LPG PARTIAL OXIDATION OVER Rh/$Ce_{0.25}Zr_{0.75}O_2$-Al_2O_3/FeCrAlloy FOR MICROTUBULAR SOLID OXIDE FUEL CELL FEEDING

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CURRENT TRENDS IN THE ENERGY INDUSTRY

Key current trends cutting across all industries

Decentralization | **Mobility** | **Personalization** | **Environmental friendliness**

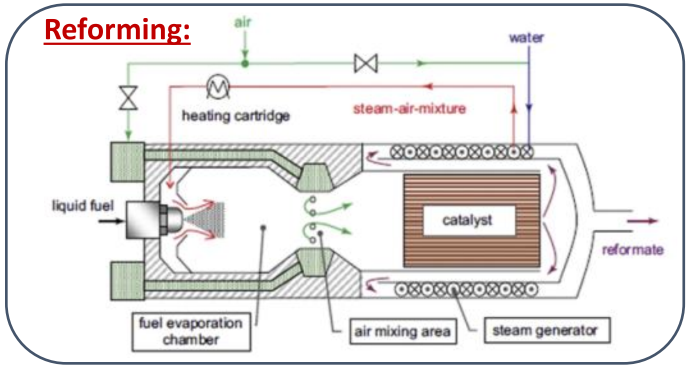
- **Portable systems** mainly use nickel-cadmium, nickel-metal hydride, and lithium-ion **batteries**. Their **energy capacity is often insufficient** to ensure long autonomous operation of modern electronic devices.

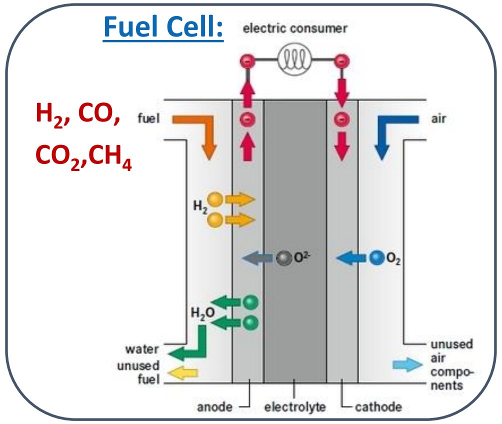
- Development of special-purpose electronic equipment and new type of devices (robots, unmanned aerial vehicles, electric transport) sets more rigorous requirements for their **power supply**.

- **Fuel cell products are the most promising** sources of power supply within the power range **from a few watts to hundreds of kilowatts**.

Reforming processes

Fuel (hydrocarbons, oxygen-containing organic compounds)

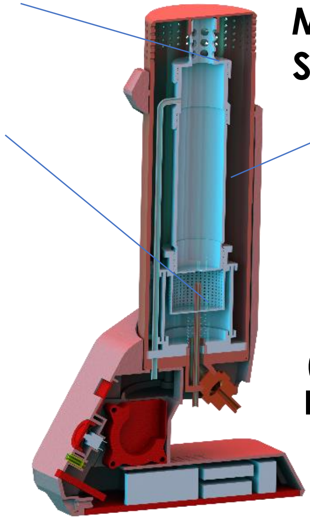




- ***Steam reforming (SR):***
- $C_mH_n+mH_2O=mCO+(m+1/2n)H_2$
- ***Partial oxidation (PO):***
- $C_mH_n+1/2mO_2=mCO+(1/2n)H_2$
- ***Autothermal reforming (ATR):***
- $C_mH_n+1/2mH_2O+1/4mO_2=mCO+(1/2m+1/2n)H_2$

