UiO : Department of Chemistry
University of Oslo

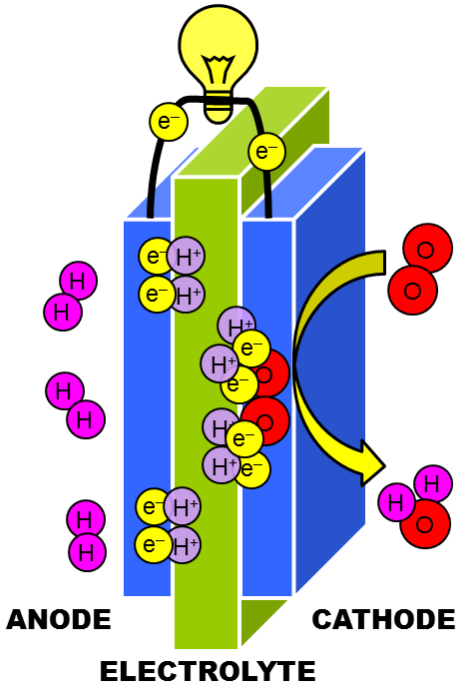
# Hydrogen and fuel cell related activities at University of Oslo

**Truls Norby**

Department of Chemistry
University of Oslo

Centre for Materials Science
and Nanotechnology (SMN)

FERMiO
Oslo Innovation Centre

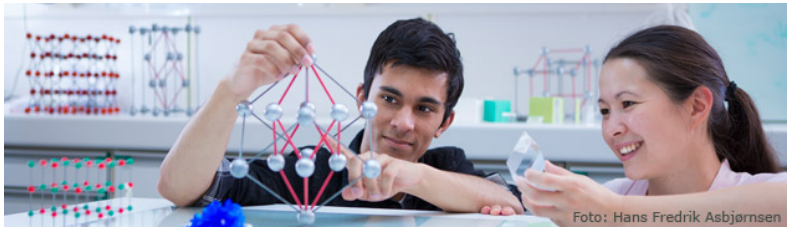



truls.norby@kjemi.uio.no
http://www.mn.uio.no/kjemi/english/people/aca/trulsn/index.html

# University of Oslo

- Founded 1811
- 30,000 students
- 6,000 staff
- Focus areas; Life Science; Energy
- Faculty of Mathematics and Natural Sciences
  - Department of Chemistry
  - Department of Physics

Kristian Birkeland

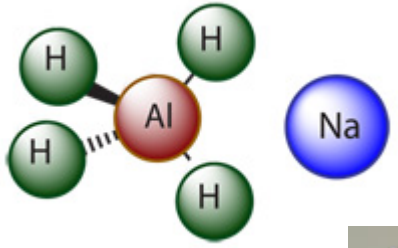



- BSc & MSc programme in *Materials, Energy and Nanotechnology* (MENA)

# Fundamentals of hydrogen in materials

- Structure, defects. Thermodynamics, kinetics, transport

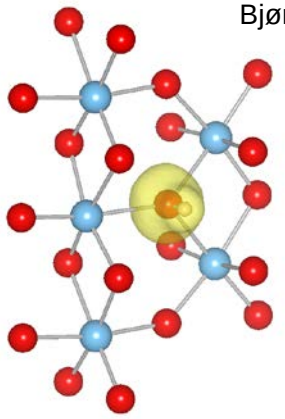
Helmer Fjellvåg, NAFUMA




- Hydrides $H^-$
  - Ionic and covalent hydrides, e.g. $NaAlH_4$
  - $H_2$ storage

- Hydrogen H, $H_2$
  - Dissolution and transport of atomic H in metals
    - Corrosion
    - Hydrogen separation membranes; Pd
  - Absorption of $H_2$ in microporous materials
    - Zeolites, MOFs
    - $H_2$ storage

Bjørn Hauback (IFE), Ole Martin Løvvik (SINTEF)
Adj. Professors, Structure Physics

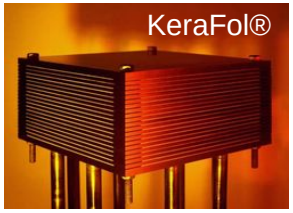


- Protons $H^+$
  - Hydration and protonation of oxides
  - High temperature proton conductors
    - Ceramic fuel cells, steam electrolyzers, hydrogen separation membranes

