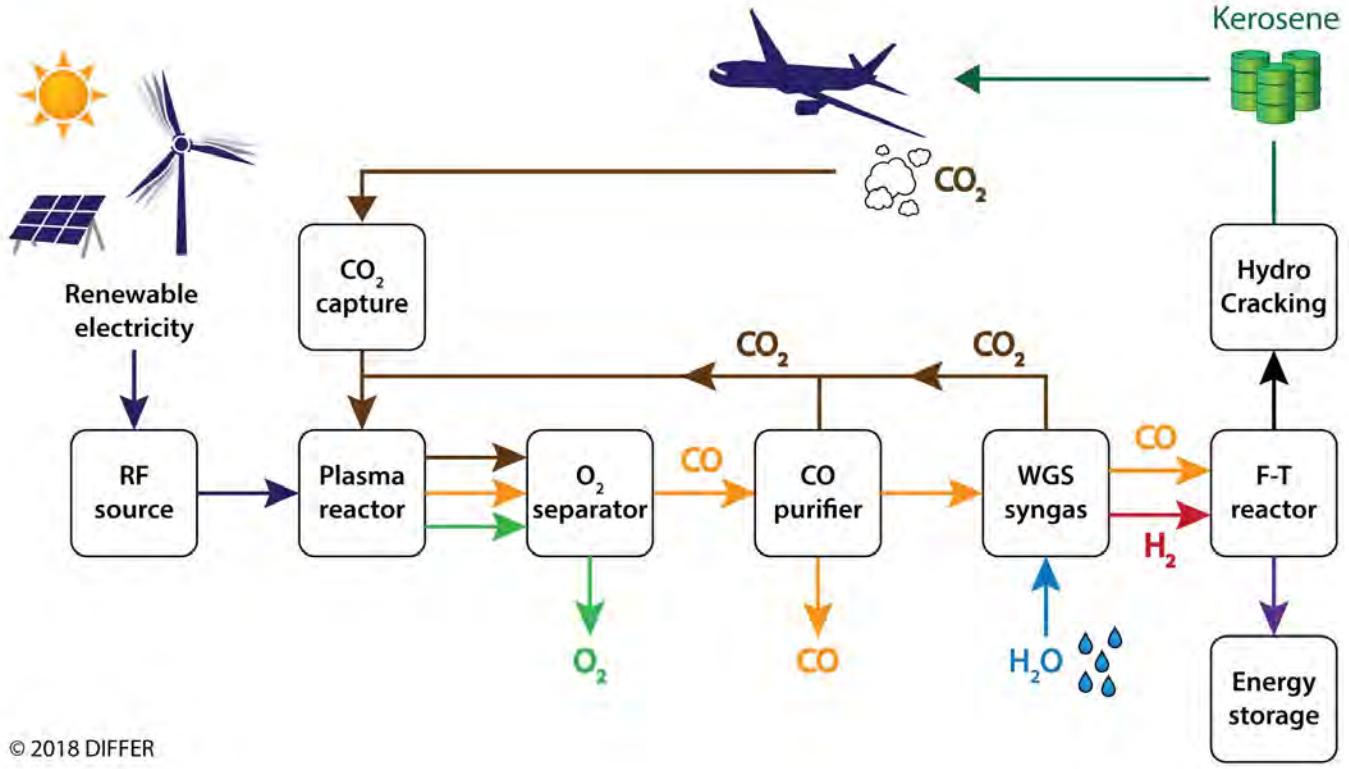
KEROGREEN

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under agreement No. 763909

Sustainable Aviation Fuel workshop, Brussels 12-11-2018



by Adelbert Goede

DIFFER
Dutch Institute for Fundamental Energy Research

Production of sustainable aircraft grade kerosene from water and air, powered by renewable electricity through the splitting of CO_2, formation of Syngas and Fischer-Tropsch synthesis

