Screen-printed $La_{0.1}Sr_{0.9}TiO_{3-\delta}$ - $Ce_{1-x}Gd_xO_{2-\delta}$ anodes for SOFC application

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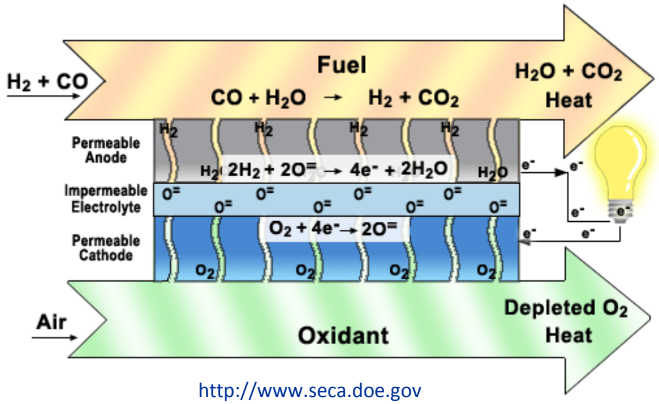
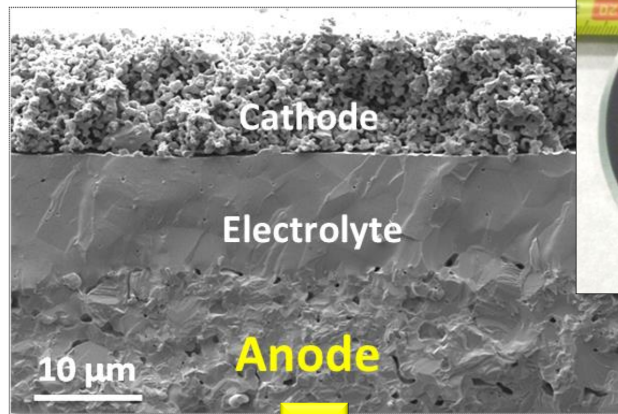
Motivation

Solid Oxide Fuel Cell



http://www.seca.doe.gov

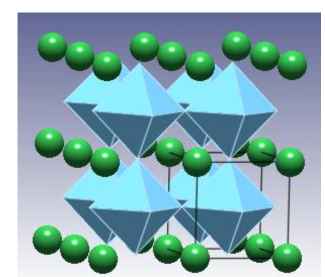


Most common anode material:

Ni-based Cermet

it still faces high level of sintering, poor redox stability and high sensitivity towards carbon deposition and sulphur poisoning