Afterburner

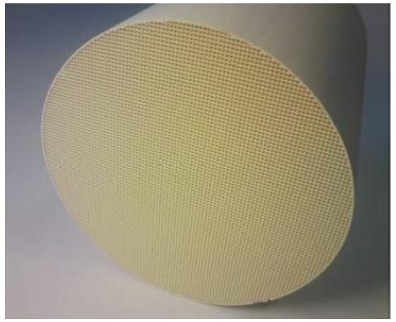
Reformer



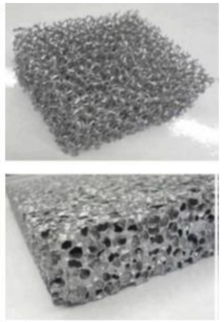
Micro tubular SOFC battery

20…100 W (depending on the length of individual SOFC and its quantity)

Structured carriers:

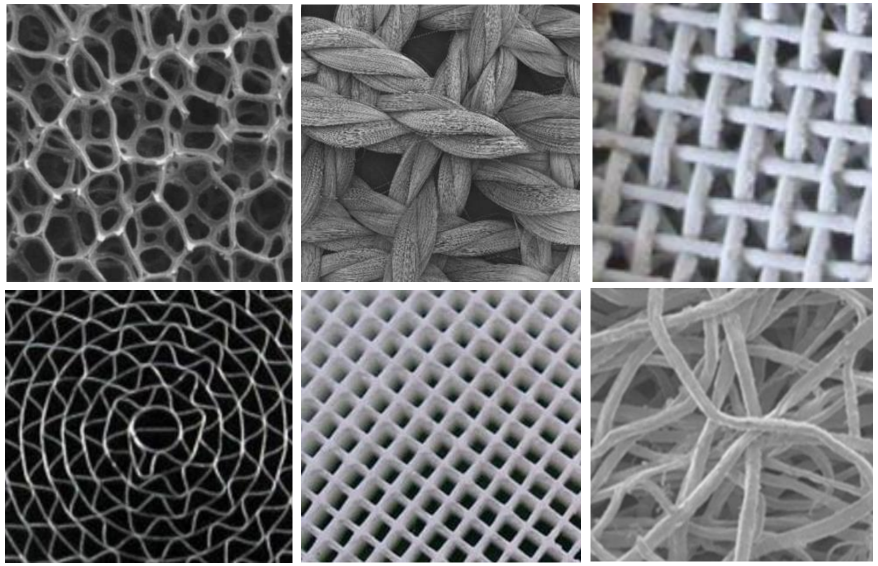


Cordierite monoliths



FeCrAl alloy monolith, foam, wire mesh

Structured Supports and Catalysts



- Increase heat and mass transfer
- Decrease temperature gradients
- Decrease pressure drop
- Increase process selectivity
- Increase catalyst efficiency

Key challenge – Formation of robust catalyst support / "protective" layer which will be mechanically stable under reaction conditions

Washcoat preparation techniques:

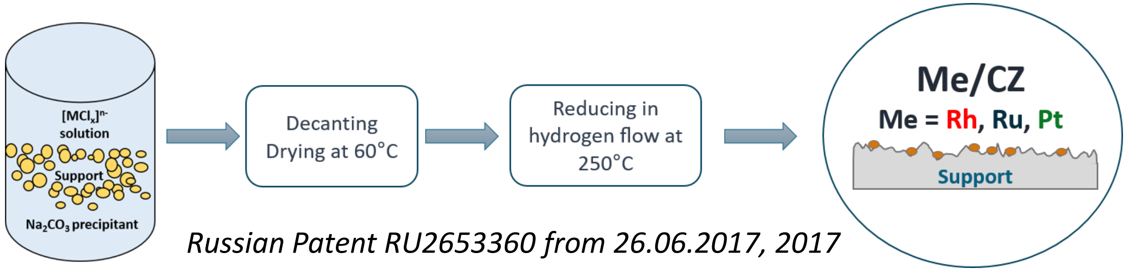
- Suspension dip coating
- Sputtering
- Electrochemical deposition
- CVD
- **Crystallization**

Crystallization:

- Deposition from salt solutions during chemical reactions
- From supersaturated solutions
  - Hydrothermal synthesis
  - Synthesis at normal pressure
- Synthesis under supercritical conditions