KIT Karlsruher Institut für Technologie · vito vision on technology · CerPoTech Ceramic Powder Technology · HYGEAR ENGINEERING FOR SUSTAINABLE GROWTH · INERATEC Innovative Chemical Reactor Technologies

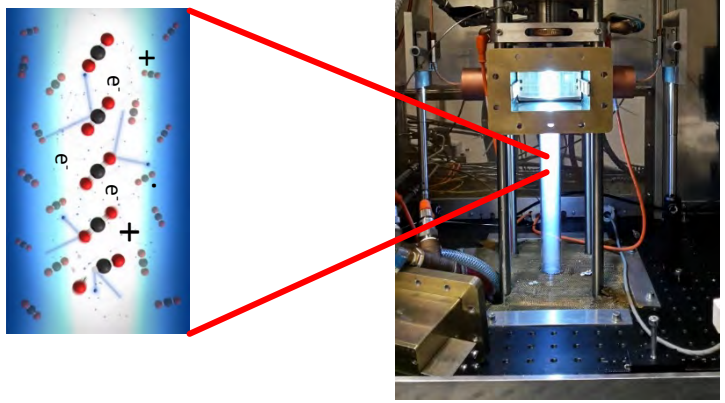
CO_2 plasmolysis DIFFER

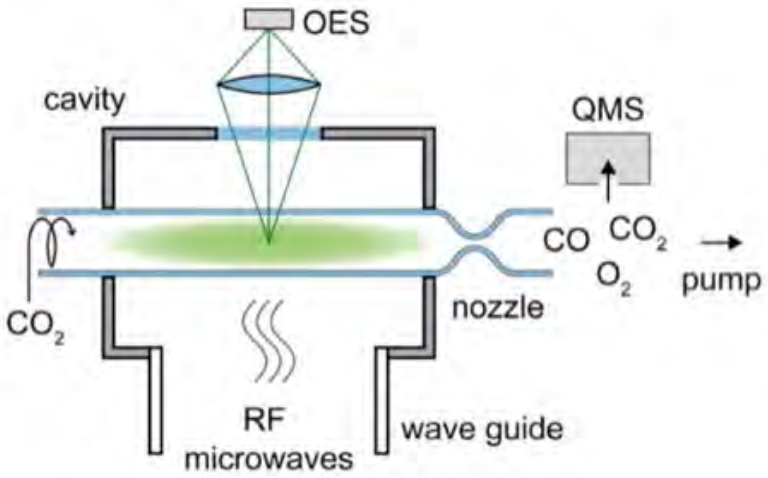
CO_2 splitting by channelling energy in molecular vibration to break the chemical bond, not to heat the gas ($T_{vib} > T_{gas}$)

Why plasma:

- High productivity: large gas flow (75slm) and high power density (45W/cm^2)
- Fast dynamic response to intermittent power supply
- No scarce materials employed
- Favourable upscaling (volume vs. surface process)

