

Hydrogen Days 2015
18. – 20. March
Hotel DAP, Prague



UNIVERSITY OF
CHEMISTRY AND TECHNOLOGY
PRAGUE

Kinetic Parameters of Oxygen Evolution Reaction in High Temperature Water Electrolysis Process

Filip Karas, Roman Kodým,
Martin Paidar and Karel Bouzek

Introduction

– High temperature steam electrolysis (HTSE)

- Perspective technology for hydrogen production
- High process efficiency → rapid electrode kinetics
- Lower electric energy demand
- No need of Pt metal based catalysts
- Demanding technology for construction materials (operational $T \sim 800\text{ }^{\circ}\text{C}$)

Introduction – HTSE

– Schematic of the steam electrolysis cell

Cathode:

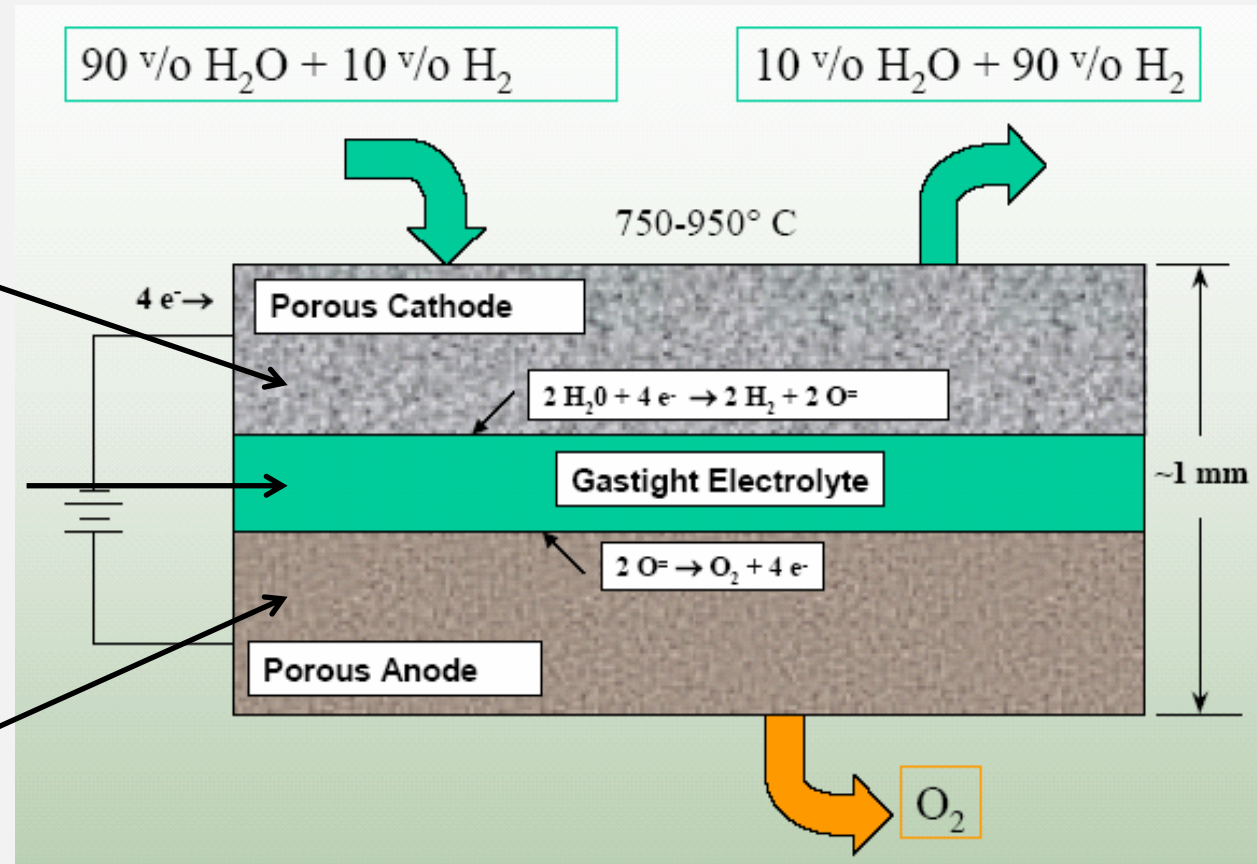
Ni/YSZ composite
„cermet“

Electrolyte:

$\text{ZrO}_2 + 8 \text{ mol. \% Y}_2\text{O}_3$ (YSZ)

Anode:

$\text{La}_{1-x}\text{Sr}_x\text{MnO}_{3-\delta}$ (LSM)
perovskite
or
LSM/YSZ composite



<http://www.greencarcongress.com>

Goals

LSM Anode overvoltage – dominating contribution to the cell activation losses

- Study of kinetic parameters of oxygen evolution reaction (2D – mathematical model of the porous oxygen electrode)
 - Influence of electrode composition (LSM/YSZ ratio)
 - Effect of oxygen partial pressure
 - Impact of temperature



Experimental procedure

- Characterization of the oxygen electrode in „symmetrical cell“
 - Influence of various operating conditions
 - Recording of voltammetry curves
 - Polarization of WE in the potential range $\pm 1\text{V}$ (10mV/s)

○ Different electrode composition:

Commercial precursors:

LSM – $(\text{La}_{0.8}\text{Sr}_{0.2})_{0.95}\text{MnO}_{3-x}$ (NexTech mat.)

YSZ – Tosoh TZ-8YS

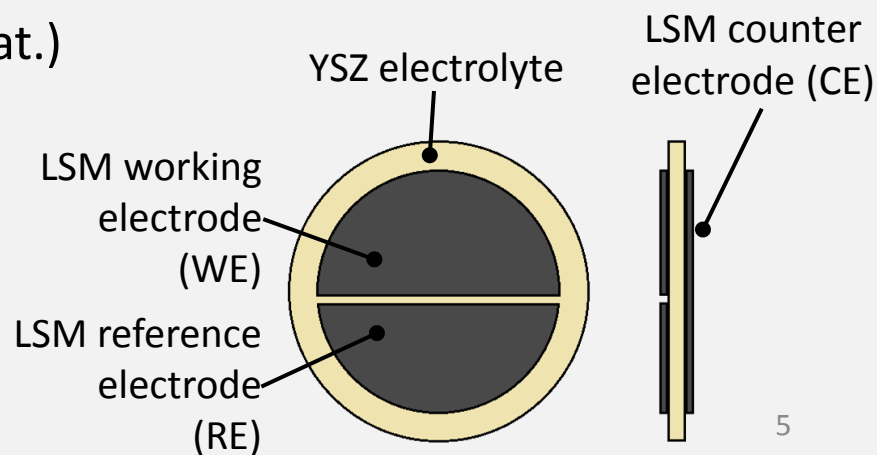
40/60 wt % LSM/YSZ

50/50 wt % LSM/YSZ

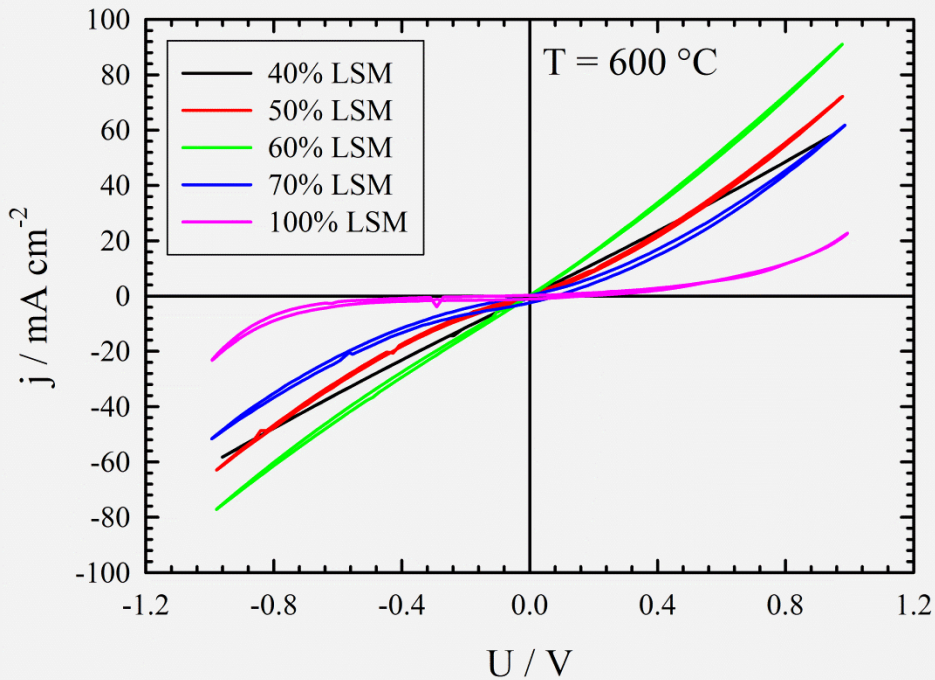
60/40 wt % LSM/YSZ

70/30 wt % LSM/YSZ

100/0 wt % LSM/YSZ

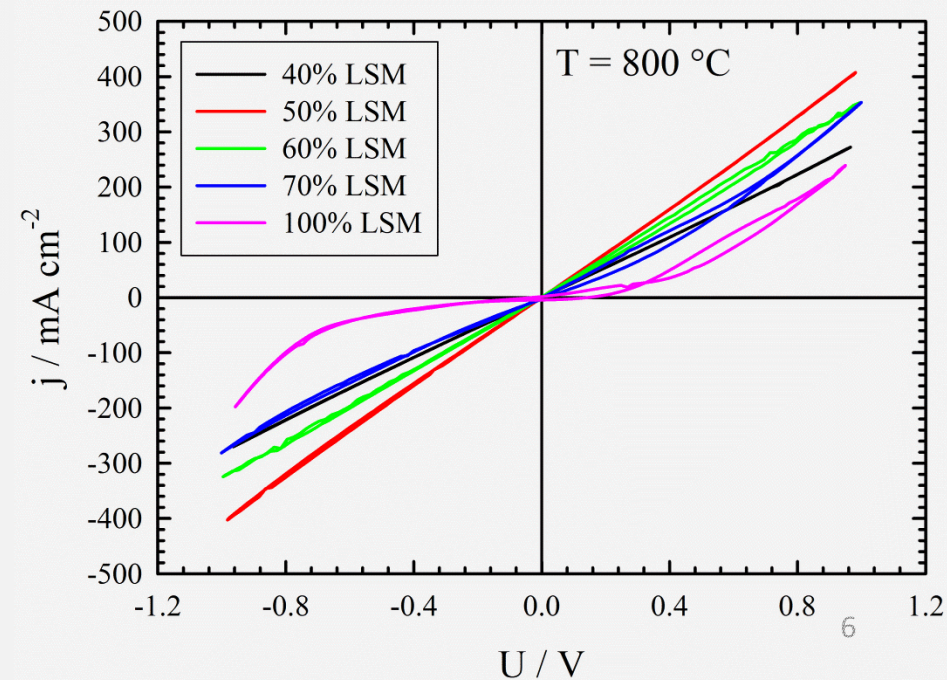


Results – CV curves (electrode comp.)

