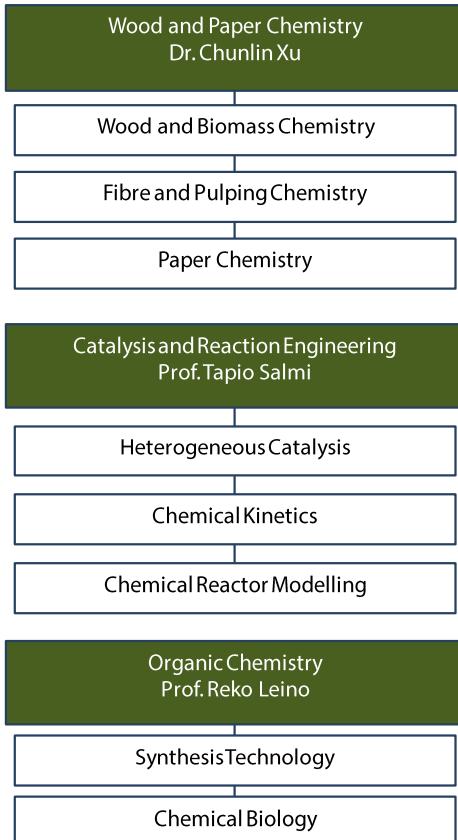
## Background:

- Research on conducting polymers in Turku **since 1988**
  - Prof. Ari Ivaska (Åbo Akademi University)
  - Prof. Jouko Kankare (University of Turku)
- **Later:** Fullerenes, carbon nanotubes, graphene, composites & applications
- **Åbo akademi University**
  - Analytical chemistry: **Electrochemical sensors**
  - Industrial chemistry: **Electrocatalysis**
  - Inorganic chemistry: **Batteries, fuel cells**
  - Physical chemistry: **Printed electrodes and sensors**
  - Physics: **Electrochemical transistors, solar cells**