Perovskite materials

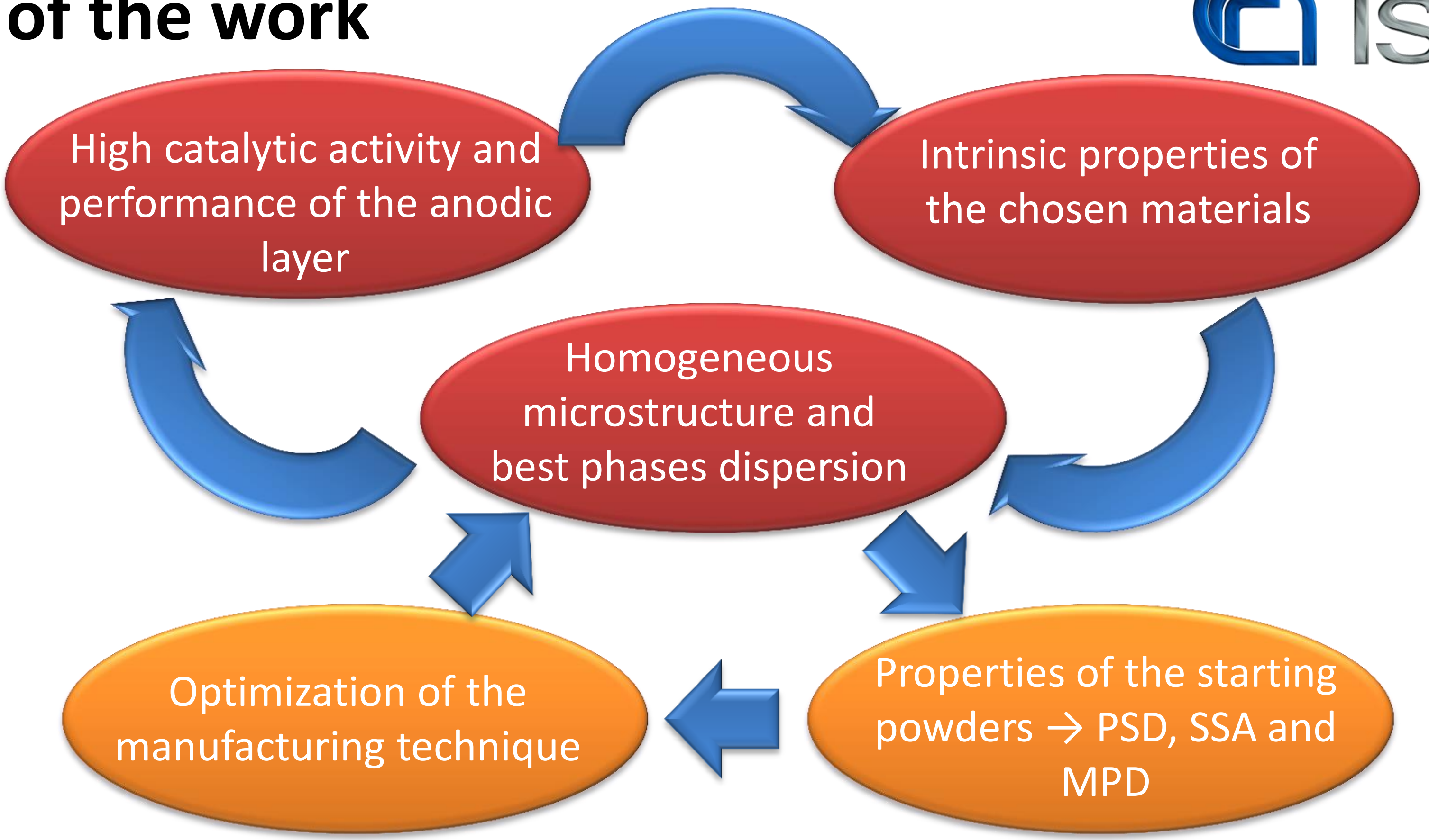


La-doped $SrTiO_3$ (LST):

- doping flexibility,
- good dimensional and chemical stability,
- TEC comparable with that of ZrO_2-based electrolyte,
- high electronic conductivity,
- tolerance for sulfur poisoning and carbon deposition.

Composite anode with Gd or Sm-doped CeO_2 (GDC or SDC) to increase electrochemical performance

Aim of the work

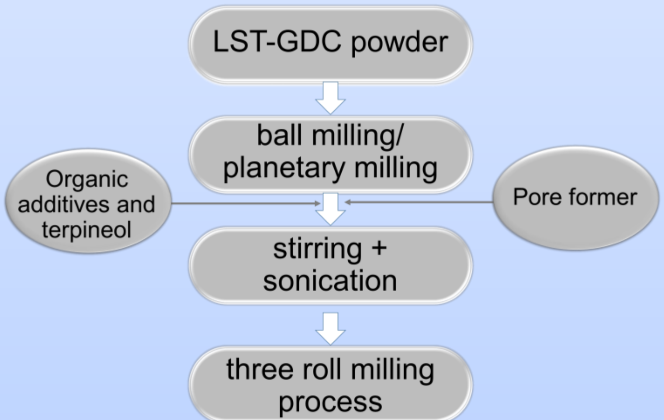


- **Establish an optimized reliable procedure for the production of screen printed LST-GDC anodes in order to fabricate well performing anode.**
- **Evaluate effects of different milling techniques to prepare the inks onto the microstructure and electrochemical performance of the composite anode**

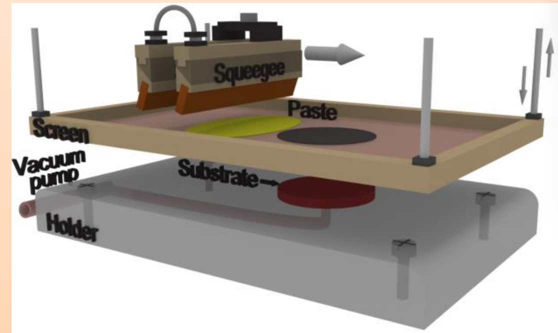
Experimental

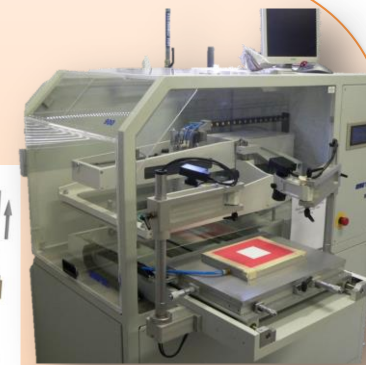
Inks production & characterization

- Choice of the amount and nature of deflocculant
- Evaluation of conventional ball milling and planetary milling processes eventually coupled with a sonication
- Thermal & rheological characterization