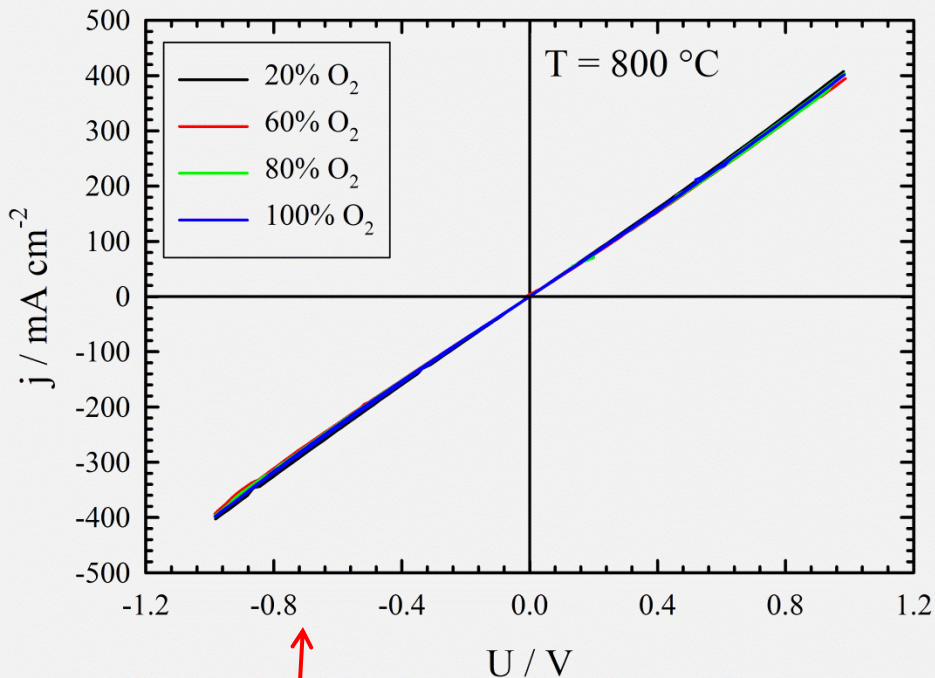


Voltammetry curves:

- Measured with 20 vol. % O_2 in N_2 on WE
- Pure oxygen on CE
- Gradual change in curve shape with increasing temperature
- Change in optimal LSM/YSZ composition



Results – CV curves (influence of O₂)

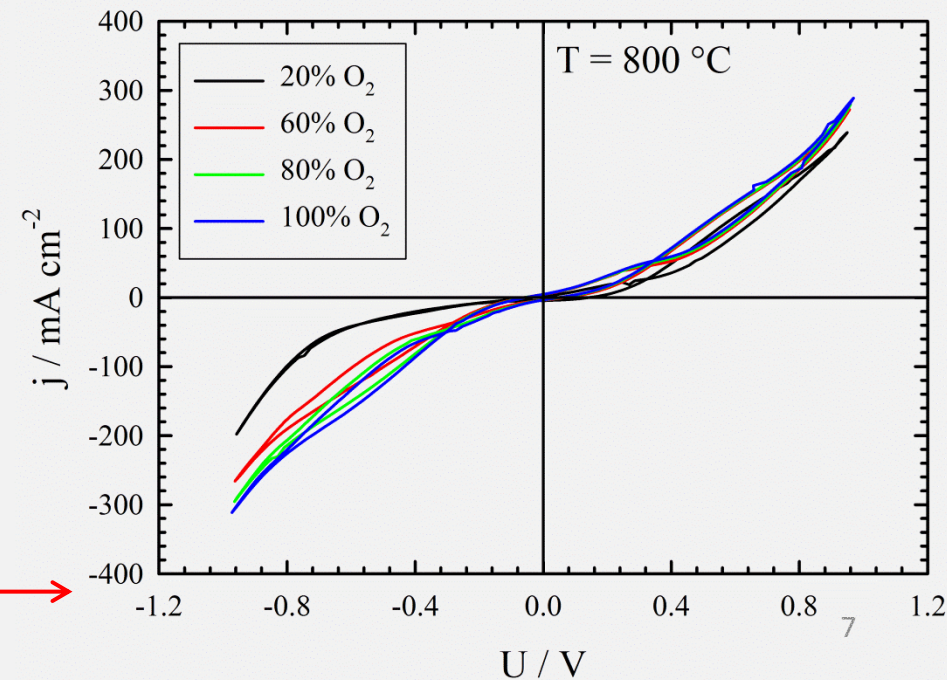


Electrode composition:
50 / 50 wt %
LSM / YSZ

Electrode composition:
Pure LSM electrode

Voltammetry curves:

- Pure oxygen on CE
- No effect of O₂ conc. when YSZ added to the electrode
- Performance of pure LSM electrode in FC regime affected by O₂ conc.
- Possible change in reaction mechanism



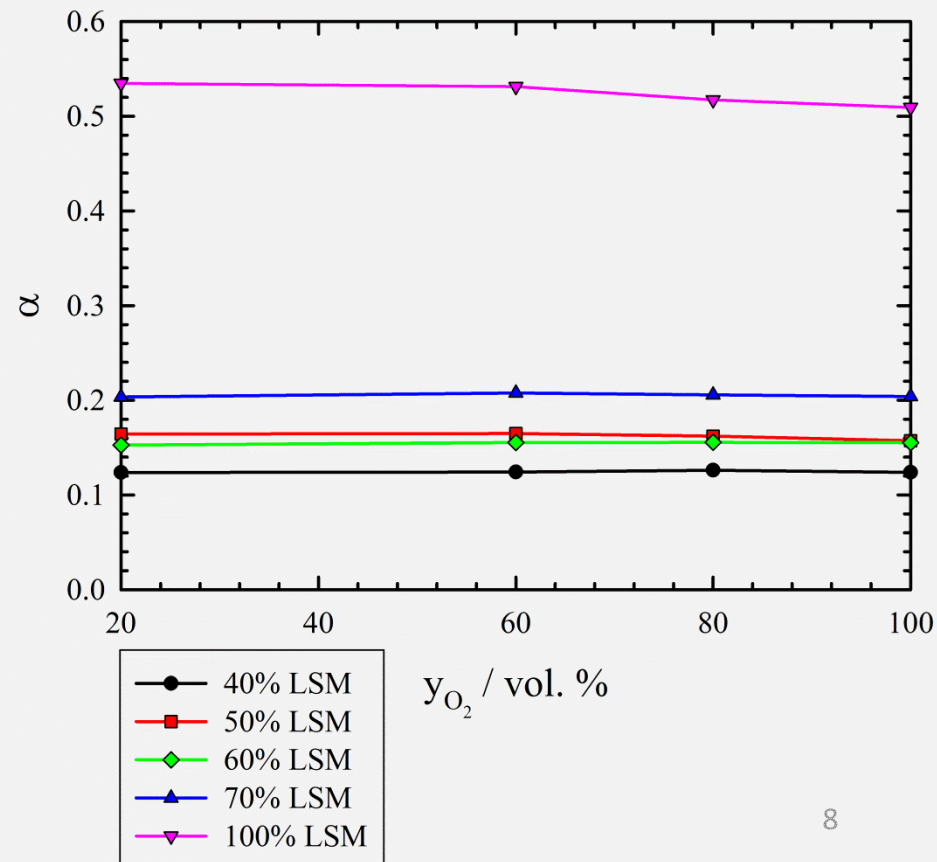
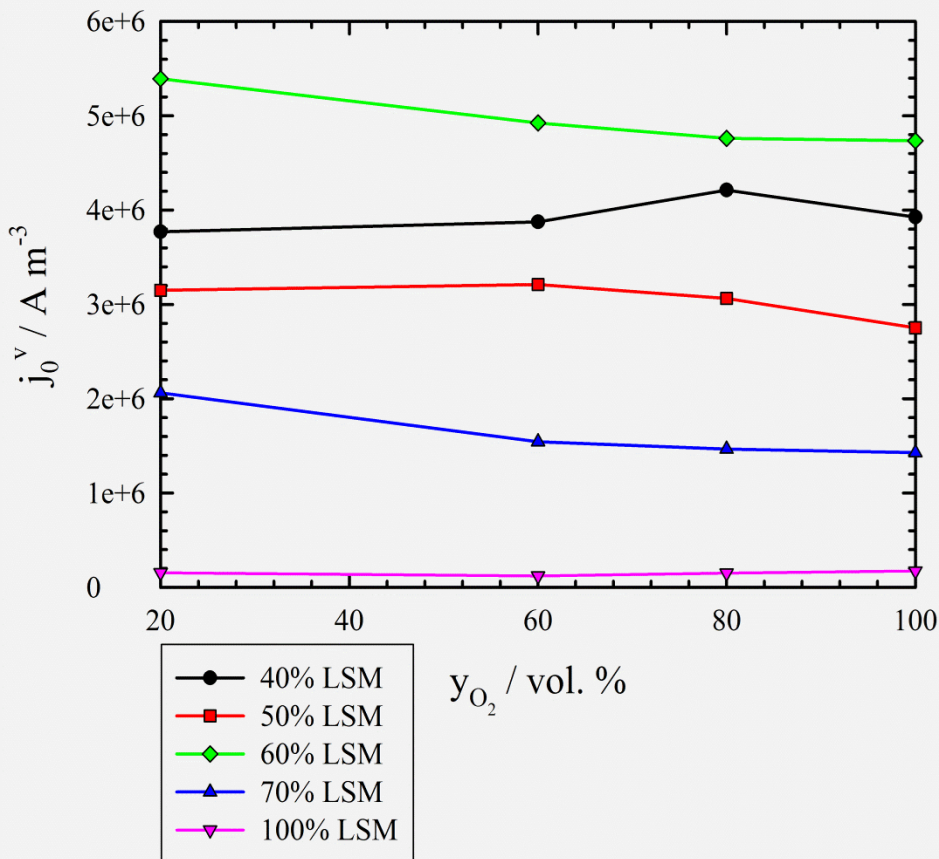
Results – j_0^v & α (mathematical model)