Johan Gadolin  
Process Chemistry Centre

**Johan Gadolin**  
**Process Chemistry Centre**



**Johan Gadolin**  
Process Chemistry Centre

**PCC: 21 years of Molecular Process Technology**

**150 PhD / DSc degrees**  
**2200 peer-review articles**  
**110 million EUR**

Contact: Prof. Johan Bobacka

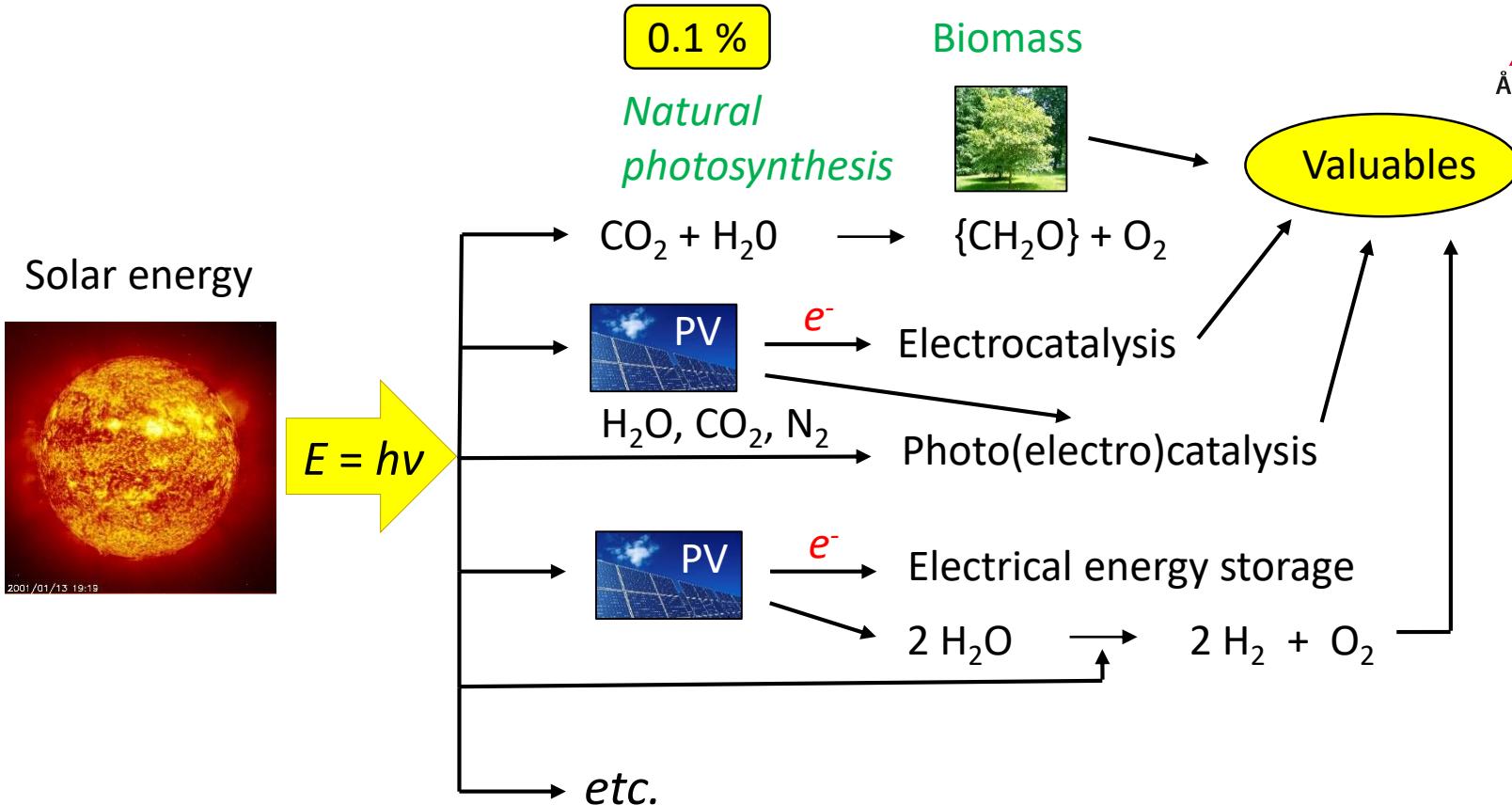


Molecular Process and  
Material Technology



# Research activities relevant to SUNRISE

- Biomass chemistry
- Catalysis
- Electroactive materials
- Electrochemistry
- Nanomaterials
- Organic synthesis
- Printing and paper coating
- Reaction engineering
- Recycling of metals
- Solar cells



# Chemistry of wood, paper and bioproducts

## Chemical technology & analytical methods



**Biorefinery and  
biobased materials**



High-value  
biomaterials  
and  
biochemicals

**Wood, Pulping, and  
Papermaking  
Chemistry**

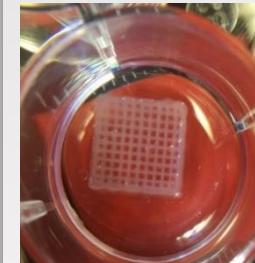


Better and  
innovative paper,  
processes, and  
products

## Bio-based products



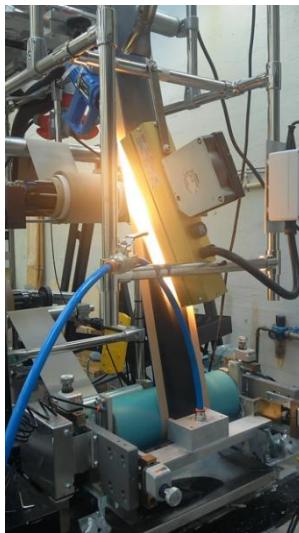
## 3D printing



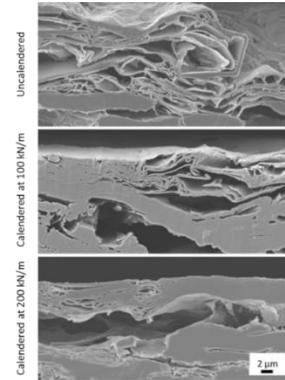
Contact: Dr. Chunlin Xu

# Towards cost-efficient and environmentally friendly energy storage systems

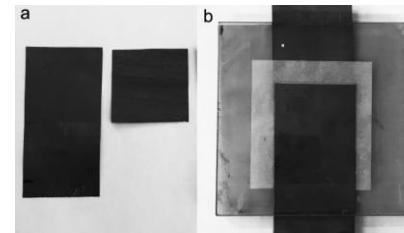
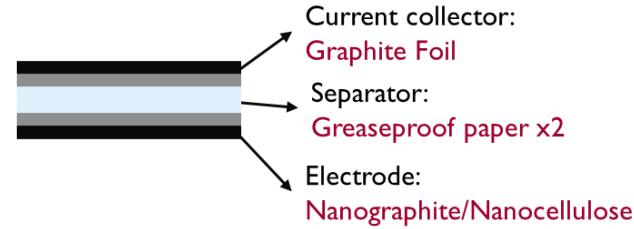
## Slot coating of carbon- and nanocellulose-based electrodes