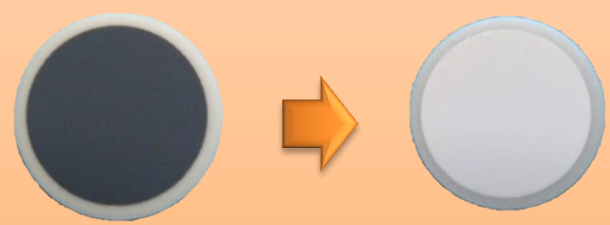


Screen printing





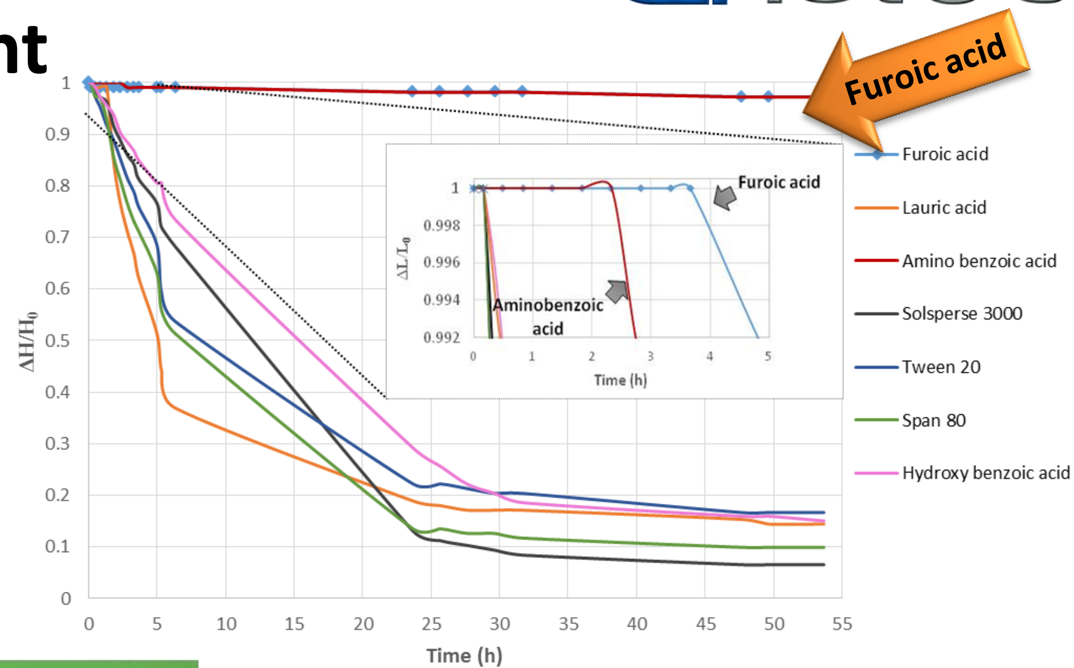
LST-GDC electrodes (Ø=16 mm) were screen printed onto YSZ pellets to obtain symmetrical cells: processing parameters adjusted to obtain 15 μm thick electrodes. Sintering at 1100°C x 5h.



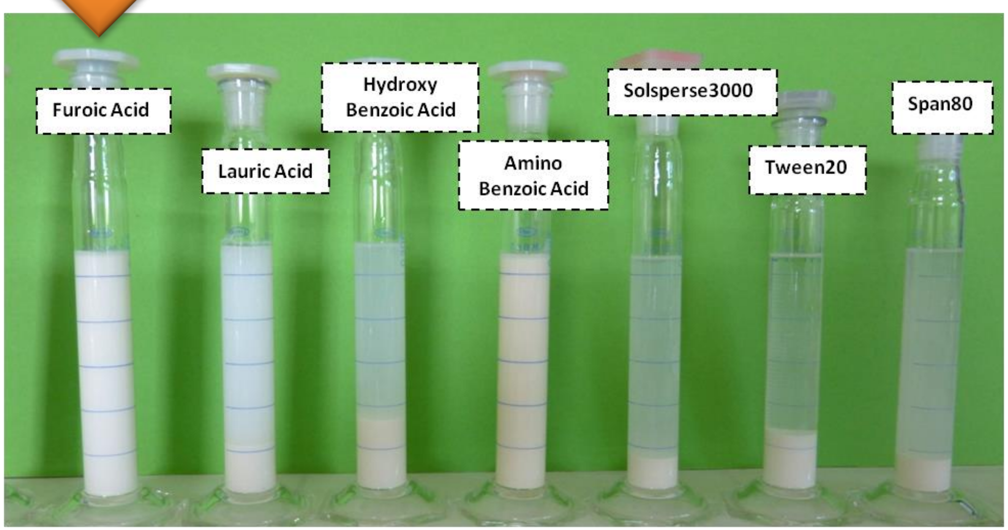
Characterization of symmetrical cells

Microstructural and electrochemical characterization

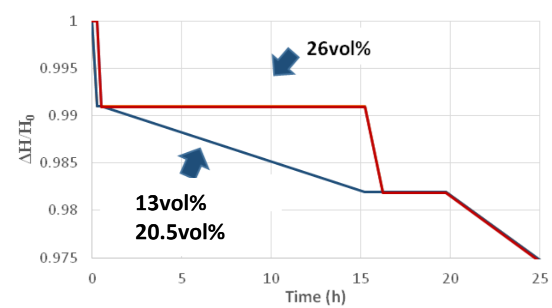
Results:
choice of the deflocculant



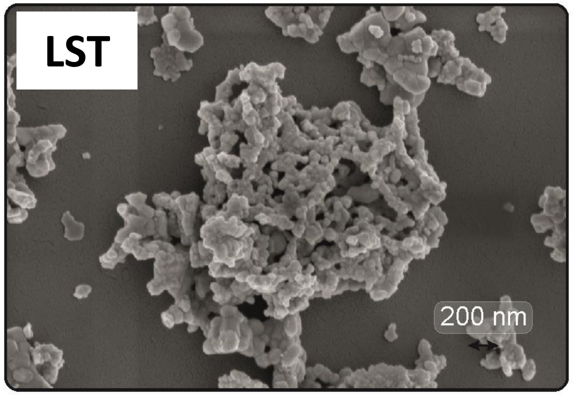
Best dispersing effectiveness achieved using the **heterocyclic compounds** of medium size and with a marked **Brosted-Lewis basic behavior**