Reidar Haugsrud, FASE

# Solid-state fuel cells

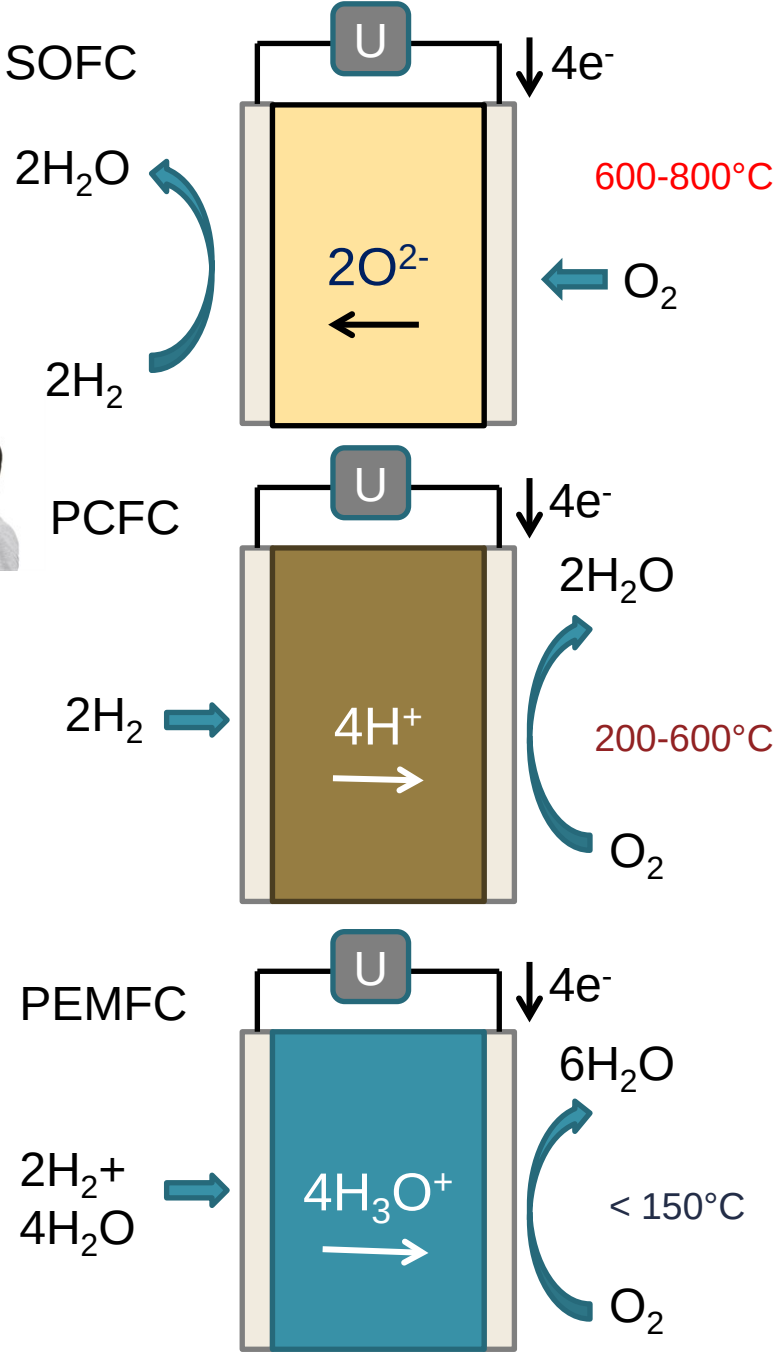
- Examples with $H_2$ as fuel
- SOFC: High T, low fuel utilisation, anode oxidation