Surface resistance  
 $\approx 1\text{-}2 \Omega / \square$  at  $15 \text{ g/m}^2$



## Supercapacitor assembly

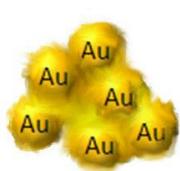


Equivalent series resistance  $\approx 1 \Omega$   
Specific capacitance  $\approx 50 \text{ F/g}$

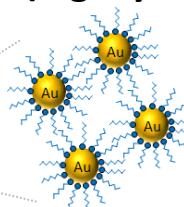
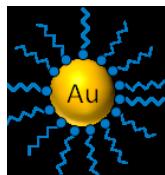
# Printed paper-based sensor platform

From synthesis and processing of colloidal materials ...

Raw material



Low- $\gamma$  solvent (e.g. xylene)



Add surfactant

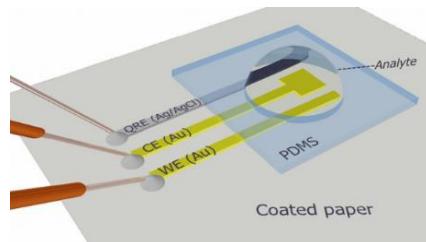
Processing by inkjet

- Viscosity: 10–12 mPa s<sup>-1</sup>
- Surface tension: 28–33 mN/m
- Particle size: < 500 nm

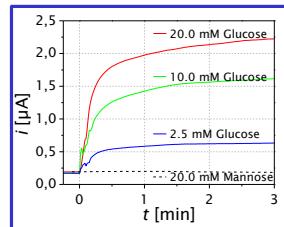


Stable ink suspension

... to printed electrodes and sensor configurations



Glucose sensor



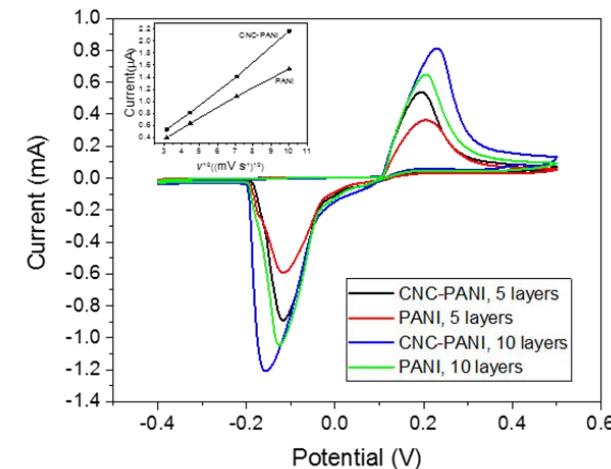
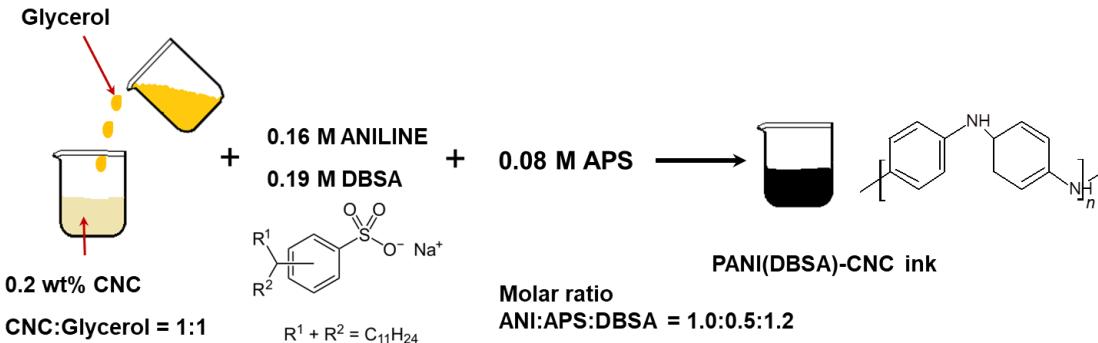
$H_2S$  sensor