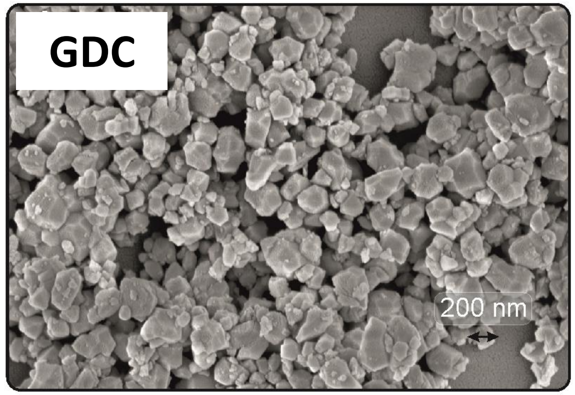


Optimization of the **deflocculant concentration** (=26 vol% in respect to the powder)

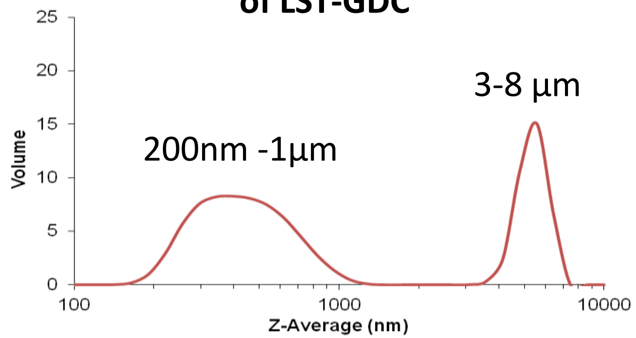


Results:
influence of the milling treatment





Dinamic Light Scattering (DLS) of LST-GDC



To break down the aggregates….

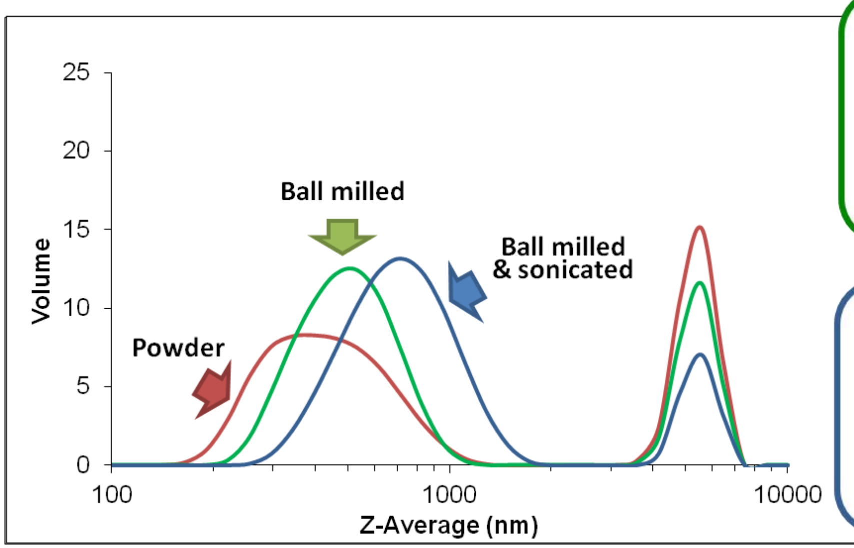
1. Conventional ball milling

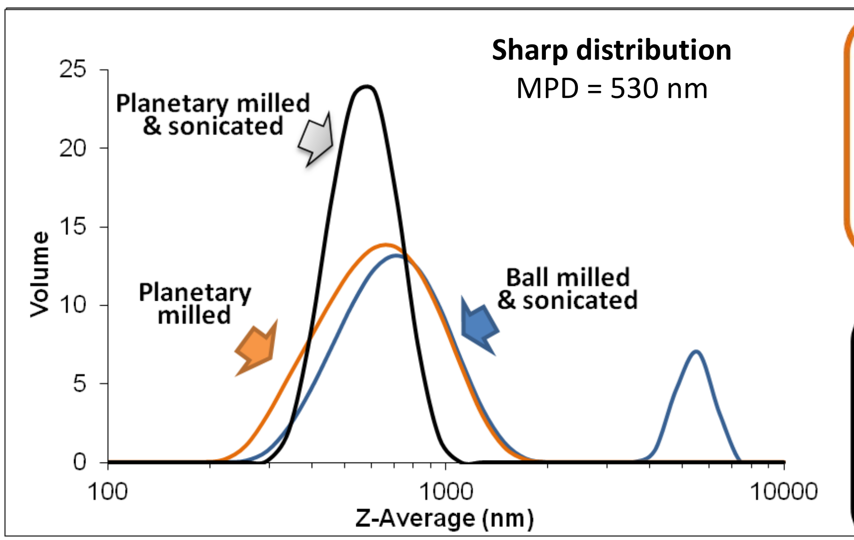
2. Planetary Milling

Sonicating probe

How does the particle distribution change using the different treatments?

