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COATED CERAMIC FOAMS FOR SYNTHESIS GAS PRODUCTION

M. Jahn, A. Michaelis, M. Pohl, A. Schliephake
Fraunhofer Institute for Ceramic Technologies and Systems IKTS

MOTIVATION

Combined heat and power (CHP) generation with solid oxide fuel cell (SOFC) systems will take an important role in the fuel cell technology market. In general synthesis gas (H_2 and CO) production can be realized in a simple reforming process. However the catalytic partial oxidation (CPO) needs a well designed reactor and a sophisticated structured ceramic-catalytic system.

Ceramic foam made of sintered silicon carbide (SSiC) has enabled us to solve the current problem of heat exchange at the inlet because of good high temperature resistance [1].

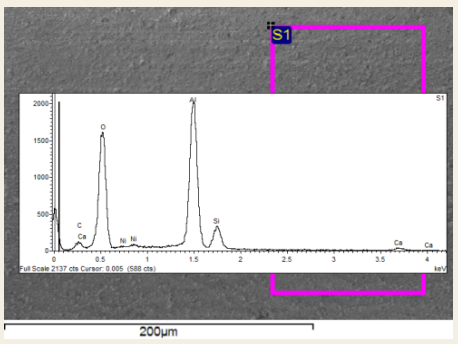
RESULTS

The catalytic foam used in this work is a combined system including Ni and Ir. It is prepared with a sequential impregnation method. At first the catalyst was impregnated with aqueous solution of H_2IrCl_6. Subsequently the foam was impregnated with an aqueous solution of $Ni(NO_3)_2{\cdot}6H_2O$. The sample was calcined at 773 K in air for 2 h (Heating rate: 1,5 K/min).

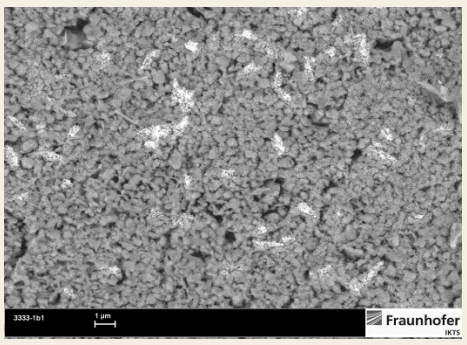
Prepared and tested catalytic systems

Sample	Catalyst support	Configuration	Coated reaction volume
A	SSiC foam (30 ppi)	Ni (5 wt.-%Ni/ $CaO{\cdot}Al_2O_3$-SSiC)/ Ir (0,5 wt.-%Ir/ $CaO{\cdot}Al_2O_3$-SSiC)	$V_{R1(Ni)}$ = 0.80 $V_{Reactor}$ $V_{R2(Ir)}$ = 0.20 $V_{Reactor}$
B	SiSiC foam (30 ppi)	Ni (5 wt.-%Ni/ $CaO{\cdot}Al_2O_3$-SiSiC)/ Ir (0,5 wt.-%Ir/ $CaO{\cdot}Al_2O_3$-SiSiC)	$V_{R1(Ni)}$ = 0.80 $V_{Reactor}$ $V_{R2(Ir)}$ = 0.20 $V_{Reactor}$
C	SSiC foam (30 ppi)	Ni (5 wt.-%Ni/Al_2O_3-SSiC)/ Ir (0,5 wt.-%Ir/Al_2O_3-SSiC)	$V_{R1(Ni)}$ = 0.80 $V_{Reactor}$ $V_{R2(Ir)}$ = 0.20 $V_{Reactor}$

The particle morphology was examined by scanning electron microscopy after preparation (Ni: Dip-Coating; Ir: Incipient Wetness) as well as pretreatment (calcination and reduction at 773 K in 5 Vol.-% H_2 in N_2 for 2 h at a heating rate of 10 K/min).



SEM image of the catalytic foam (inlet) after preparation (Ni including segment).



SEM image of the catalytic foam (outlet) after preparation (Ir including segment).

The active component Ir (white sections, r) can be identified in the SEM image of the catalytic foam. The gray structure is allocated to the $CaO{\cdot}Al_2O_3$ washcoat including Ni.

Schematic of apparatus.

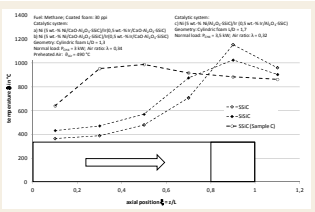
Ceramic foam (SiSiC; 20 ppi; CT graphic).

The novel catalytic system with two active components combined on a single ceramic foam was tested in stainless-steel reactor at constant normal load. The reforming process can be described by the following equation:

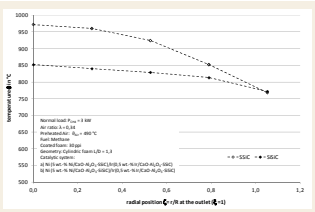
Direct partial oxidation: $CH_4 + 0{,}5O_2 \rightleftarrows CO + 2H_2$ $\quad \Delta_r h^0$ = -35.7 kJ/mol
Respectively combustion, steam reforming and dry reforming as well.

CONCLUSIONS

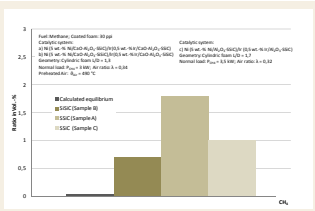
Coated ceramic foams can be effectively used for catalytic partial oxidation of methane to produce synthesis gas for fuel cell applications.



Measured axial temperature profile.



Measured radial temperature profile.



Measured methane-slip vs. calculated equilibrium.

- The production of synthesis gas for SOFC systems is realized with CPO reforming (H_2 > 30 Vol.-% and CO > 15 Vol.-%)
- Segmented ceramic foams are designed to provide a fast system start-up
- Silicon-infiltrated sintered silicon carbide (SiSiC) enables a temperature decrease in the oxidation zone
- Over 80 % of the catalytic system is coated with an economical component (Ni)

REFERENCES

[1] M. Jahn, C. Locke, A. Michaelis, M. Pohl. Foam follows function – A parametric study of ceramic based CPO-reforming catalyst for hydrogen production, 7th International Conference on Environmental Catalysis, Lyon, France (2012).