Structured Me/Support catalyst on FeCrAl wire mesh

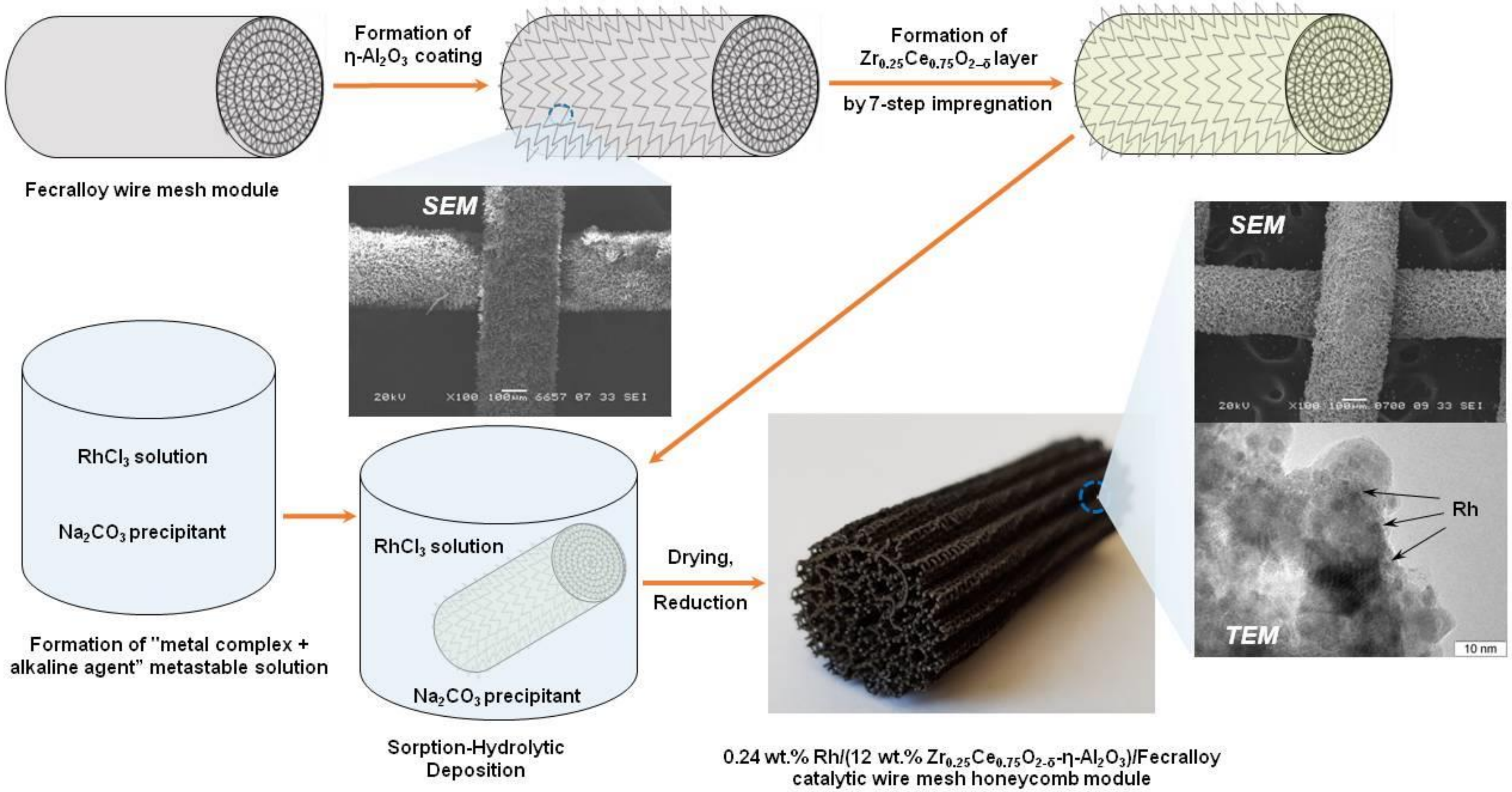
A sorption-hydrolytic deposition technique