Results:
influence of the milling treatment





Conventional ball milling

\+

Sonicating probe

- **1st peak narrower**
- **↓ volume large aggregates**

Trend more pronounced

Planetary Milling

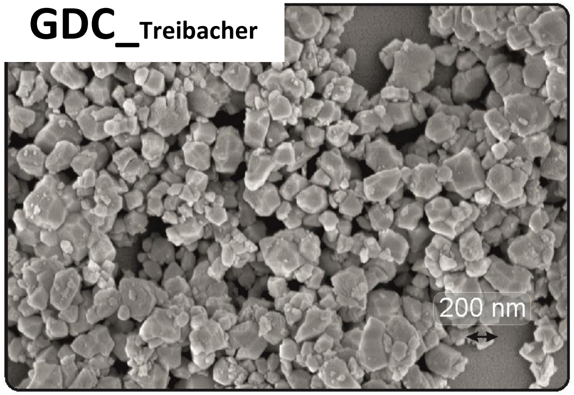
\+

Sonicating probe

Elimination of the large aggregates

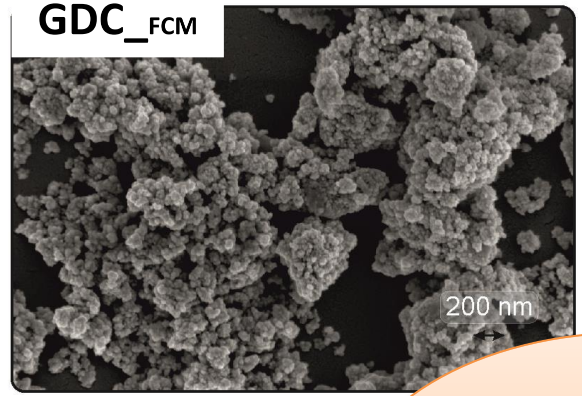
Results:
influence of the specific surface area

