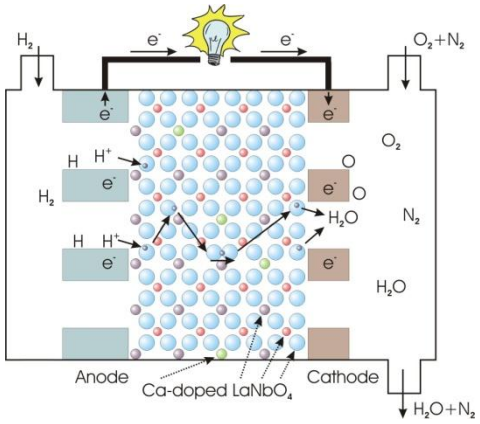
EFFIPRO

Efficient and robust fuel cell with novel ceramic proton conducting electrolyte (EFFIPRO)



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227560

Truls Norby
University of Oslo

1. Project achievements

EFFIPRO partnership

Beneficiary Number	Beneficiary name	Beneficiary short name	Country
1 (coord.)	University of Oslo	UiO	Norway
2	Centre National de la Recherche Scientifique; Institut des Matériaux Jean Rouxel, IMN	CNRS	France
3	Inst. Chemical Technology, U.P. Valencia/ CSIC	CSIC-ITQ	Spain
4	SINTEF	SINTEF	Norway
5	Forschungszentrum Jülich	JÜLICH	Germany
7	Fuel Cells and Solid State Chemistry Department, Risø National Laboratory for Sustainable Energy, Technical University of Denmark	RISØ-DTU	Denmark
8	Ceramic Powder Technology (CerPoTech)	CERPOTECH	Norway

PCFC

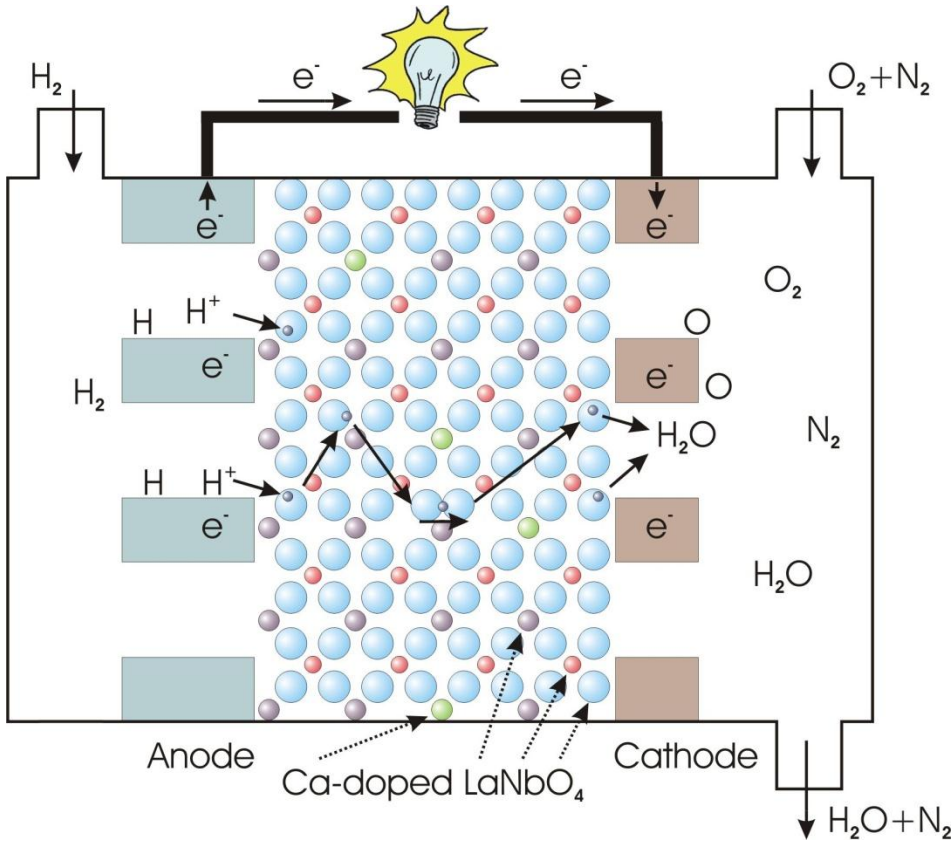
- Proton conducting SOFC (PC-SOFC)
- Proton Ceramic Fuel Cell (PCFC)

- Proton conduction by hydration of acceptor-doped oxides

- 100% fuel utilisation with H_2 fuel

- $Ba(Ce,Zr,Y)O_3$ state of the art perovskites; GB resistance, high sintering temperature, too basic