Contact: Prof. Jouko Peltonen

# Electroactive composites for printing

Conducting ink based on cellulose nanocrystals (CNC) and polyaniline (PANI) for flexographic printing

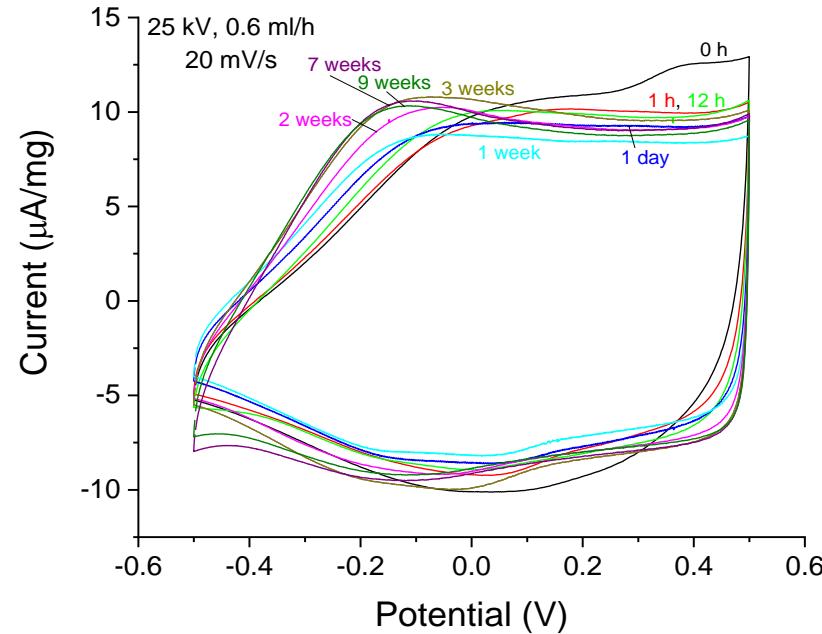
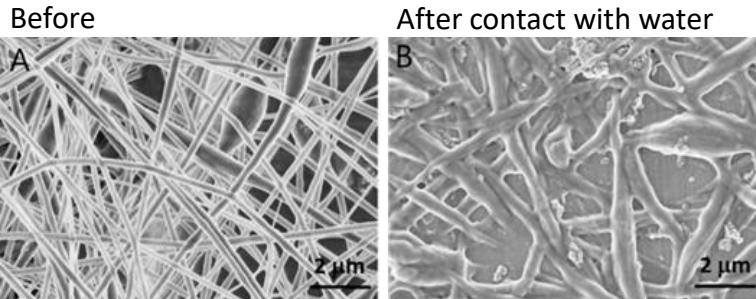
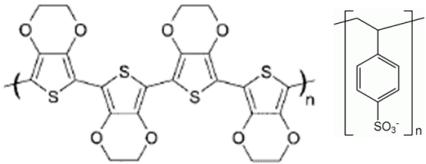


R.-M. Latonen, A. Määttänen, P. Ihalainen, W. Xu, M. Pesonen, M. Nurmi, C. Xu, J. Mater. Chem C, 5, 2017, 12172-12181.

Contact: Dr. Rose-Marie Latonen

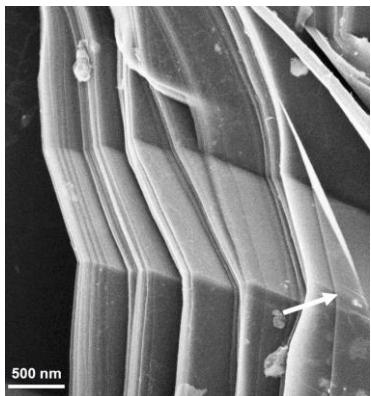
# Electrospinning of electroactive composites

Conductive electrospun water-resistant nanofibers of cellulose nanofibrils (CNF) and PEDOT(PSS)