1 kW 2.45 GHz



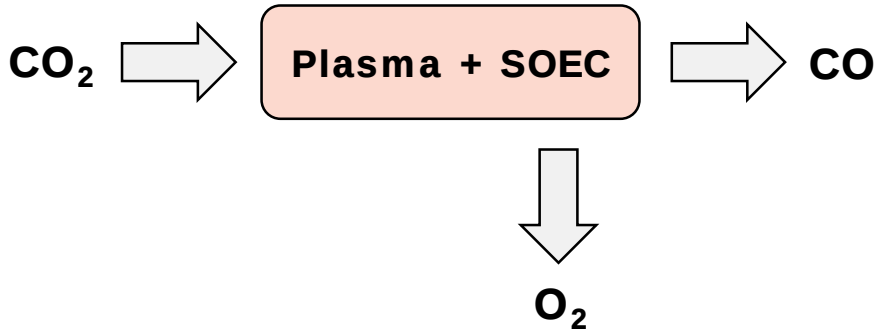


30 kW RF @ 915 MHz

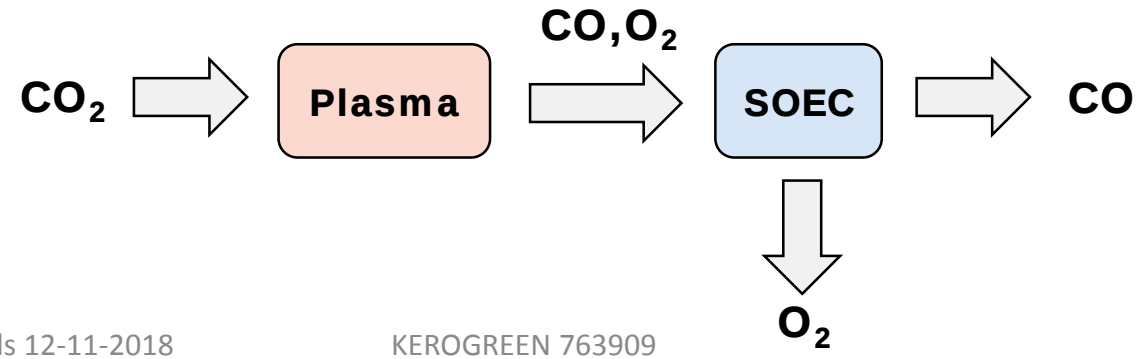
Oxygen separator concept DIFFER

Two Concepts pursued in parallel

- **Oxygen separation integrated inside the plasma reactor**
  - Aiming for synergistic plasma membrane interactions
  - Exploitation of non equilibrium chemistry

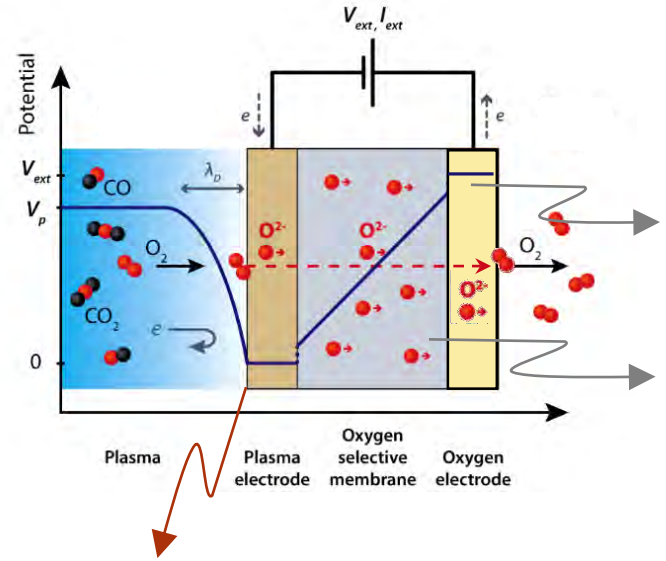


- **Oxygen separation at the plasma reactor output**
  - Independent control of plasmolysis & oxygen separator
  - Backup scenario