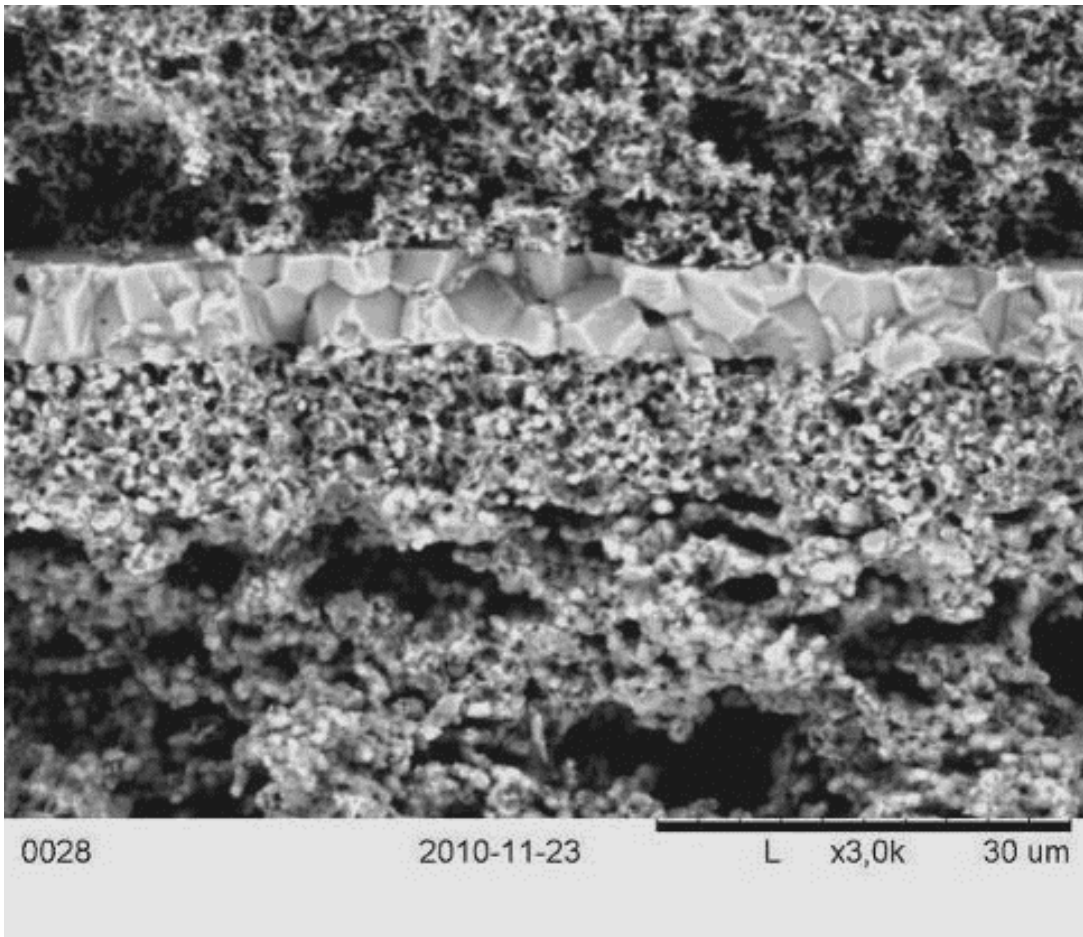
- Ba-free alternatives?
- $LaNbO_4$? "La_6WO_{12}"?



EFFIPRO approach

- Ca-doped $LaNbO_4$

- Chemical stability
- Proton conductivity
- Materials production & cost
- Thin films
- New support
- New anode
- New cathode
- PCFC electrode kinetics



EFFIPRO targets

Property or conditions	1st generation; Project midterm	2nd generation; Project final	Long term future developments
Temp. of operation	800 °C	700 °C	5-600 °C
Atmospheres	Moist H_2/air	Moist H_2/moist air	Dry H_2/air
Fuel utilization	Small	> 90 %	> 95 %
Electrolyte $\sigma_{H+,DC}$, S/cm	0.001	0.0015	0.002
Electrolyte thickness; ASR	5 µm; 0.5 Ωcm^2	3 µm; 0.2 Ωcm^2	2 µm 0.1 Ωcm^2
σ_{anode}; $\sigma_{cathode}$, min., S/cm,	100; 50	200; 75	300; 100
Electrode kinetics, each	0.5 Ωcm^2	0.2 Ωcm^2	0.1 Ωcm^2 (0.1 V overp.)
Thermochemical and – mechanical stability	No reactions between electrolyte, electrodes, CO_2. Structures thermally cycleable without electrolyte cracks.		