- **PCFC: Intermediate T, high fuel utilisation, no anode oxidation**

- PEMFC: Low T, water management, cooling challenges

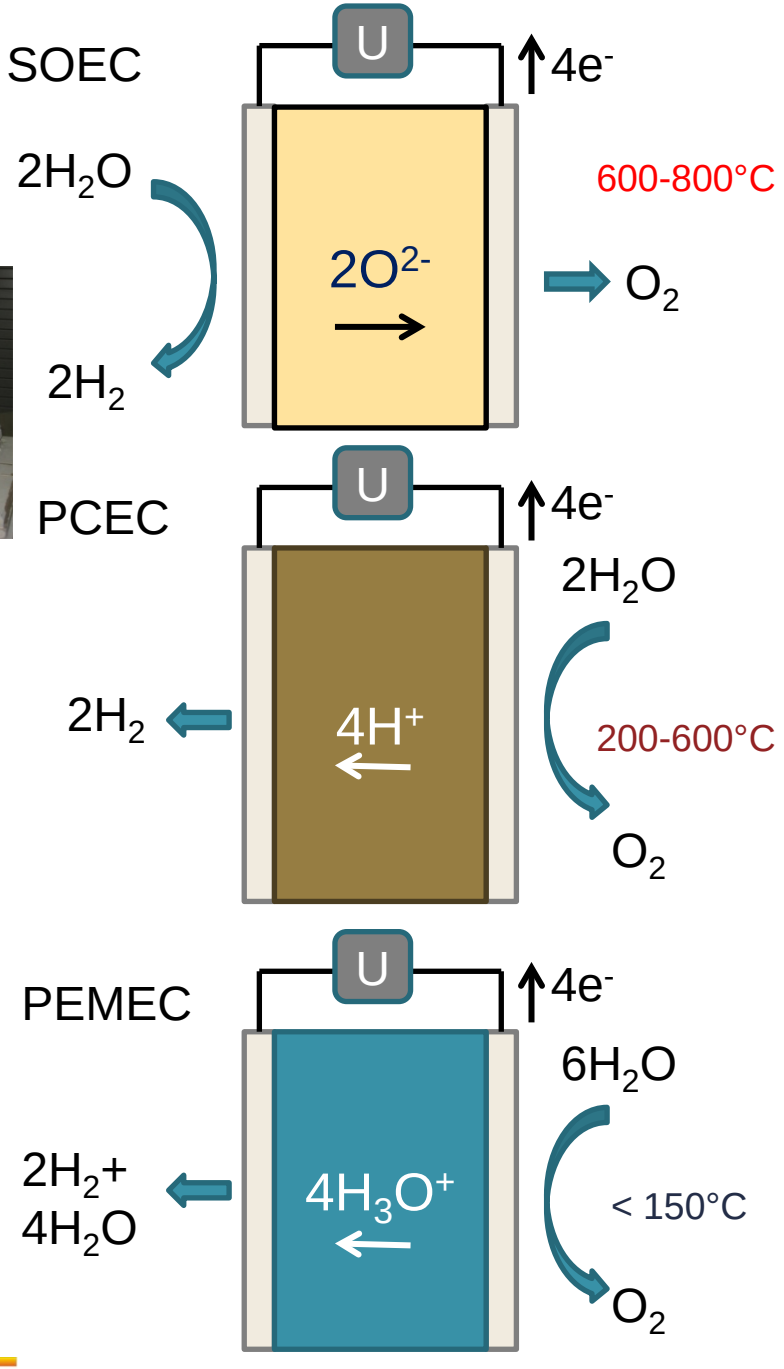



# Solid-state electrolyser cells

- SOEC: Utilises steam&heat
- Produces wet $H_2$

- PCEC: Utilises steam&heat
- Produces dry $H_2$ directly
  - Metallic $H_2$ electrode and support not exposed to oxidising conditions
  - Also standalone $H_2$ compression

- PEMEC: Uses liquid water
- Produces wet $H_2$



# Innovation

Company startups from $H_2$-related research at UiO:

- NorECs Norwegian Electro Ceramics AS
  - 2001… Sample holders, gas mixers. Worldwide sales
  - Private owners
  - Equipment for characterisation of electrical properties of materials and components
  - High temperatures, controlled atmospheres

- Protia AS
  - 2008…
  - Owners: CoorsTek/Ceramatec
  - Ceramic proton conductors
  - Dehydrogenation, aromatization, GTL

$$6CH_4 = C_6H_6 + 9H_2$$