GDC_Treibacher



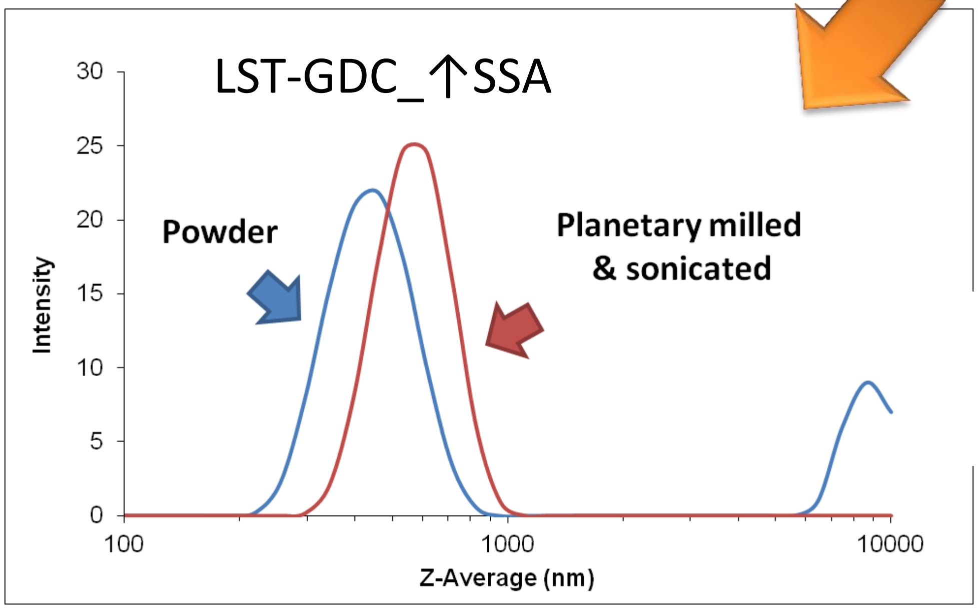
SSA = 9.10 m^2/g

GDC_FCM



SSA = 36.5 m^2/g

Higher SSA to increase the active surface



Monomodal distribution

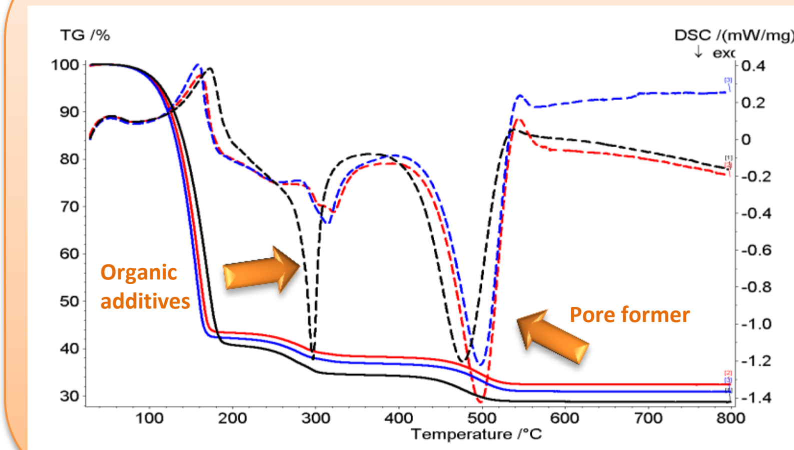
MPD = 570 nm

Results:
Inks formulations & characterizations

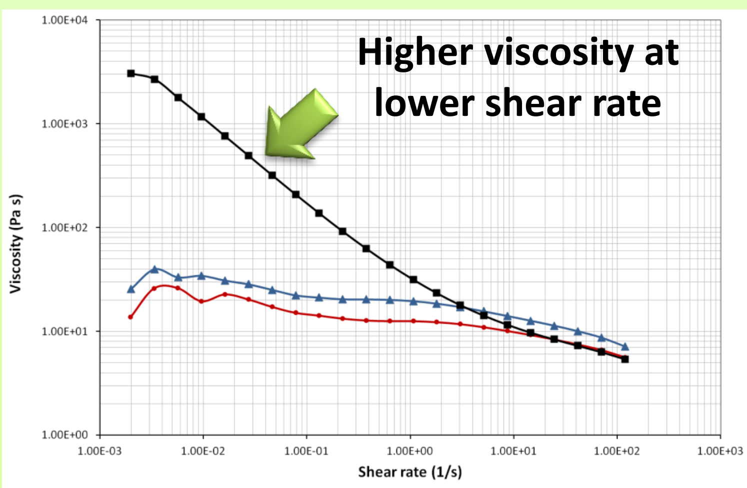
Vol %	LST-GDC	LST-GDC mill	LST-GDC ↑SSA
SLT	3.39	3.36	3.16
GDC	3.39	3.36	3.16
Solvent	82.61	81.79	77.03
Dispersant	**2.14**	**3.11**	**8.74**
Binder	5.57	5.51	5.19
Pore former	2.90	2.87	2.71

Re-optimization of the deflocculant amounts through analyses of the particle size distribution of suspensions