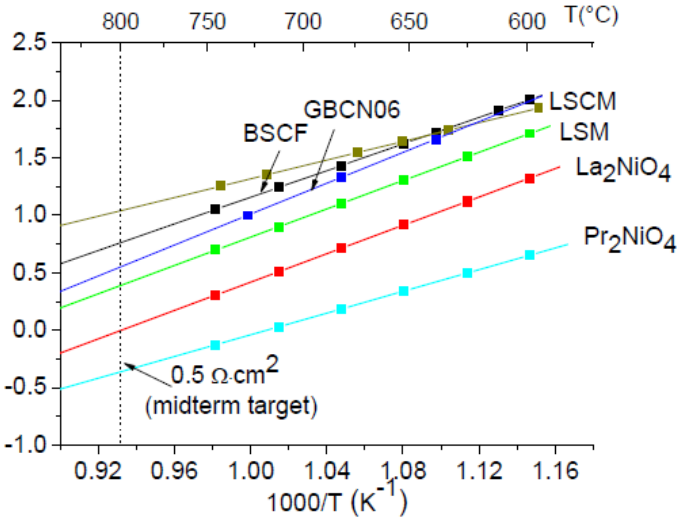
EFFIPRO midterm

- Achievements:
  - Ni-$LaNbO_4$ cermet anode OK
  - Thin films 5 µm on suitable anodes OK
- Learning:
  - $LaNbO_4$ conductivity could not be increased
  - “Line” compounds like $LaNbO_4$ challenging
- New proton conductor fulfils requirements:
  - “La_6WO_{12}” = $La_{\sim 5.6}WO_{\sim 11.4}$ = ?
  - Stable. Conductivity OK for final target
  - Electrode development ongoing

Progress towards SoA

- PCFCs offer
  - 100% FU
  - thus higher overall efficiency
  - simpler BoP

- EFFIPRO: Ba-free materials & materials combinations
  - Materials and production technologies for $LaNbO_4$ class demonstrated, but electrolyte and cathode performances not to target.
  - Fulfilment of targets with "La_6WO_{12}" (LWO) on track
  - EFFIPRO approach 100% FU competitive in 2020



Log area-specific cathode resistance on LWO

2. Alignment to MAIP/AIP

- Correlation with Application Areas
  - PCFC technology generically applies to
    - Hydrogen more than fossil fuels
    - Both use and production; fuel cells, electrolysers
    - Small to large; mobile, heavy transport, stationary

Transport & Refuelling Infrastructure
Hydrogen Production & Distribution
Stationary Power Generation & Combined Heat & Power

» Long term development to market

2. Alignment to MAIP/AIP

- Detailed activities vs MAIP/AIP targets
  - EFFIPRO PCFC technology can have a potential impact in 2020 onwards, i.e. perspectives longer than FCH-JU
  - It will where applicable improve efficiency of SOFCs and PEMFCs running on H_2 with estimated 10%

2. Alignment to MAIP/AIP

- Gaps and bottlenecks in MAIP/AIP
  - None, from a PCFC perspective for short term market impact
- For long term developments of H_2 energy:
  - Elevated temperature H^+ conducting fuel cells (PCFC, SAFC, HT-PEMFC) are ultimate solutions over O^{2-} conducting SOFCs and H_3O^+ conducting PEMFCs
  - More focus on long term development of such technologies may be considered

4. Cross-cutting issues

- Training and education in EFFIPRO
  - 4 post-docs and 1 PhD
  - 2 schools in defects, transport etc. for PCFCs
- Safety, regulations, codes, standards
  - NA
- Dissemination and public awareness
  - Scientific publication
  - Conferences (attendance, organisation)
  - PCFCs and project highlighted in Chemistry Year 2011 and Univ. Oslo 200 Anniversary events

5. Enhancing cooperation and future perspectives

- Technology transfer and collaboration
  - Integration with Norwegian PCFC projects triples effort
  - Patent applications considered by partners
  - Interaction with Norwegian SME actors
    - Inside consortium: CerPoTech AS
    - Outside consortium: Protia AS
  - User Forum Group brings feedback from major industry

5. Enhancing cooperation and future perspectives

- Project future perspectives
  - Proposed future research approach
    - EFFIPRO is long term / high risk in 7FWP/Energy
    - Follow-up research proposed in 7FWP/Energy and FCH JU.
  - International collaboration and future opportunities
    - EU is the academic locomotive for PCFC
    - US and Japan offer important PCFC technology
    - PCFC and HT-PEMFC opportunities for EU leadership and SMEs & industry
    - PCFC and HT-PEMFC should get focus in future FCH JU.