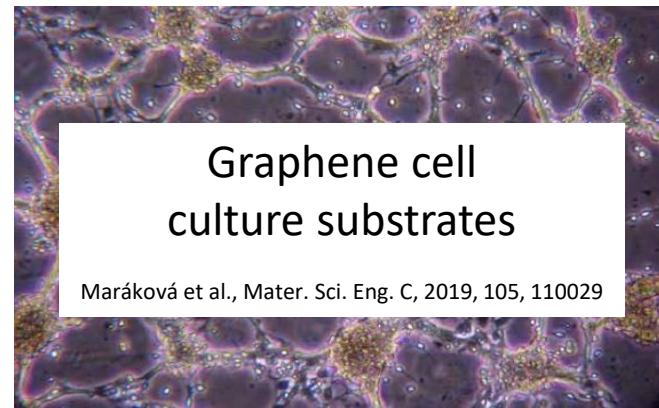
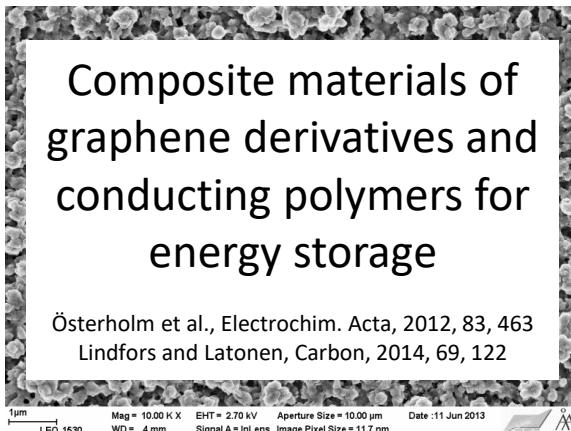
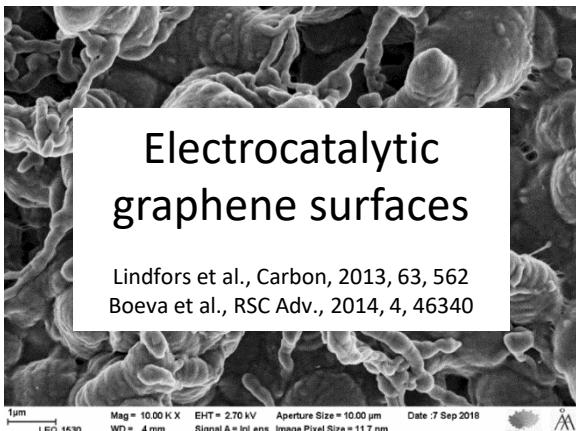


Contact: Dr. Rose-Marie Latonen

# Graphene



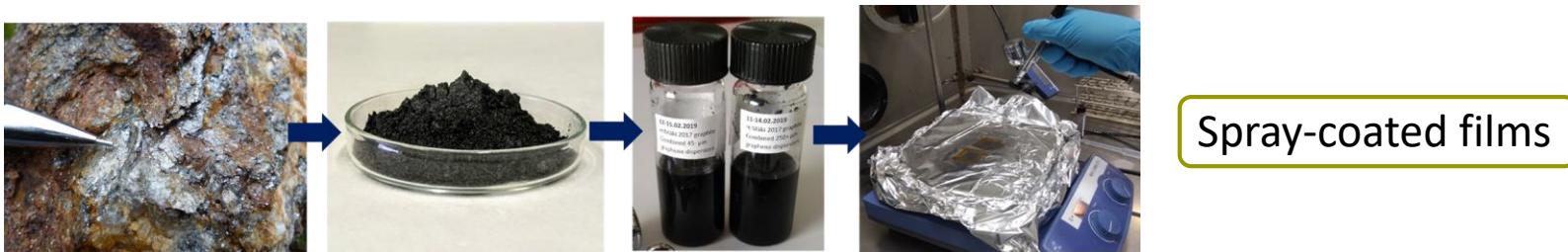
High-shear  
exfoliation of  
Finnish flake  
graphite



Contact: Dr. Tom Lindfors

# Graphene–nanocellulose composites

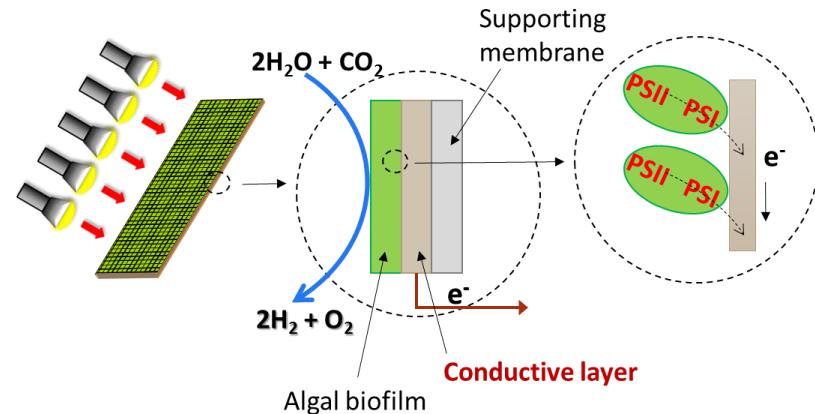
High-shear exfoliation of Finnish flake graphite to nanocellulose suspension → graphene–nanocellulose composites