Russian Patent RU2653360 from 26.06.2017, 2017

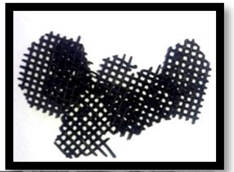
Metal in the catalyst exists on the support surface predominantly in a form of 1 - 3 nm nanoparticles

- Preparation procedure

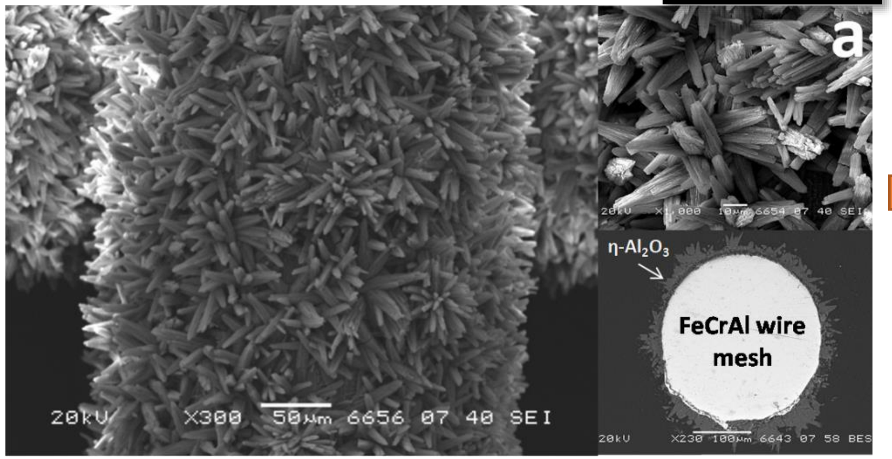


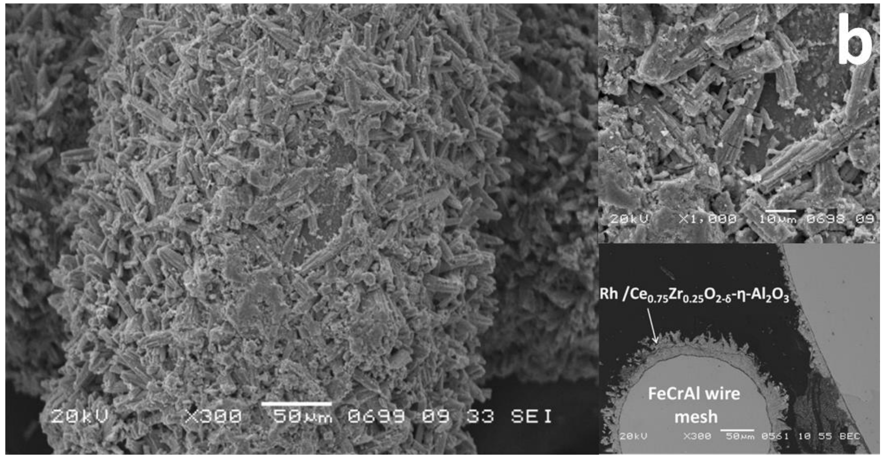
Structured Rh/CZ catalyst on FeCrAl wire mesh

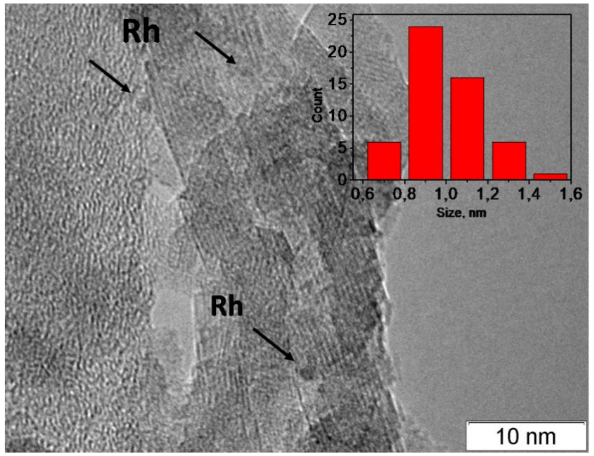
FeCrAl alloy wire mesh (0.5 x 0.5 mm, thickness 0.25 mm) with protective coating of 6 wt.% of η-Al_2O_3