Materials Cerpotech, membranes VITO

Functionalities of oxygen separator

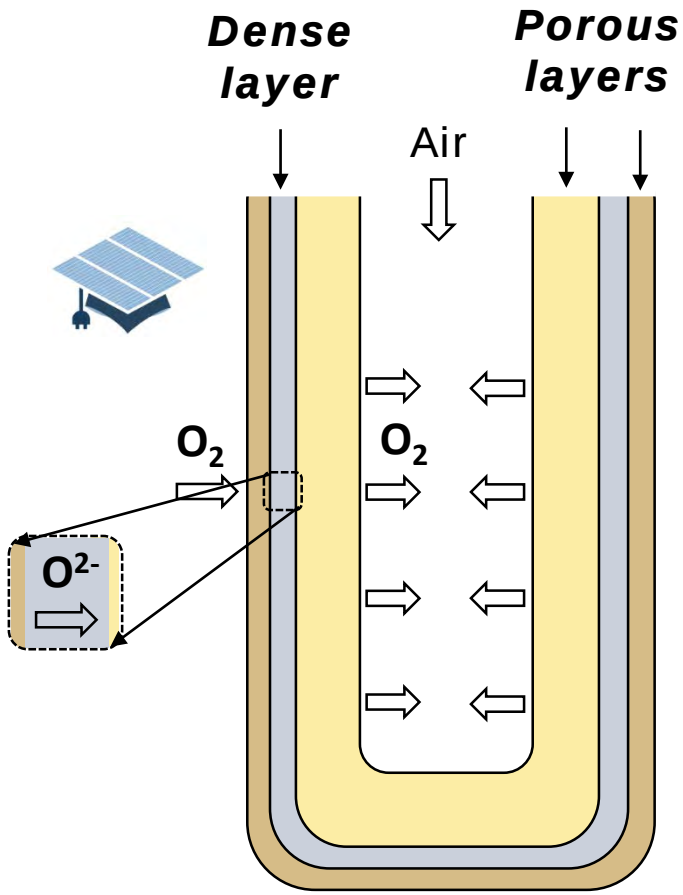


LSM/YSZ or LSCF

YSZ

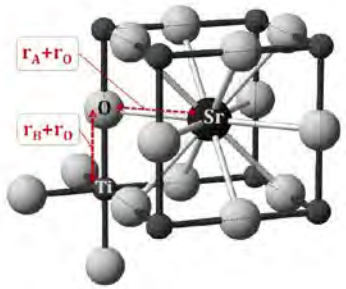
- Electronic conductivity (e^-)
- Ionic conductivity(O^{2-})
- Low catalytic activity
- Electro(chemical) stability
- Mechanical stability