Conductive biodegradable electrodes  
for a photosynthetic electrochemical cell



UNIVERSITY  
OF TURKU



# Urban mining as a part of circular economy

# Recycling of critical metals used in:

- Electric vehicles & batteries: Co, Li, REE, Cu
  - Fuel cells: Pt (Ru, Pd, Au)
  - Photovoltaic (solar cells): Si, Au, In, Ga, Se, Te, Ge, Ru, Te, Dy, ...
  - Thermo-electrics, opto-electronics, LEDs: Bi, Te, Si, In, Ga, As, Se, Ge, Sb, ...

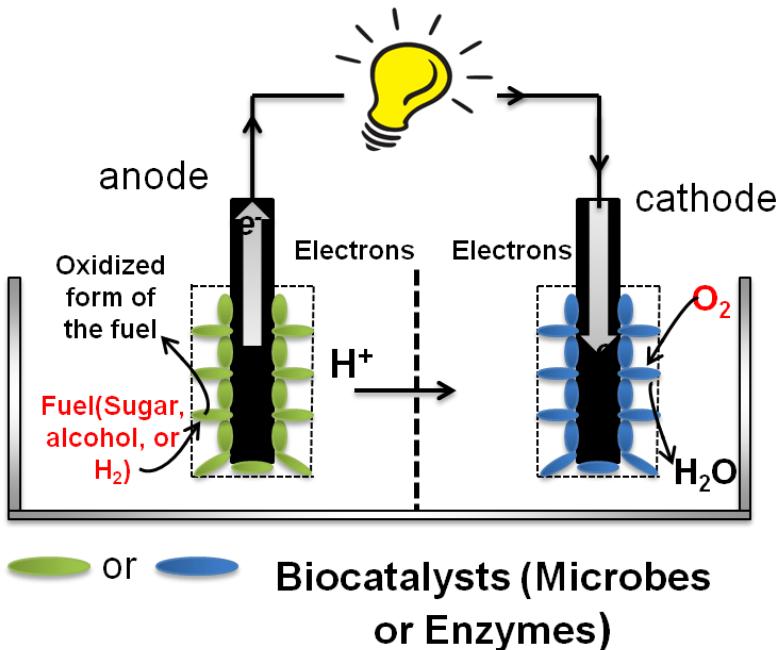
H	EU critical materials (RMI)												He				
Li	Be												B	C	N	O	
Na	Mg												Al	Si	P	S	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
K	Ca	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt									
Precious metals				Semiconductor materials				Rare earth elements (REE)				Technology metals					

New solutions and understanding through

- hydro- and pyrometallurgic processes
  - electrometallurgy
  - thermodynamic modelling

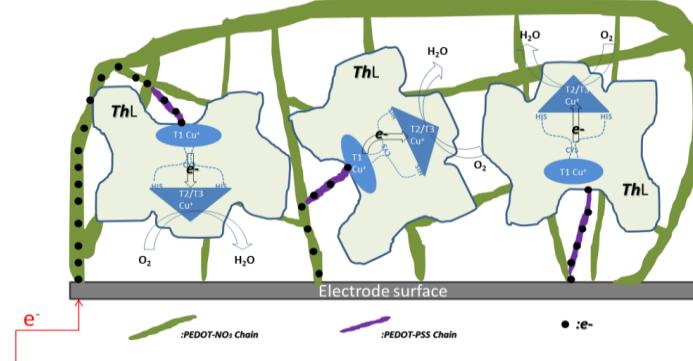
Contact: Prof. Leena Hupa

# Biofuel cells



X. Wang, R-M. Latonen, P. Sjöberg-Eerola, J-E. Eriksson, J. Bobacka,  
H. Boer, M. Bergelin, *J. Phys. Chem. C* (2011) 115, 5919-5929.