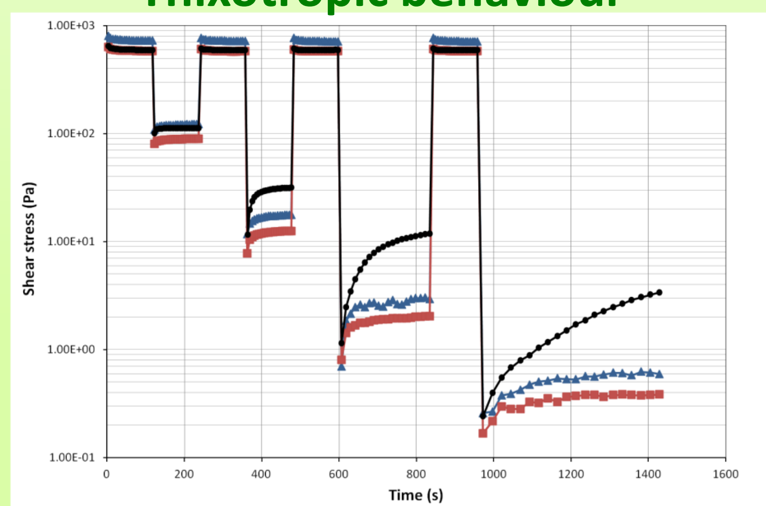
Thermal behaviour



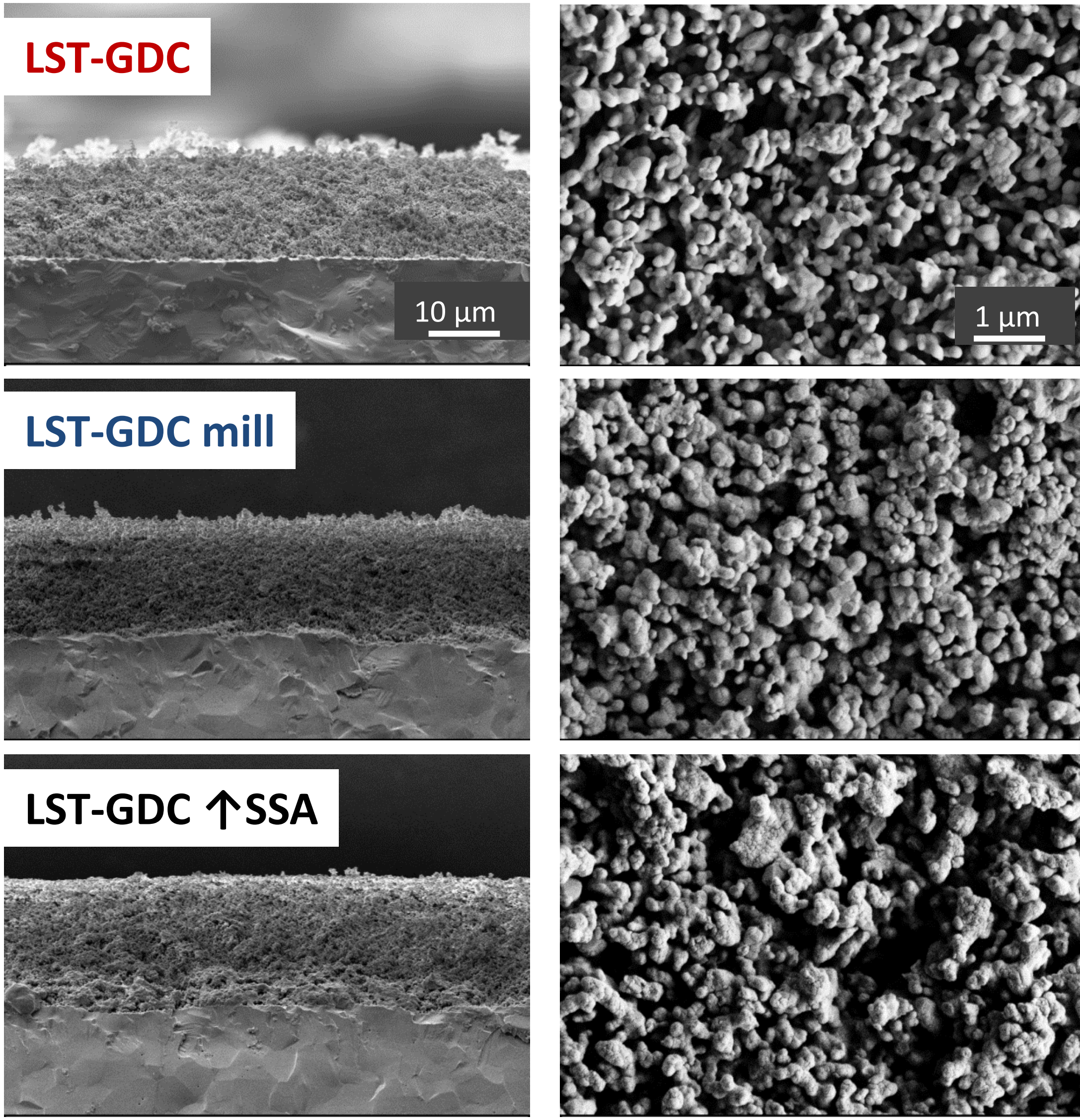
Flow curves



Thixotropic behaviour



Results:
Microstructural characterization

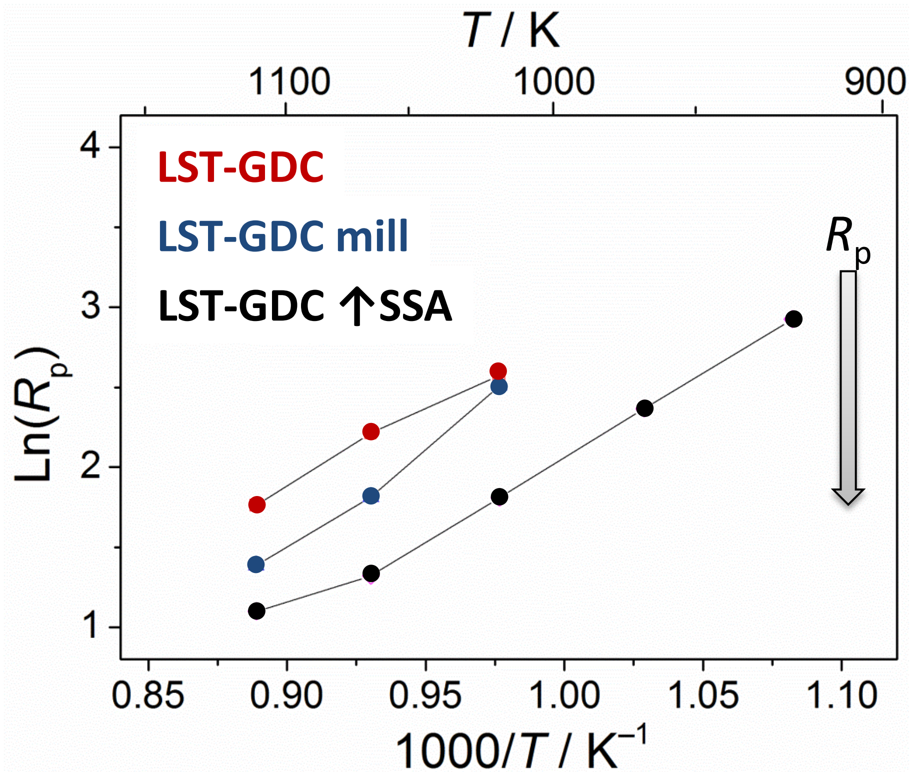


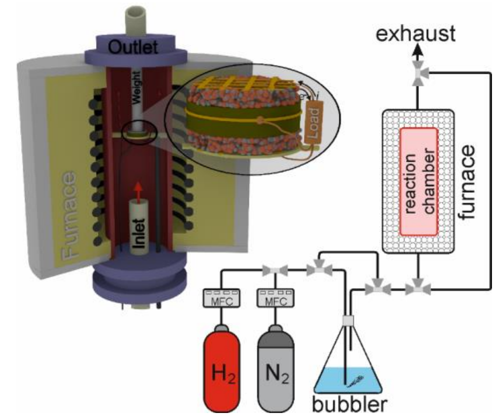
Similar microstructures with a well-leveled surface even in the case of the highly viscosity ink

	Porosity (vol %)	*Organics in the green layers (vol %)*
LST-GDC	56± 1	58.4
LST-GDC mill	60 ± 3	63.1
LST-GDC ↑SSA	68 ± 2	72.4