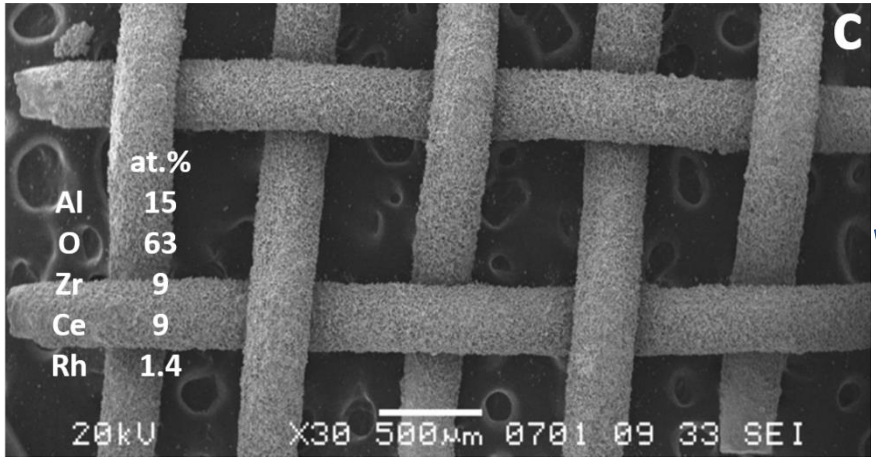


Structured 0.24 wt.% Rh/CZ-η-Al_2O_3/FeCrAl









Structured metal catalysts for syngas production

Natural gas (CPOX)

CH_4 + Air

Liquid petroleum gas (CPOX)

C_3H_8 + Air

Gasoline, Diesel, Jet fuel (ATR)

C_xH_y + Air + H_2O

0.24 wt%Rh/$Ce_{0.75}Zr_{0.25}O_{2-\delta}$/η-$Al_2O_3$/FeCrAl

Syngas with various H_2/CO ratio

Specific Syngas Productivity: 65 53 6 $m^3L_{cat}^{-1}h^{-1}$

SOFC feeding

Heat

Electricity

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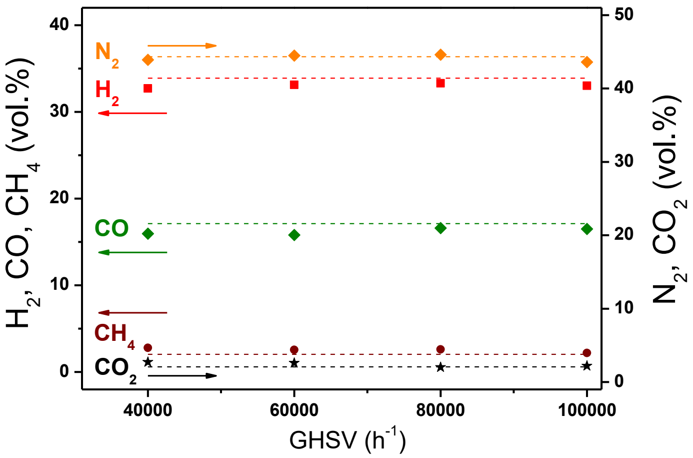
Structured metal catalysts for catalytic partial oxidation of natural gas and LPG