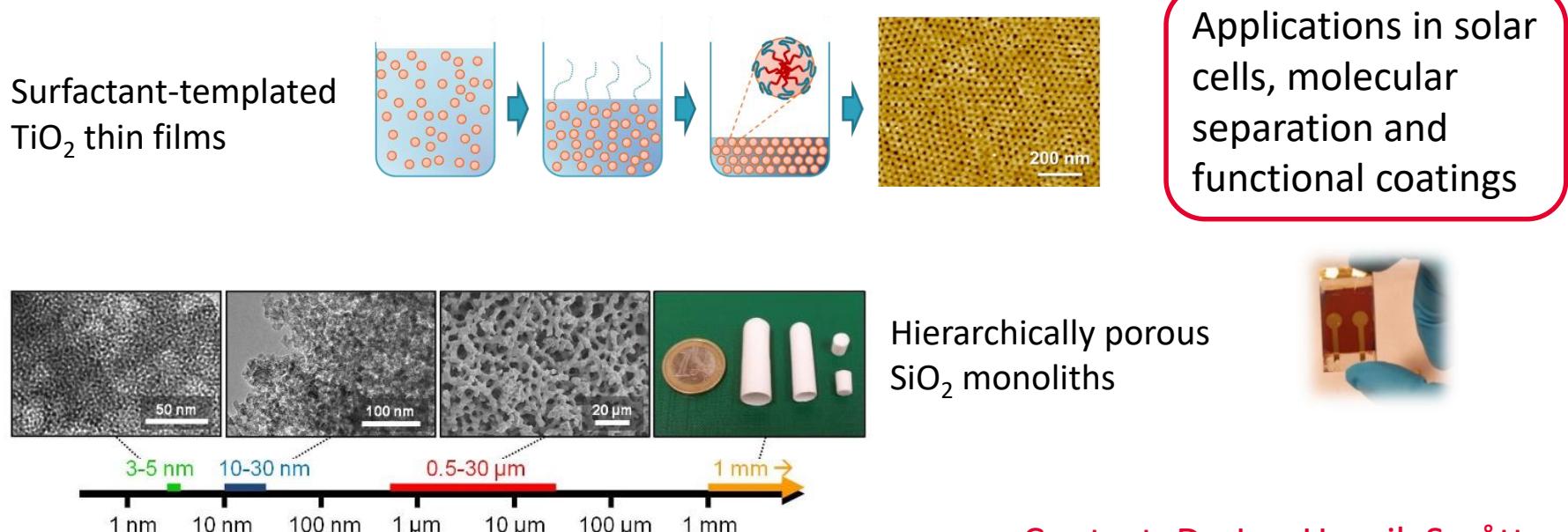
Direct electron transfer bioelectrocatalysis for *ThL* in a fine-tuned dual-layer-architecture of PEDOT films



Contact: Dr. Xiaoju Wang

# Nanostructured metal oxides for solar cells

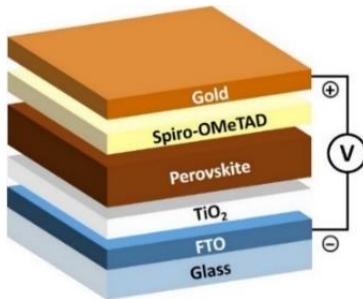
Design of novel metal oxide materials with tunable porosity and morphology using solution processing



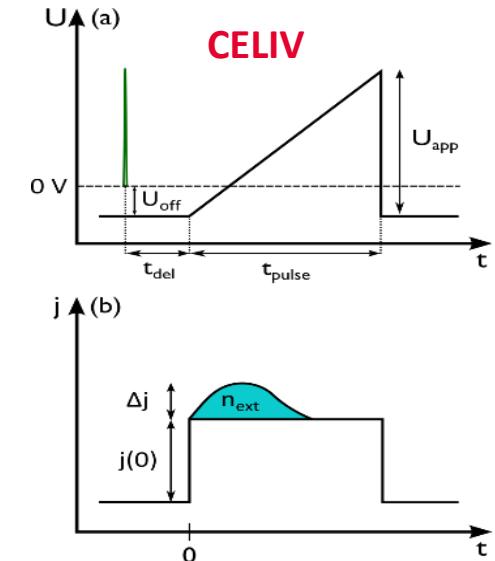
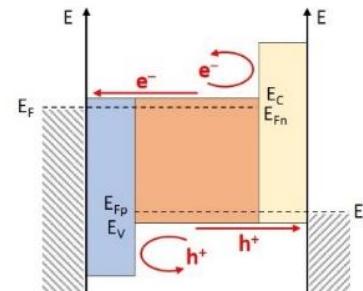
# Solar cells