Kinetic parameters calculated for $T = 600\text{ }^\circ\text{C}$

Parameter „ α “ value decreases with increasing YSZ content

→ Evidence of change in reaction mechanism when YSZ added to the electrode

Kinetic parameters not affected by oxygen concentration

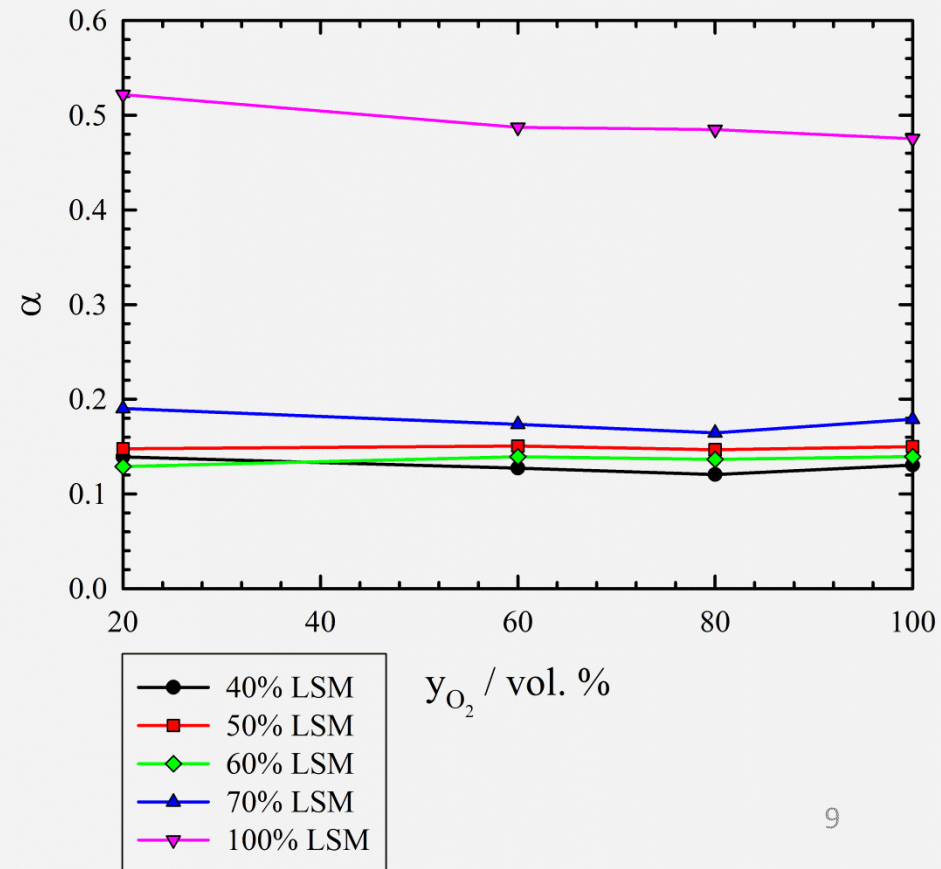
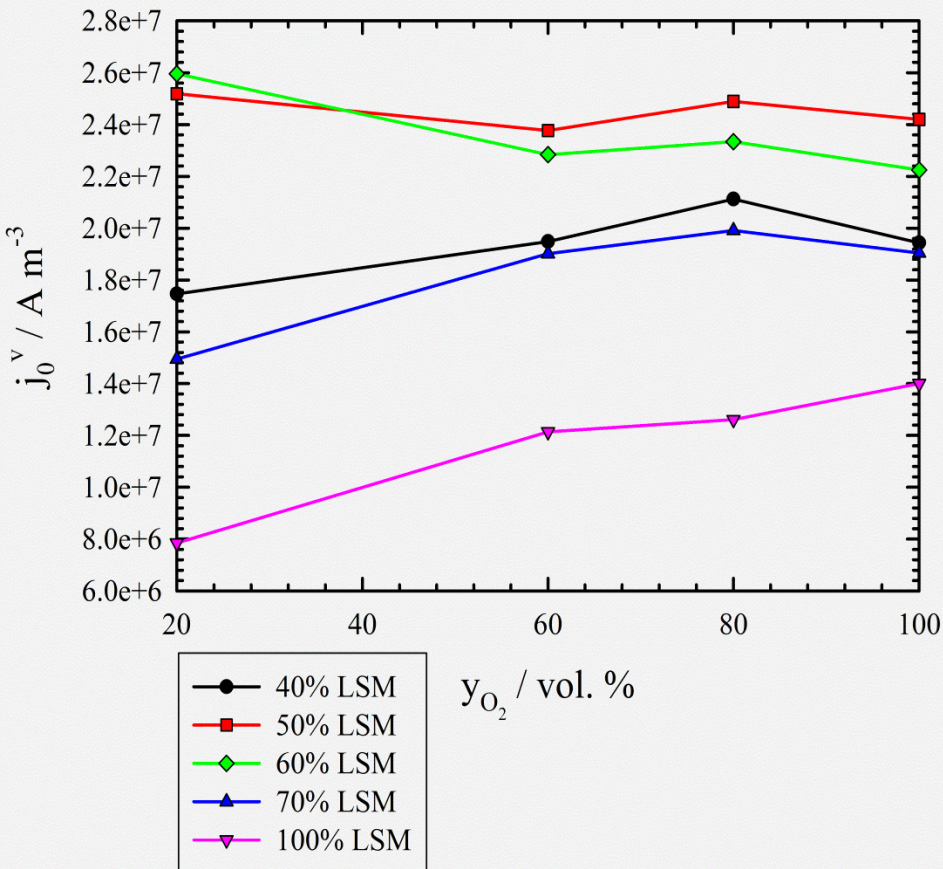


Results – j_0^v & α (mathematical model)

Kinetic parameters calculated for **T = 800 °C**

Similar behavior as at 600 °C

Smaller differences in $j_0^v \rightarrow$ fast reaction kinetics



Conclusions

- Positive impact of YSZ addition to the oxygen (LSM) electrode structure on its properties
 - Increase of electrochemical active surface area
 - Gradual change of the reaction mechanism
 - Optimal composition (800 °C) – 50/50 wt %
- At 800 °C reaction kinetics fast enough → ohmic resistance dominant
- O₂ conc. affects only pure LSM electrode → dissociative adsorption in FC-regime

Thank you for your attention