Natural gas CPOX

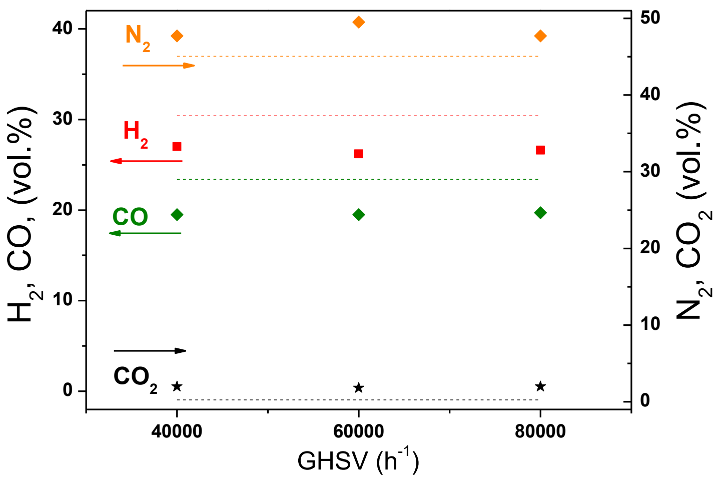


Inlet composition (vol%) at 700 °C:

58.2 N_2, 15.7 O_2,

23.5 CH_4, 1.3 C_2H_6, 0.6 C_3H_8, 0.7 Ar

LPG CPOX

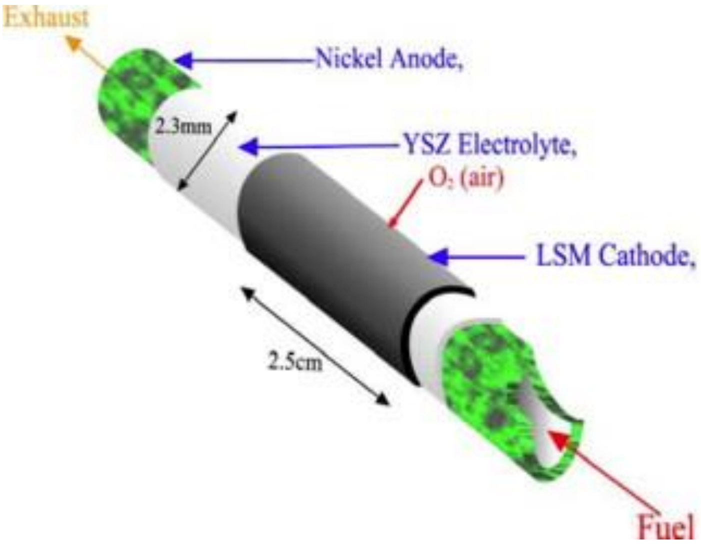


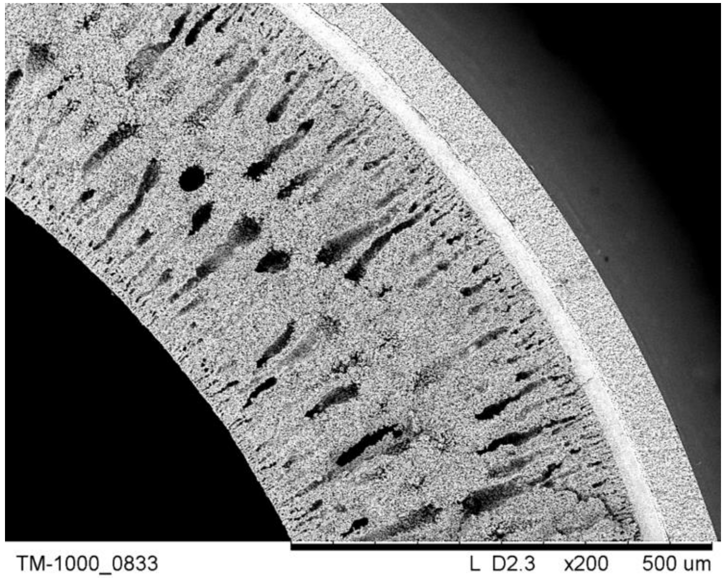
Inlet composition (vol%) at 850 °C:

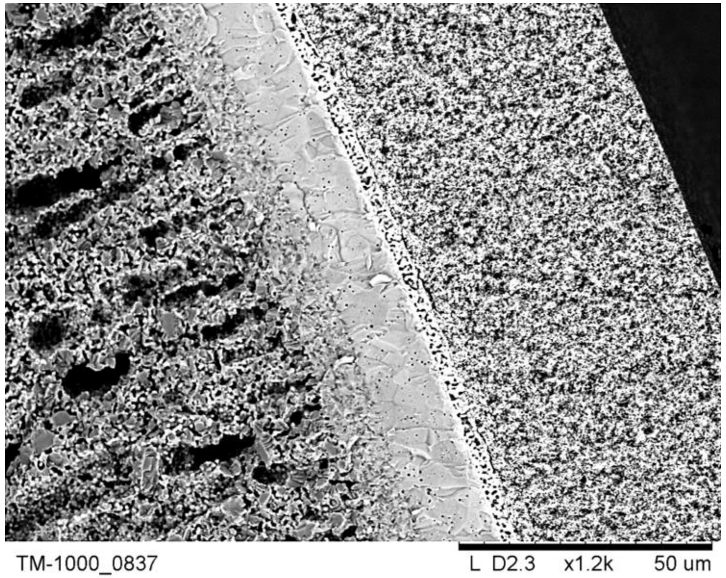
69.1 N_2, 18.6 O_2,

9.2 C_3H_8, 2.3 C_4H_{10}, 0.8 Ar

Microtubular SOFC (MC SOFC)

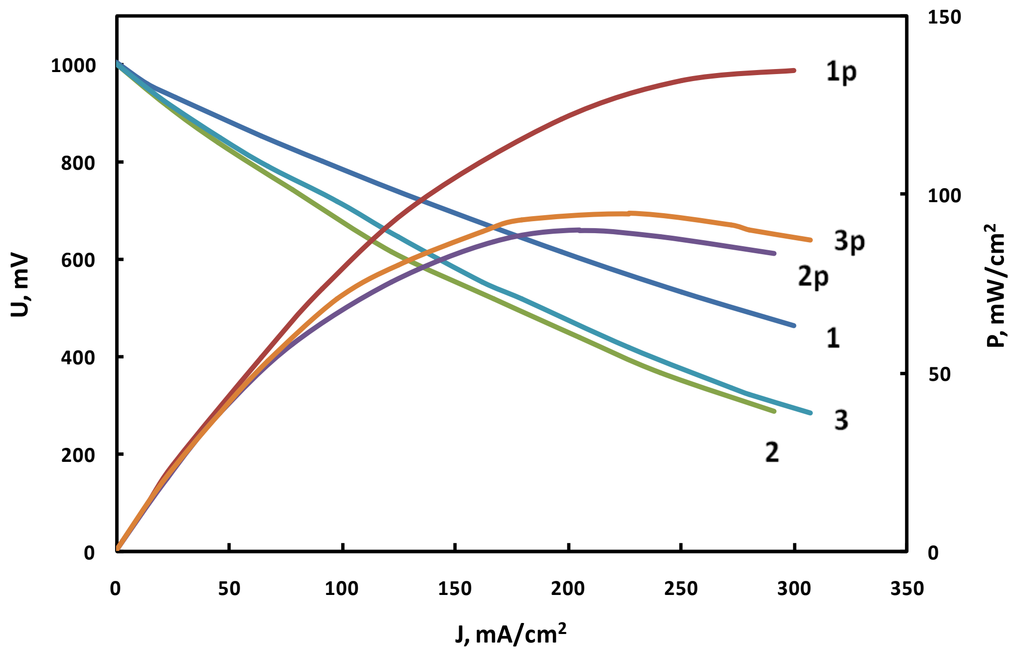






NiO-YSZ|YSZ|LSM

Feeding of MT SOFC by various fules



Voltage (1-3) and power density (1p-3p) as a function of current density for MC SOFC fed by H_2 (1, 1p), 30 vol.% H_2 in N_2 (2, 2p) and syngas (H_2:CO:N_2 = 30:20:50) (3, 3p).

Thank you for your kind attention!

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