- Developed charge carrier extraction techniques (CELIV) as in-device spectroscopical tools
- 1D and 2D drift-diffusion simulations of thin-film solar cells
- Understanding charge selectivity of contacts

## Perovskite solar-cells



## Modelling of charge selectivity

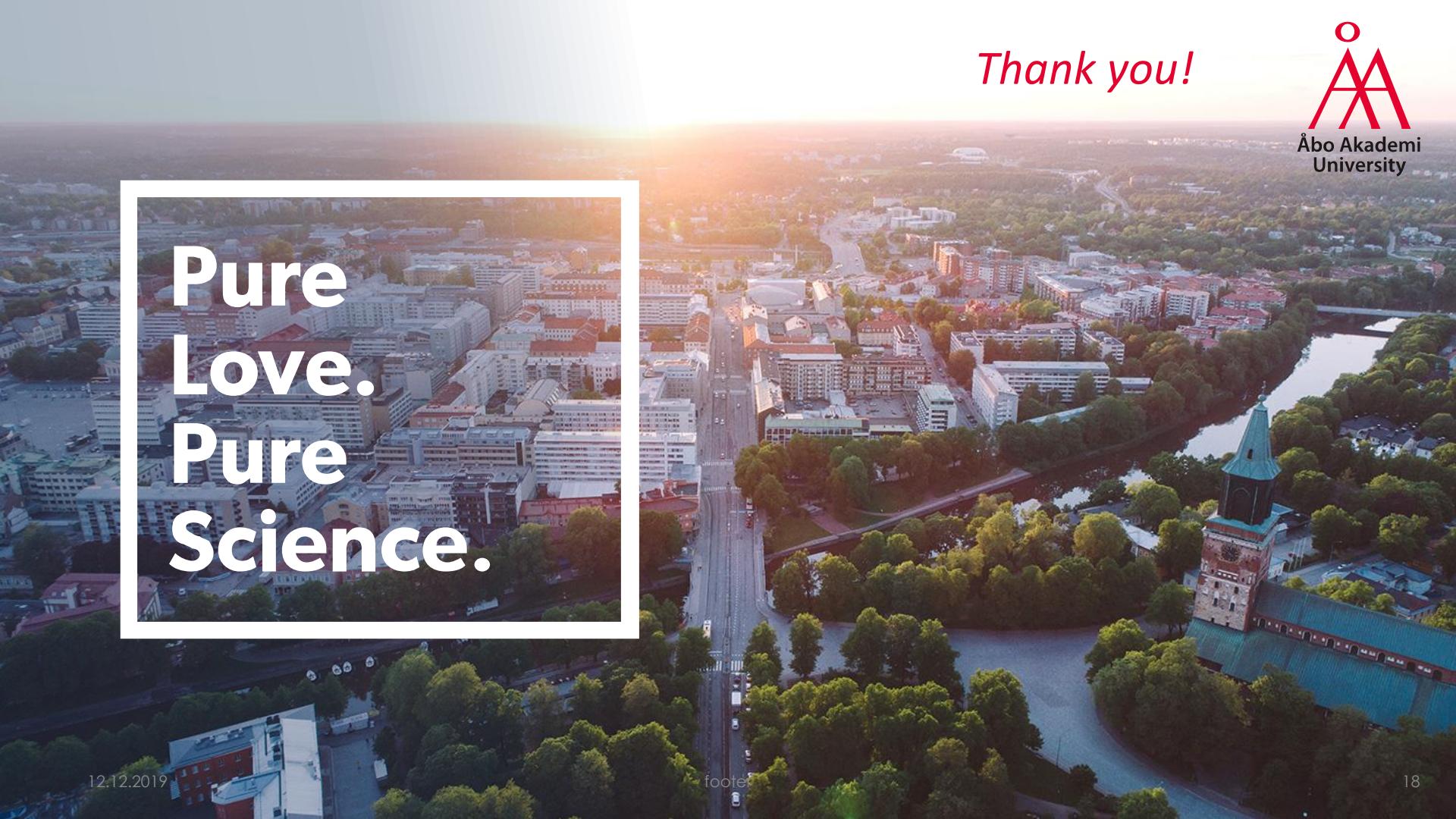


Contact: Prof. Ronald Österbacka

Looking forward to a successful **SUNRISE**



Start  
something  
epic.



*Thank you!*



Pure  
Love.  
Pure  
Science.