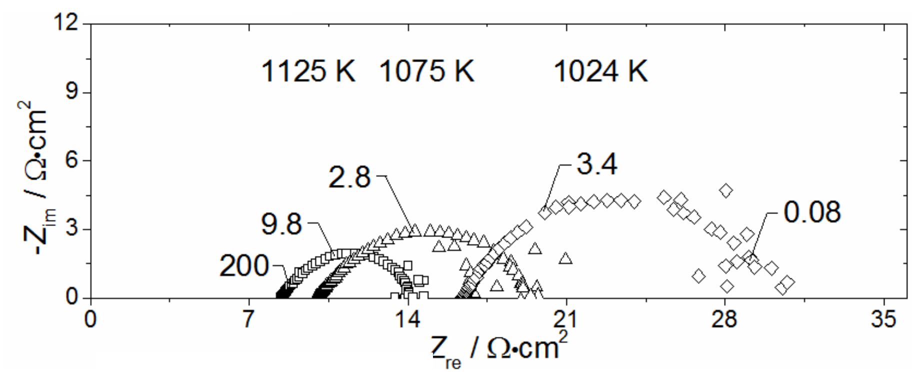
High values of porosity → in accordance with the vol % of the organics present in the different anodic layers.

Results:
Electrochemical characterization

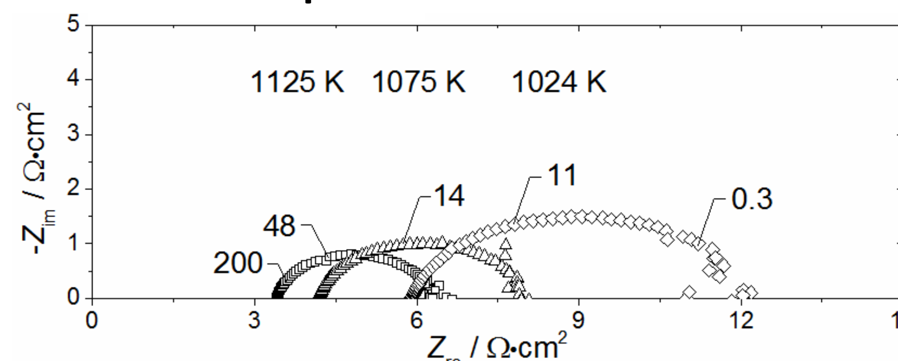




LST-GDC



LST-GDC ↑SSA



The symmetrical cell with LST-GDC↑SSA shows significantly improved performance

Conclusions

The influence of the processing parameters on the microstructures and electrochemical behavior of screen printed LST-GDC anodes was evaluated. In particular :

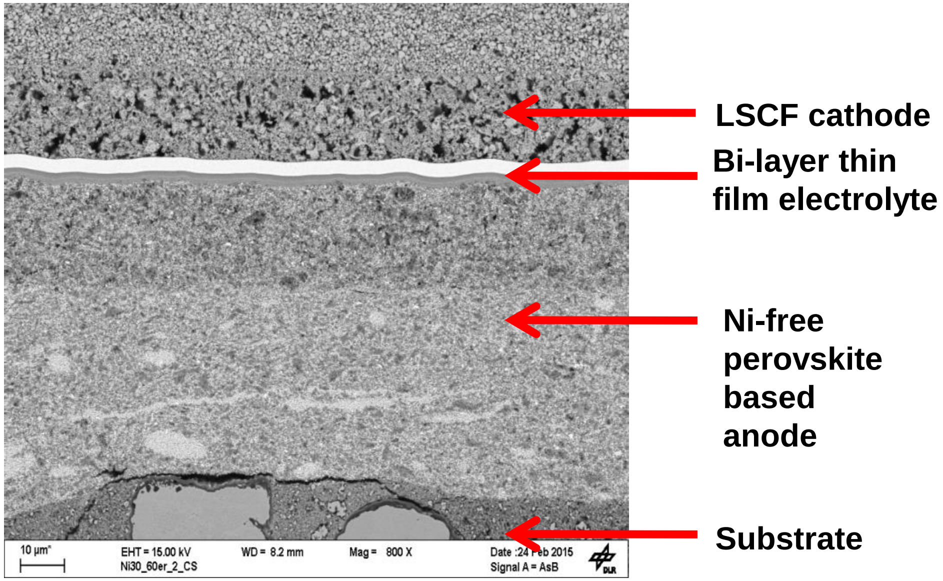
- **The deflocculant amount must be adjusted when a powder milling treatment is implemented into the process to obtain well-disperse and homogeous suspension.**
- **Planetary milling coupled with sonication treatment results the best procedure to produce monodispersal and homogeneous inks.**
- **The milling treatment does not affect so much the thermal and reological behaviour of the resulting inks as well as the microstructures of the sintered anodes BUT improves the electrochemical performances.**
- **The use of GDC with an higher SSA in combination with the optimized milling treatment leads to inks with slightely different thermal and reological properties BUT with a significant improvement of the performance.**

Other then the intrinsic properties of the electrodic materials, the production process plays a critical role to implement the performance of an electrode!!

Acknowledgement

Project EVOLVE: Evolved materials and innovative design for high-performance, durable and reliable SOFC cell and stack

FCH JU (303429) DLR coordinator
Nov. 2012 - Oct.2016



- Implementation of $SrTiO_3$ based anode materials
- Reduction of Nickel content at the anode side
- Thin film electrolyte

Thank you for your attention!