Lanthanum based SrTi Perovskites

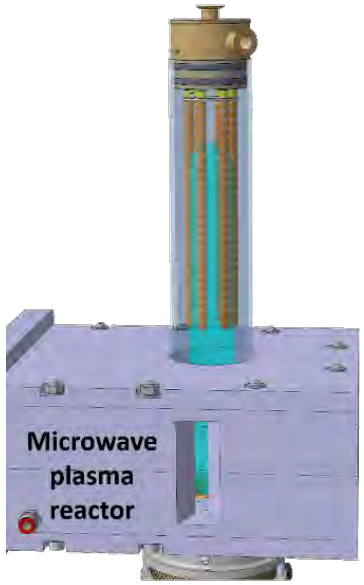


Tubular design

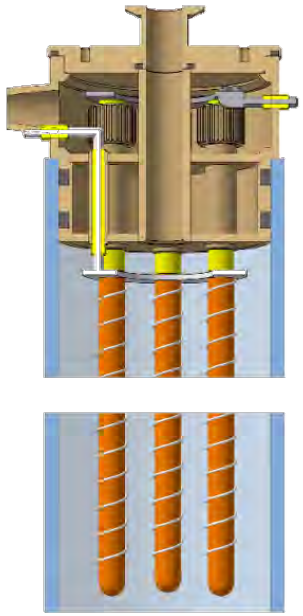
$SrTiO_3$

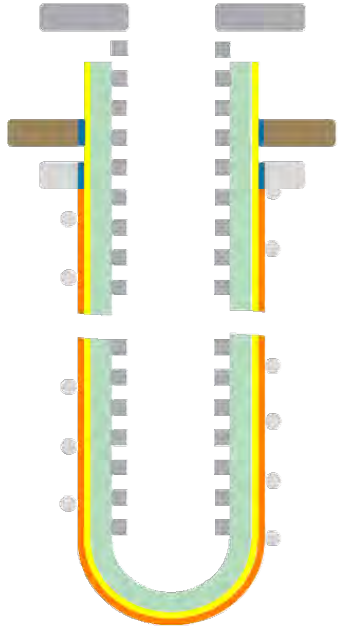


Separator engineering HyGear



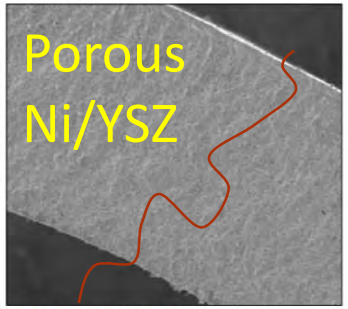
Tubular cell array



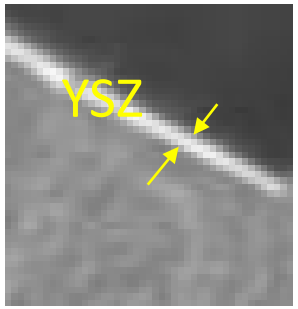


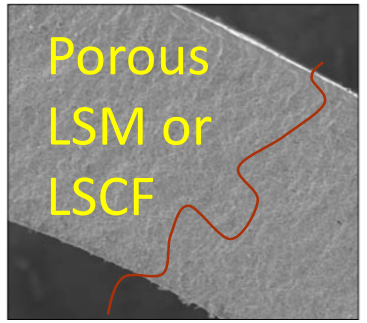
Electrode supported tubular cell

- Plasma electrode
- Electrolyte
- Oxygen electrode
- Insulating layer
- Current collector of plasma compartment
- Current collector of oxygen compartment
- Reactor casing



NiYRSZ Tubular Half Cell Coated with 8YSZ (x100)





Syngas synthesis of hydrocarbons

KIT/INERATEC

Fischer-Tropsch testing unit producing 5–10 ltr/day FT crude

Issues:

Kerosene combustion, lubrication and pollution depend on ratio n-paraffin to olefin to iso-paraffin

Catalyst deactivation by presence of oxygen

INERATEC container sized Power-to-Liquid Fuel plant based on co-electrolysis and FT synthesis

Project Status

Kick off 5-6 April 2018

Mid term Review Oct 2019

End of project March 2022

Activities:

- Recruiting
- project website http://www.kerogreen.eu
- promotional literature (brochure)
- 3 Consortium meetings
- Plasma splitting validation, plasma modelling
- Oxygen separation, perovskite membrane modelling and selection, suppliers perovskite SOC material, fabrication membranes, first CO2 exposure test, plasma membrane interaction
- Process flow optimization/consolidation, I/F definition
- Sustainability Analysis first results

Overall Objectives

What are we aiming for:

UNFCCC CoP 2050 agreement and EC Directives
CO_2 emission 80% to 95% below 1990 level
Transportation: 60% CO_2 emission reduction
Aviation: 40% sustainable fuel by 2050
UN-ICAO: CO_2 emissions 50% below 2005 level

Challenge to meet CO_2 reduction target of Transportation
Aviation being a case in point

Business as Usual:

Aviation 2-3% of global CO_2 emission to date
Kerosene consumption, currently 5Mb/day, set to grow between 2.5 and 3.5%/yr over next 30 yrs, hence CO_2 emissions more than doubled in 2050
This number accounts for efficiency improvements

What are the alternatives?

Hydrogen – too low energy density
Batteries – too heavy
Hybrid – range limited
Bio-fuel – Current EC policy.
However, resource limited
fuel vs. food/flora trilemma

Wider Perspective

- P2X can provide vast seasonal energy storage capacity and flexibility of supply from Renewable Electricity though sector Coupling
- P2X enables small scale production plants at decentralized RE source (cf. Ammonia or CO)
- P2X-DAC yields a CO_2 neutral fuel cycle based on hydro-carbons and existing infrastructure
- Technical challenge: innovation in CO_2 splitting and O_2 separation
- Economic challenge: cost reduction
- business case expected to emerge around 2030, when cost of CO_2 reaches € 200/ton, ETS, C-tax